Impact of Crop Improvement and Management: Winter-Sown Chickpea in Syria

**Ahmed Mazid, Koffi Amegbeto, Kamil Shideed
and Rajinder Malhotra**

ICARDA

International Center for Agricultural Research in the Dry Areas

ISBN: 92-9127-203-8

Headquarters
International Center for Agricultural Research in the Dry Areas (ICARDA)
P.O. Box 5466, Aleppo, Syria
Tel: (+963) (21) 2213433, 2225112, 2225012
Fax: (+963) (21) 2213490, 2225105, 5744622
E-mail: ICARDA@cgiar.org
Website: www.icarda.org

Recommended citation:
Mazid, A., K. Amegbeo, K. Shideed and R.S. Malhotra. 2009. Impact of crop improvement and management: winter-sown chickpea in Syria International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. 52 pp.

Acknowledgments
The authors are grateful to the Syrian Agricultural Extension Directorate, General Commission of Scientific Agricultural Research, General Organization of Seed Multiplication, and Agricultural Directorates in Aleppo, Idleb, El-Ghab and Dara'a. The support we received from these Directorates during the course of this study is gratefully acknowledged. In particular, we acknowledge the vital contributions of Mohammed El Abdallah, Ghasan Ziadeh and Juma' Al Mustafa from the Directorate of Agricultural Extension. We also acknowledge the assistance provided by the technical staff of agricultural extension departments in Aleppo, Idleb, Hama (Al-Ghab) and Dara'a provinces who were involved in the research activities and in field data collection.

From ICARDA, Hisham Salahieh, George Arab and Hala Khawam supervised the field work; Dr Aden Aw-Hassan, Director of the Social, Economic and Policy Research Program, provided valuable comments on earlier drafts; and Ms Nazly Poshoyan undertook the design and typesetting.

We thank the many farmers in Syria who provided useful information, without which this study could not have been completed.

Contents

1. Introduction

Chickpea (*Cicer arietinum* L.) is an annual grain legume or 'pulse' crop used extensively for human consumption. Dried chickpea seed is commonly used in soup in India, while in the Middle East and elsewhere it is more frequently cooked and blended with rice dishes. The primary use in Syria is to prepare the *homus bet-hina* dish or *falafel*. Major chickpea producing countries include India, Pakistan, Mexico, Turkey, Canada, Syria, and Australia. Chickpea accounts for over 20% of world pulse production, and is the most important pulse crop after dry bean and pea.

Chickpea provides important economic advantages to smallholder farm households: it is a source of protein (an alternative to meat) and a source of cash income, and improves soil quality when grown as a break crop in cereal-dominated farming systems. Despite the importance of chickpea, yields in Syria – and many other developing countries – have remained very low. The major constraints to productivity are the low yield potential of landraces, their susceptibility to biotic and abiotic stresses, and poor cultural practices.

In Syria, chickpea is traditionally sown during spring on conserved soil moisture, if winter rainfall has been sufficient. Productivity is limited mainly by terminal drought and vascular wilt. With increasing pressure on land in Syria, profitability of spring chickpea is declining relative to other crops. This is a major reason for fluctuating or declining area and production.

Chickpea farmers in Syria – as in other parts of the Central and West Asia and North Africa (CWANA) region – avoid winter sowing for two reasons: risk of crop loss in a severe winter; and the fungal disease Ascochyta blight that can kill plants, reduce yield, and affect seed quality. However, winter-sown chickpea plants have a longer flowering period, more pods, and higher yields than those sown in spring. This is because crops benefit from winter rainfall, and lower temperatures as they approach maturity, so that less of the moisture they receive is lost to evaporation. Winter-sown chickpea can thus enable more productive use of land, stabilize chickpea area, and sustain the farming system.

This study was conducted in the 2005/06 season to collect information from farmers on the performance of winter-sown cultivars in comparison with the traditional spring plantings. The data were used to analyze the impact of winter chickpea technology and to identify constraints to its adoption, in order to guide future research at ICARDA.

2. Study Objectives

Impact assessment of agricultural research programs is generally conducted to evaluate how well research programs have done in the past, to inform stakeholders on returns to investment, to demonstrate accountability and thus convince research financers to continue their support, and to draw lessons from past performance to improve research efficiency (IAEG 1999).

ICARDA's chickpea improvement project developed winter chickpea technology, which was disseminated in Syria in collaboration with the Directorate of Agricultural Extension and General Commission of Scientific Agricultural Research (GCSAR). For the last few years, ICARDA has conducted chickpea growers' meetings at Tel Hadya and distributed seed of the variety Ghab 3 for winter planting. There has been a good response from farmers, and chickpea productivity in the target areas has increased during the last three years, but no impact analysis has been conducted.

Two new varieties, Ghab 4 and Ghab 5, were released by the Ministry of Agriculture in Syria in 2002. Seed of these varieties has been multiplied at Tel Hadya and shared with the General Organization of Seed Multiplication (GOSM) and with farming communities. In 2003, ICARDA distributed small quantities of seed of these two varieties to about 150 farmers for their evaluation and seed increase, supplied a considerable amount to GOSM for multiplication, and supplied some to GCSAR for demonstrations in Syria. In 2005, ICARDA supplied about 7.2 t of seed of Ghab 4 and Ghab 5 to farmers in Aleppo, Idleb, Suweida, and Al-Ghab, sufficient to plant an area of 0.2 hectare per farmer. The Agricultural Extension Directorate also distributed seed to poor farmers and to new areas or villages where there had been little or no previous distribution.

This study aimed to collect information from farmers on the performance of these cultivars in comparison with the traditional spring plantings. The data were used to analyze the impact of winter chickpea technology, identify the constraints to its adoption, and thus inform future research at ICARDA. The specific objectives of the study were to:

- Document the adoption of winter chickpea in Syria
- Identify biological and socioeconomic constraints that influence the adoption process
- Assess the impact of this technology on rural household livelihoods in terms of productivity, income, food security, and labor opportunities by gender.

3. Chickpea Production in Syria

According to statistics published by the Syrian Ministry of Agriculture and Agrarian Reform (MAAR), chickpea is the country's second most important rain-fed food legume crop in terms of area planted, after lentil. This has been the case for the past 25 years, and over this period chickpea area has remained relatively constant at about 2% of the total area planted to annual rainfed crops.

The patterns of variation in chickpea production and area are remarkably similar (Fig. 1). Production figures are the product of area and yield; the latter is shown in Fig. 2. There are considerable annual variations in yield, but there are more differences in the directions of variation about the trend when yield is compared to production rather than to area. Thus, although there has been a noticeable increase in area planted to chickpea, the trend in increased production is less noticeable due to the downward trend in yield. It was initially to reverse this downward trend that the new winter varieties were developed.

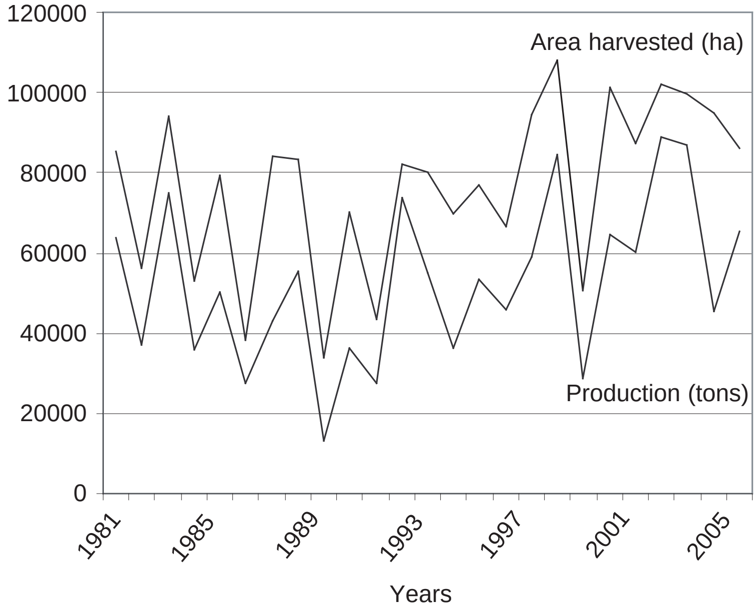


Figure 1. Variation in area and production of rainfed chickpea in Syria

Chickpea in Syria is grown under rainfed conditions. Syria has a range of rainfall zones (as classified by the government) that suit dryland cropping to varying degrees. Zone 1 has mean annual rainfall > 350 mm and is located along the coastal plain, the coastal mountains, and the Hauran region in the south. It also includes an area to the extreme northeast, in the Jazirah area near the Tigris River. Zone 2 has an annual rainfall of 250-350 mm, with no less than 250 mm falling during two-thirds of years, and lies adjacent to Zone 1 to the east and south behind the western mountains and across the Jazirah. Within both zones, there are two geographical areas that together constitute about 95% of the chickpea area. These are the southwest, in particular Dara'a and Suweida provinces; and the northwest, especially Idleb and western Hama (Al-Ghab) provinces; and western and northern Aleppo province. Chickpea is of minor importance in the Jazirah, where lentil is the favored legume. Both zones are characterized by the predominance of cereals and food legumes in their rainfed farming systems, although tree crops such as olives, nuts, and some fruits are becoming increasingly important.

Much of the annual variation in chickpea yield and cultivated area, and perhaps the long-term trend, can be attributed to rainfall patterns. For example, a study of rainfed agriculture in Syria showed a correlation coefficient of 0.83 between a national annual rainfall index and chickpea yields (ICARDA 1979). Because of the earlier planting and more efficient use of available soil moisture, annual winter chickpea yields should be less subject to minor rainfall variations than spring chickpea yields. Coefficients of variation (CVs) in winter-sown varieties have been lower than in spring-sown checks in agronomic trials (ICARDA 1984). Moreover, winter sowing may encourage the cultivation of chickpea in drier areas where it is not commonly grown. This somewhat anomalous circumstance is directly related to the place of chickpea in rainfed farming systems. Spring chickpea is largely dependent on stored soil moisture; the decision to plant and how much to plant depends on rainfall already received, and not, like winter-sown crops, on expectations of rainfall. Yields of spring chickpea may be less variable because, in dry years, farmers may simply choose not to plant and thereby save costs of production and avoid risks of crop failure. This option for spring (but not winter) chickpea has important implications for adoption of winter-sown varieties, for the substitutability of winter-sown for spring-sown chickpea, and thus for the goals of reducing annual variations in planted area and production.

There have been some noticeable shifts in national chickpea production patterns over the past 25 years. Because most chickpea in Syria is spring-sown, national average yields are still low. For example during 1981-2005 the average was 668 kg/ha, range 382-900 kg/ha (Table 1). The total chickpea area during the same period fluctuated between 34,000 and 108,000 ha. Unfortunately, the national statistics do not distinguish between winter-sown and spring-sown chickpea.

Table 1. Chickpea area, yield, and production in Syria during 1981-2005 seasons

	Minimum	Maximum	Mean	Std. Deviation	CV (%)
Area harvested (ha)	34,000	108,012	76,865	20,821	27
Yield (kg/ha)	382	900	668	127	19
Production (t)	13,000	88,781	52,488	20,035	38

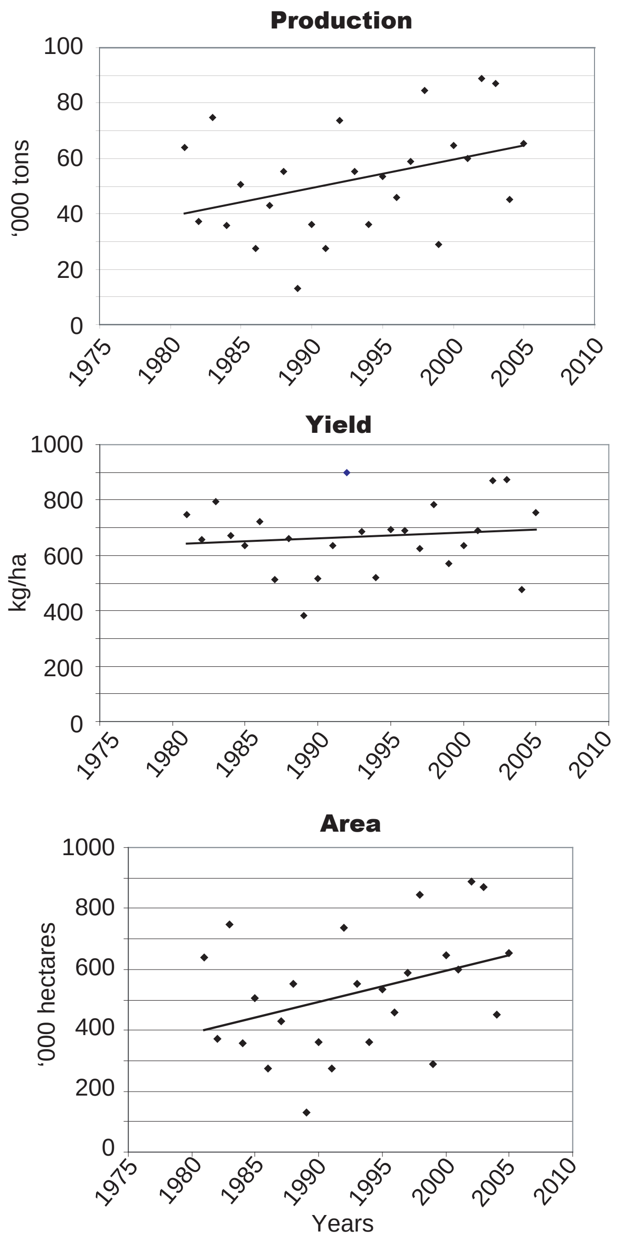


Figure 2. Area, production and yield of rainfed chickpea in Syria

Production during 1981-2005 increased at an average rate of 1.6% per annum. Annual growth rates during the same period were 1.4% for planted area but only 0.29% for yield (Fig. 2).

One reason for chickpea's presumed profit advantage has been its place in the farming system. Chickpea is traditionally planted in spring as part of either a two-course or three-course rotation. In the Hauran, the prevalent rotation is a chickpea-wheat-fallow (El-Mott 1984). More common in the northwest is a chickpea-summer-crop-wheat rotation or, more simply, a two-course chickpea-wheat rotation. Because it is planted in spring after the critical rainfall months of December-February, chickpea planting decisions can be adjusted according to received rainfall. If insufficient rain has fallen then fallow can be substituted for chickpea, thus saving the costs of land preparation, seeding, and fertilization. By leaving the intended chickpea field fallow, the farmer reserves the option of growing a modest summer crop (often melons) on residual moisture should heavy late rains fall in March-April after the chickpea planting date has passed. In essence, chickpea (like a summer crop) has a much lower risk of crop failure or economic loss than cereals, which must be planted before the winter rains.

Long-term national production is almost stagnant, at an annual increase of 1.6%, but the CV over time is high at 38%. Actual production has ranged from 13,000 t in 1989 to 88,800 t in 2002. This can be attributed more to annual variations in area planted than to yield fluctuations. The immediate reaction is to seek a way to increase yield and simultaneously reduce the annual variation. If this is possible, there will be substantial benefits to farmers and to the national economy. Winter-sown chickpea offers a potential solution. The new varieties, with their higher yield potential and resistance to Ascochyta blight (hence more stable yields) provide economic as well as environmental benefits.

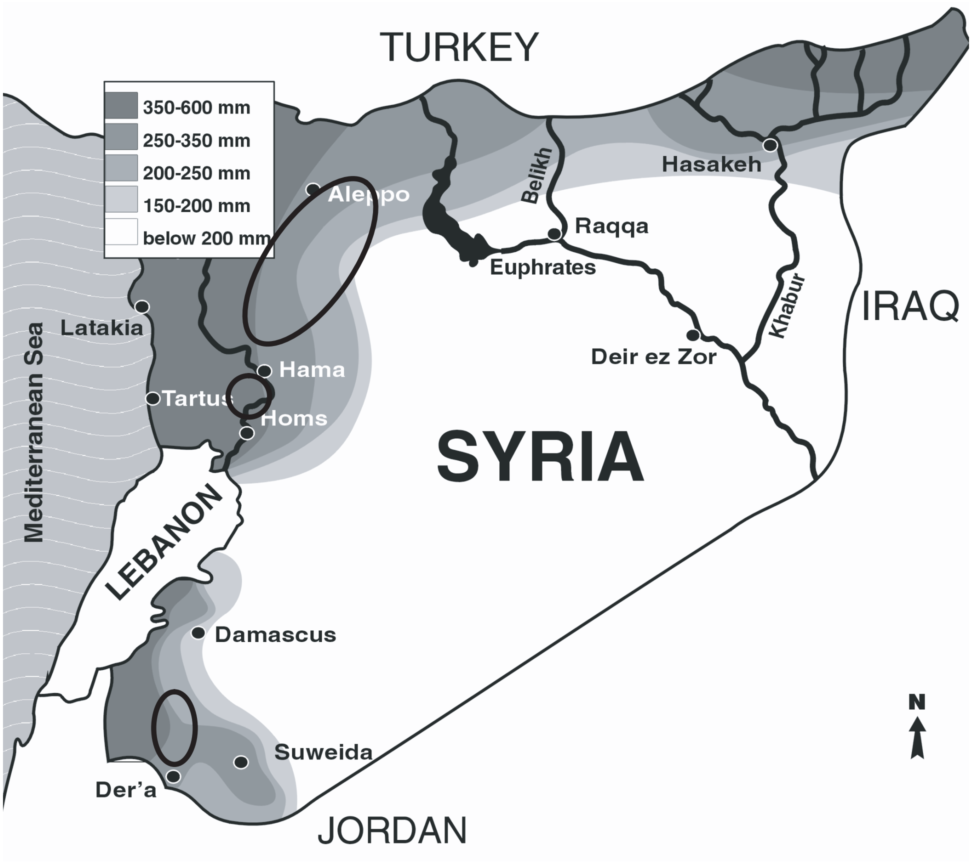
4. Methods and Sampling Design

4.1. The study area

Chickpea is grown in all Syrian provinces, but is relatively more important in Aleppo, Idleb, Hama, Homs, Dara'a, Suweida, and Al-Hassakeh. Given limited resources and time, the target areas in the study included only four provinces: Aleppo, Idleb, Al-Ghab (Hama), and Dara'a (Map 1).

4.2. Sampling design and data collection

This study was conducted in close collaboration with the Syrian national program, especially the Extension Directorate, GCSAR, and Agricultural Directorates in Aleppo, Idleb, Al-Ghab, and Dara'a.



Map 1. Locations of the study areas

A cross-sectional sample was used in this study, which included farmers that received winter chickpea seeds from official sources such as ICARDA or GOSM, in addition to other farmers who grew chickpea. The households surveyed were drawn randomly from lists of farmers growing winter chickpea in the 2004/05 season, as provided by the Extension Directorate and GOSM. In addition, other lists of farmers who grew chickpea, either spring and/or winter, in the target areas were also used. However, the sample included two types of farmers:

- Farmers adopting winter chickpea, including those who received seeds from ICARDA in 2004/05, or who bought seeds from GOSM in 2004/05
- Other farmers.

The sample included 470 farmers on the basis of their seed resources and provinces (Table 2). The sample covered about 160 villages in 40 sub-districts of 15 districts in four provinces. The survey questionnaire focused on many subject areas such as: the place of chickpea in the farming system, cultivation practices, production economics, crop performance and yield, household assets, household livelihood, and farmer evaluation of adoption potential. About half of the sample obtained seeds from official sources and used new chickpea varieties, and the other half obtained seeds from other sources. About 63% of farmers in the sample grew only winter chickpea, 27% grew spring chickpea, and 10% grew both.

4.3. Analytical methods

Several tools were implemented in this study, including descriptive and econometrics methods, as summarized below.

4.3.1. Descriptive analysis

Descriptive statistics techniques are useful in organizing and summarizing data, and are particularly useful when large amounts of data need to be interpreted. Descriptive statistics techniques used in the analysis include frequencies, graphs, percentages, cross-tabulations, and averages.

4.3.2. Logit model

The purpose of adoption analysis is to utilize a range of statistical procedures to identify the most significant factors influencing adoption decisions. Farmers' deci-

Table 2. Sample distribution by seed source and province

	Provinces					
Seed source	**Aleppo**	**Idleb**	**Hama/El Ghab**	**Dara'a**	**Total**	**%**
Research & Extension	30	37	24	30	121	26
GOSM	29	55	16	4	104	22
Research & GOSM	1	11	1	1	14	3
Other source	75	94	37	25	231	49
Total	135	197	78	60	470	100
%	29	42	17	13	100	

sions regarding adoption of new technologies are usually complicated; however, understanding adoption behavior often requires looking beyond relationships between single variables. There are several methods for examining multivariate relationships. Adoption is a categorical dependent variable, and logit models are useful for estimating the probability of events, such as adoption, that take one of two mutually exclusive values, such as 'adopt' or 'not-adopt'.

In deciding on adoption of a given new technology, farmers are assumed to weigh the consequences of adoption of an innovation against its economic, social, and technical feasibility, as well as other factors. A farmer usually evaluates any new technology in terms of the benefit that results from adoption. Naturally, if the benefit from a new technology is higher, the preference or utility (U) for that technology will be higher, for anyone who prefers more to less.

Let (X) represent a vector of factors related to adoption of a given technology. An individual's utility from adopting a new technology is denoted by $U_n(X)$, and the utility from retaining the traditional technology by $U_t(X)$. The utility from adopting the new or old technologies can be defined mathematically (Kebede et al. 1990) as:

$$U_n(X) = XB_n + E_n \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$U_t(X) = XB_t + E_t \quad \ldots\ldots\ldots\ldots \quad (2)$$

where B_n and B_t are response coefficients; and E_n and E_t are random error terms reflecting unobserved factors.

If the index of adoption is denoted by Y, which has a value of 1 if a farmer adopts the new technology and 0 otherwise, the probability that a given person adopts the new technology can be written as a function of X as follows:

$$\begin{aligned} P(Y = 1) &= P(U_n > U_t) \quad \ldots\ldots\ldots\ldots \quad (3) \\ &= P[(XB_n + E_n) > (XB_t + E_t)] \\ &= P[X\,(B_n - B_t) > (E_t - E_n)] \\ &= P(XB > E) \\ &= F(Z) \quad \ldots\ldots\ldots\ldots \quad (4) \end{aligned}$$

where P is the probability function; $B = (B_n - B_t)$ is a vector of unknown parameters that can be interpreted as the net influence of independent variables on adoption of the new technology; $E = (E_t - E_n)$ is a random error associated with adoption of new and traditional technologies; and F(Z) is the cumulative distribution function F evaluated at XB.

In the logit model, the probability of an individual adopting a new technology (N), given the vector of factors (X), is $P(N \mid X)$ and can be written as:

$$\begin{aligned} P(N \mid X) &= \exp(XB + E)/[1 + \exp(XB + E)] \\ &= 1/[1 + \exp(-XB - E)] \quad \ldots\ldots\ldots\ldots \quad (5) \end{aligned}$$

The probability of an individual retaining the traditional technology (T), or in effect not adopting the new technology, is the reciprocal of $P(N \mid X)$:

$$P(T \mid X) = 1 - P(N \mid X)$$
$$= 1 - [\exp(XB + E)/\{1 + \exp(XB + E)\}]$$
$$= 1/\{1 + \exp(XB + E)\} \quad \text{..........................} \quad (6)$$

The relative odds of adopting versus not adopting a new technology is therefore:

$$P(N \mid X)/P(T \mid X) = [\exp(XB + E)]\ [1 + \exp(XB + E)]/[1 + \exp(XB + E)]$$
$$= \exp(XB + E) \quad \text{..........................} \quad (7)$$

By taking the natural logarithms of both sides:

$$\ln[P(N \mid X)/P(T \mid X)] = XB + E$$
$$\ln[P(N \mid X)/\{1 - P(N \mid X)\}] = XB + E \quad \text{..........................} \quad (8)$$

Using P to denote $P(N \mid X)$, this simplifies to:

$$\ln[P/(1 - P)] = XB = Z \quad \text{..........................} \quad (9)$$

or $\exp(Z) = P/(1 - P)$

therefore $P = 1/[1 + \exp(-Z)] = 1/[1 + \exp(-XB)]$

The dependent variables in Equation (9) are simply the logarithm of the odds (the definition of odds is the ratio of the probability that an event will occur to the probability that it will not) that a particular choice will be made. The logit model will be estimated as:

$$\ln[P/(1 - P)] = b_0 + b_1x_1 + b_2x_2 + \ldots + b_nx_n + E_i \quad \text{...................} \quad (10)$$
$$= b_0 + \Sigma\, b_j\, x_{ij} + E_i$$

The probability of the event P can then be estimated from this as:

$$P = 1/[1 + \exp(-b_0 - \Sigma b_j X_{ij})] \quad \text{..........................} \quad (11)$$

4.3.3. Diffusion

Diffusion of new technologies is directly linked to the adoption process. According to most theories on adoption and diffusion of new agricultural technologies, the adoption of a new technology is not a single sudden event, but a process. The diffusion of an innovation has been defined as a process by which the innovation is communicated through certain channels over time among the members of a social system (Rogers 1983). A social system is defined by Rogers (1983) as "a population of individuals who are functionally differentiated and engaged in collective problem-solving behavior". In the present study, the social system consists of potential adopters, or farming communities, in the target areas.

The time dimension is essential in the diffusion process, and is an important aspect of any communication process. Researchers (Rogers 1983, Mahajan and Peterson 1985, CIMMYT 1993) have shown that adoption of an innovation when plotted against time is often normally distributed. If the cumulative number of adopters is plotted over time the resulting distribution is an S-shaped curve, in which there is slow initial growth in the use of the new technology, followed by a more rapid increase, and then a slowing down as adoption approaches its maximum. Early research focused on describing diffusion patterns in terms of pre-specified distributions (Mahajan and Peterson 1985). Subsequent research has attempted to develop more theory-based models. Diffusion models have been developed to represent the spread of an innovation amongst a given population in terms of a simple mathematical function of time elapsed since its introduction. Such a diffusion model provides valuable information about adoption trends and prospects for a new technology, and helps predict future progress and demand for inputs. It also allows extension services to quantify the change in the number of technology users over time in order to evaluate impact (CIMMYT 1993).

The logistic function was used in this research, as a well-known function in determining the level of adoption of new technologies. The function is S-shaped and expressed as follows:

$$Y_t = K / (1 + e^{-z - xt})$$

where Y_t is cumulative share of the adopter in time t; K is the maximum adoption rate; and X and Z are constants.

The function could be written as follows:

$$\ln\left(\frac{y_t}{K - y_t}\right) = z + X_t$$

4.3.4. Linear production function

A production function that describes the amount of possible output, given the amounts of inputs and the existing state of technological knowledge, is fundamental to economic analysis. Production function analysis provides a theoretical framework to estimate the comparative productivity of inputs used in a production process.

A yield production function can be used to measure the impact of a given innovation (Shideed and El Mourid 2005). This approach relates yield per unit area to a set of explanatory variables, such as levels of input use, type of technology, and environmental factors. A production function can be specified in its general form as: $Y_K = f\,(X_K, Z_K, I_K) + e_K$

where: Y_K is per hectare output of producer k; X_K is vector of variable input levels; Z_K is vector of environmental factors; I_K is vector of improved technologies or management practices; and e_K is a random error term.

The value of marginal product, $\Delta\pi_i = (dY_K/dI_K)\ P$, is the impact of the adoption of innovation (I) on profit, at output price (P) and holding all other inputs unchanged. The production function approach has several advantages. First, the regression model is capable of statistically isolating the individual effects of production factors, and interactions among technologies and inputs can be tested statistically. Second, the data used to estimate the production function are taken from farmers themselves, rather than from controlled experiments.

4.3.5. Cobb-Douglas production function

The Cobb-Douglas function is by far the most widely used in agricultural economics research because of its simplicity and ease of estimation. Its specification satisfies theoretical properties of strict monotonicity, quasi-concavity, strict essentiality, non-empty input set requirement, continuity, differentiability, and homogeneity. The Cobb-Douglas function permits the calculation of returns-to-scale and embodies the entire marginal productivity theory of distribution. The exponents constitute the output partial elasticities with respect to inputs, and in competitive equilibrium where inputs are paid their marginal products, they represent factor income shares.[1] The general form for the Cobb-Douglas function is:

$$Y = A \prod_{i=1}^{n} X_i^{\beta_i} \qquad \beta_i > 0 \qquad i = 1,2 \ldots n$$

where Y is the output, and X a vector of essential inputs used in production. The parameter A is the combined effect of all inputs (rainfall, weather, and disease outbreaks etc) that are not under the strict control of the farmer in the production function. Empirically, a logarithmic transformation in the following format was made, and dummy variables included differentiating the impact of the new technological package (or its components) on crop productivity:

$$\ln(Y) = \ln(A) + \sum_{i=1}^{n} \beta_i \ln(X_i) + \sum_{j=1}^{j} \delta_j D_j + \varepsilon \qquad \beta_i > 0 \quad i = 1,2,\ldots.n \qquad j = 1,2,\ldots J$$

where Y is output measured per unit land area; X_i are variable inputs such as seeds, fertilizers, labor, machinery used per unit of land; D_j are dummy variables for technological package /component (improved variety or adoption versus non-adoption); and ε the error term of the regression equation. Based on the Cobb-Douglas production function, net impact of a winter chickpea variety was estimated using the formula below:

$$\text{Net impact} = e^{\delta} - 1$$

where δ is the coefficient related to variety in the Cobb-Douglas model.

1. It is well known that the Cobb-Douglas form is not flexible in the sense that it restricts *a priori* the Allen elasticity of substitution among inputs to be equal to one. The risk of using it is that if it is the wrong specification, then statistical inferences and conclusions may be incorrect.

4.3.6. Factor analysis

One main point in the impact assessment is to show how technology affects farmers of different socioeconomic status. This can be done by first classifying households into different socioeconomic types using their assets (e.g. human, natural, physical, social and financial) and then determining the adoption of technology in these household-types. This allows determining whether the technology is beneficial to poor households as much as to more wealthy households.

For this purpose, factor analysis is used to create the wealth index, which is a statistical technique similar to Principal Components Analysis. These analyses have the common objective of reducing relationships between many interrelated variables to a small number of factors. However, the primary purpose of factor analysis is to describe the relationships among the many variables in terms of a few underlying but unobservable factors; thus many original variables are combined into a few derived variables.

In calculating the wealth index, the coefficients of variables estimated by factor analysis were multiplied by standardized values of the respective variables for each factor (X_i). Household-specific wealth indices were constructed from scores obtained from factor analysis, according to:

$$X^* = \Sigma w_i X_i$$

where X* is the score for each household; X_i is the value of factor i and has a mean of zero and standard deviation of 1; and w_i is weight, specified for the maximum variance of factor i.

5. Chickpea Technology Development and Transfer

ICARDA has a regional responsibility for improvement of Kabuli-type chickpea. The Center helps develop and deliver improved technologies to national programs in collaboration with national agricultural research systems and advanced research institutions.

ICARDA's plant breeding objectives address the specific needs of different agro-ecological regions and key stresses prevailing locally. There is a fully-fledged plant breeding program for chickpea. Following a bulk pedigree method, and a decentralized breeding strategy, the breeding program develops new genotypes to deliver to the national institutions. To aggregate desirable genes, rigorous gene mining and their pyramiding are an important part of ICARDA's integrated gene management programs.

Improved agronomic packages from ICARDA were very limited up to the mid-1980s. About 10 years of joint work with national programs generated very useful information on planting dates, plant population, rhizobia inoculation, and weed control (including herbicides and mechanical harvest). These findings led to the development of improved agronomic packages, which are now being used by farmers and researchers in Syria as well as in the wider region.

In collaboration with the Department of Agricultural Extension in the Syrian Agricultural Ministry and GCSAR, ICARDA has had a vital role in dissemination of winter chickpea technology in Syria. Many field days were organized by ICARDA and the Syrian national programs in farmers' fields, small amounts of seed of new varieties were distributed to chickpea producers, in addition to printing and distributing extension materials or publications on winter-sown chickpea.

5.1. Technology development

Chickpea is traditionally sown during spring in Central and West Asia and North Africa (CWANA) on conserved soil moisture. Productivity is limited mainly by terminal drought and vascular wilt. Rainfall in Syria (and most of CWANA) is mainly in winter; and farmers normally plant chickpea in spring if there has been sufficient winter rainfall. Spring planting allows chickpea to escape from conditions that enhance Ascochyta blight, a disease promoted by humidity and moderate cold. Late planting also means that the reproductive stage of spring chickpea occurs when rainfall is minimal and temperatures are high (ICARDA 1987).

The first winter-sown chickpea variety developed by ICARDA and released in Syria in 1982 was Ghab 1. This was followed by Ghab 2 in 1986, Ghab 3 in 1991, Ghab 4 and Ghab 5 (with larger seed size than Ghab 3) in 2002. These five varieties have the potential to considerably increase national chickpea productivity.

The winter-sown varieties were developed to be resistant to both Ascochyta blight and cold. In over 10 years of scientific trials, both on-station and on-farm, winter-sown chickpeas have consistently yielded more than local spring-sown cultivars, usually by 50-100% (ICARDA 1987). The higher yields are due to a longer growing season, better moisture utilization during growth and maturation, higher germination rates, more favorable soil moisture and temperature during reproductive growth, better nodulation, and less insect damage (ICARDA 1981).

Advancing the planting date of chickpea by up to four months in Syria's Mediterranean climate has the obvious advantage of giving the crop an opportunity to receive more precipitation. Generally speaking, rain begins in October and continues until February-March, when it becomes markedly less frequent. The rainy season ends in spring, and late-season droughts and high temperatures are not unusual. However, there are dangers inherent in winter sowing. Ascochyta is an ever-present threat, and killing frosts also occur. Syria's highly variable rainfall pattern produces some years in which a good start in October-November is followed by an absence of rain in December-January, sometimes continuing longer. In such years, winter-sown chickpeas would germinate and emerge, only to die or fail to mature due to the mid-season drought. Therefore, breeding and agronomy research emphasized resistance to Ascochyta blight and cold tolerance, together with cultural practices to reduce risks from variable rainfall within a season. Weather factors can never be completely overcome. Nonetheless, research has proven that over a multi-year period the new varieties should considerably outperform the local spring chickpeas, both in yield and economic return.

Concurrently with agronomic trials, winter-sown chickpea was assessed for economic feasibility using partial budgeting techniques. Careful records of variable costs were kept and compared to those for spring chickpea. In each year that this was done, the net return from winter chickpea was substantially higher than for the local spring variety, although the actual difference varied with year and location. For example, in 1985/86, a year of average rainfall but spring drought, winter chickpea gave average net revenue 68% higher than spring chickpea. In 1988/89, a year of drought, the winter varieties had average net revenues 48% higher. The differences in income benefits were largely due to yield differences. Production costs were much the same for both types, with one important exception; weeds that emerge with winter rainfall are destroyed during tillage and planting of spring-sown chickpeas, but for winter-sown varieties the weed infestations must be controlled within the growing crop. Since this is usually done by hand, costs of weed control in winter chickpea are typically 2-3 times that for spring chickpea. However, these additional production costs were more than compensated for in net revenue from the yield advantage.

ICARDA assessed on-farm chickpea practices in 30 on-farm trials in northwest Syria during 1985-1989 (Pala and Mazid 1992). The results indicated that changing the sowing date from spring or late winter to early winter increased seed yields. Rhizobium inoculation produced inconsistent yield responses. Weed control (weed cleaning) increased seed yield compared to non-weeded controls, but was less effective than hand weeding. Application of 50 kg P_2O_5 per hectare increased seed yields in the first three seasons. Drilling chickpea seed increased seed yield by 10% compared with the common practice of broadcast sowing. It was concluded that a combination of early winter sowing, drilling, weeding, and where appropriate, phosphorus application, was likely to maximize net revenues and produce high yields.

5.2. Recommended winter chickpea package components in Syria

In collaboration with the national program in Syria, a package of recommendations was developed for winter chickpea. This package had main and optional components.

The main components included:

- Using improved varieties: Ghab 3, Ghab 4 or Ghab 5
- Seed rate of 120 kg/ha
- Planting date in the first half of January
- Chemical seed treatment
- Protective spray against fungi during the second half of March
- Weed control when plants reach 10 cm high.

The optional components included:

- Reliable seed source
- Using a drill for planting
- Using super phosphate fertilizer at 100 kg/ha
- Using herbicide before planting
- Using mechanical weed control
- Using additional spraying, 1-2 times when needed.

5.3. Technology transfer

The years immediately following the release of the new chickpea varieties were devoted to a controlled seed multiplication program using private farmers under contract to GOSM. The purpose was to accumulate sufficient seed stocks for general release of certified seed. Multiplication was done in plots of 1-12 ha. Yields were high and there were no major incidences of diseases or pests; economic analyses showed high profit margins (ICARDA 1988a, 1988b, 1990). At the beginning of the 1989/90 growing season sufficient seed stocks had accumulated, and the new varieties were made available for sale to the general public through

GOSM. Announcements concerning the new varieties and their availability were widely disseminated through mass media and extension services. At the same time, the Socio-Economic Studies and Training Section of the Syrian Scientific Agricultural Research Center, together with ICARDA scientists, organized a farm-level survey to assess the performance of the new technology in on-farm conditions and for farmers to evaluate the potential for adoption and positive impacts.

In the last few years, several chickpea growers meetings have been conducted at Tel Hadya and seeds of Ghab 3 distributed for winter planting. In 2003, small quantities of seeds were distributed by ICARDA to about 150 farmers for their evaluation and seed increase. In addition, in 2003, ICARDA supplied sufficient seed of these two varieties to GOSM for multiplication, and to GCSAR for demonstrations in Syria. In 2005, ICARDA supplied about 7.2 t of seeds of Ghab 4 and Ghab 5 to farmers (for planting 0.2 ha per farmer) in Aleppo, Idleb, Dara'a, Suweida and Al-Ghab.

5.4. Seed multiplication

GOSM in Syria is part of the public sector, and responsible for multiplying and distributing improved seeds of main crops such as wheat, barley, lentil, chickpea, cotton, and potato. During the period of the study, GOSM multiplied Ghab 3 as winter chickpea and sold it to farmers.

In the 2003/04 season, GOSM started to multiply Ghab 4 and Ghab 5, in addition to Ghab 3, at GOSM stations. Average yields at Jarablos Station (located in Zone 2) during the 2003/04 season were 1341, 1250, and 1453 kg/ha, for Ghab 3, Ghab 4, and Ghab 5, respectively. The quantities of Ghab 3 seed sold by GOSM in Syria were: 575 t in 2004/05, 95 t in 2003/04, and about 3000 t in 2002/03. The variation was essentially due to differences between market price and GOSM price, which was fixed at SYP 27.2 per kg. Ghab 3 seed distribution by provinces in 2004/05 was: 176 t in Aleppo, 306 t in Idleb, 19 t in Hama, 64 t in Dara'a (Izra'a), 9 t in Hassakeh, and 1 t in Homs.

The main reasons for slow diffusion of winter chickpea technology among farmers, identified during rapid rural appraisal were:

- Risk of Ascochyta blight – no variety is resistant to Ascochyta, and winter varieties are only tolerant
- Lack of farmer knowledge on winter chickpea technology
- Insufficient farmer awareness of chemical spray options (e.g. type and quantity), and no clear pest management program for winter chickpea
- Increased risk of crop failures in some areas because farmers do not apply all components of the package.

6. Farmers' Chickpea Production Practices

6.1. Land use

The cropping system in Zone 1 is very diverse. Cereals constitute about 40% of the arable area (Fig. 3); chickpea was 19%, and other food legumes and tree crops together covered about 25%. A range of market crops, such as vegetables, potato, and cumin accounted for some 10%. In Zone 2, cereals occupy over 50% of the arable area, chickpea and lentil about 35%, and olive trees about 10%. Fallow area was not significant in both zones.

6.2. Land preparation and previous crop

Farmers' practices for land preparation for both winter and spring chickpea are summarized in Table 3. There was no significant difference in land preparation for the two chickpea types. The majority of farmers plowed their land three times, using moldboard equipment for the first cultivation, and a cultivator for the second and third cultivations. Most farmers (80%) planted chickpea after cereal crops, particularly wheat.

6.3. Varieties and seed sources

Ghab 3 was the dominant winter chickpea variety, used by > 50% of growers due to its availability in the market and from GOSM (Table 4). The large-seeded Maracshi was the dominant variety of spring chickpea used by farmers. The main seed source for winter chickpea, apart from seeds distributed by ICARDA, was

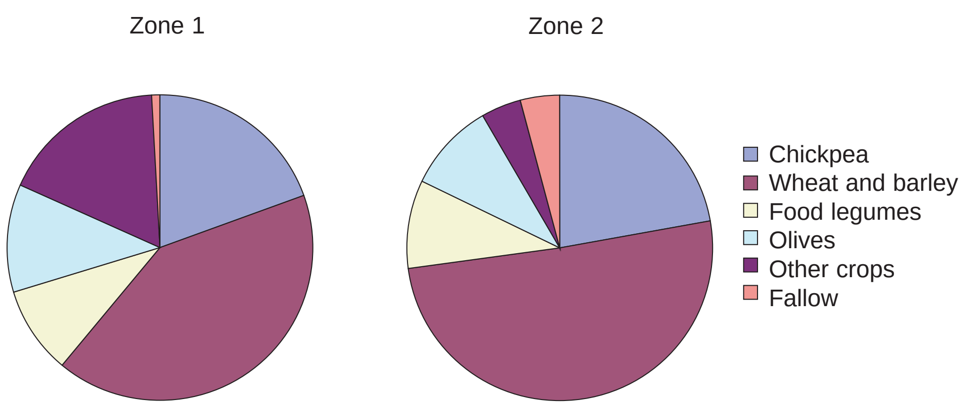


Figure 3. Land use in Zones 1 and 2 of the sampled area

Table 3. Farmers' practices for land preparation (% of farmers)

Operation	Winter chickpea	Spring chickpea
Cultivations		
One cultivation	93.2	94.0
Two cultivations	79.5	72.5
Cultivation before planting	77.4	63.7
Equipment used for 1st cultivation		
Moldboard	67.9	81.9
Disc	22.2	8.2
Chisel	0.6	1.2
Cultivator	9.2	8.8
Equipment used for 2nd cultivation		
Moldboard	12.7	18.2
Disc	3.4	1.5
Cultivator	84.0	80.3
Equipment used for cultivation before planting		
Moldboard	5.7	11.2
Disc	1.1	1.7
Chisel	0.4	-
Cultivator	92.7	87.1
Previous crop		
Wheat	80.1	86.0
Barley	9.3	4.7
Legumes	4.0	5.3
Summer crops	3.1	2.9
Cumin	1.6	0.6
Other crops	1.9	0.6

Table 4. Seed sources and chickpea varieties used (% of farmers)

	Winter chickpea	Spring chickpea
Variety used		
Ghab 1	1.8	-
Ghab 2	0.9	-
Ghab 3	51.6	-
Ghab 4	25.2	-
Ghab 5	16.9	-
More than one variety	3.3	-
Local variety	0.3	38.4
Maracshi	-	50.0
A Turkish variety	-	3.3
Other varieties	-	8.3
Seed source		
Own	11.4	33.5
GOSM	30.7	0.5
Market	16.6	59.3
Neighbor	1.2	4.9
Research-Extension	35.2	-
More than one source	4.8	1.6
Seed dressing with fungicides	52.4	23.7

GOSM (31% of farmers), then the market. About 11% of farmers kept winter chickpea seed from the previous year for sowing the next year. For spring chickpea, the market was the source for seed and one-third of farmers usually kept their seed to plant in the next year. More than half of winter chickpea growers treated their chickpea seed with fungicides, compared to 24% for spring chickpea.

6.4. Sowing methods, seed rate, and planting date

The majority of farmers use machines to sow chickpea, with different equipment for winter and spring chickpea. An ordinary drill was used by about two-thirds of winter chickpea growers compared to 22% of spring growers (Table 5). Sowing methods differed among provinces; about 80% of farmers used a drill in Aleppo and Idleb provinces, while hand broadcasting was dominant in Dara'a and Al-Ghab. The average seed rate was 140 and 132 kg/ha for winter and spring-sown chickpea, respectively, but the difference was not significant. However, it is clear that farmers' seeding rates for winter chickpea were higher than the recommended

Table 5. Sowing methods and planting dates for winter and spring chickpea (% of farmers)

	Winter chickpea	Spring chickpea
Sowing methods		
Drill	63.1	21.6
Hand	17.5	26.7
Spinner	7.3	7.4
Tubs	12.1	44.3
Sowing date		
2nd week of November	1.0	1.8
3rd week of November	0.3	1.2
4th week of November	2.0	0.6
1st week of December	8.9	4.2
2nd week of December	9.9	4.2
3rd week of December	5.9	1.8
4th week of December	7.9	0.6
1st week of January	19.1	3.0
2nd week of January	26.0	1.8
3rd week of January	5.6	1.8
4th week of January	3.6	0.6
1st week of February	7.9	6.6
2nd week of February	1.0	4.2
3rd week of February	0.3	4.2
4th week of February	0.3	9.6
1st week of March	19.1	16.9
2nd week of March	-	12.6
3rd week of March	-	7.2
4th week of March	-	7.8
April	-	9.0
Seed covering		
Mold	28.6	42.0
Disc	11.6	2.5
Cultivator	52.7	55.6
Drill	7.1	0
Seed rate (kg/ha)	140	132

120 kg/ha, Only 23% of farmers used the recommended seed rate and 60% used a higher rate. Seed rates varied among farmers according to province. In Aleppo, farmers used an average rate of 158 kg/ha, higher than Idleb, Al-Ghab, and Dara'a with 142, 117, and 109 kg/ha, respectively.

Winter chickpea was sown at the recommended date by 45% of farmers, before the recommended date by 36%, and after the date by 19% (Table 5).

6.5. Harvesting and yields

Harvesting times and methods used by farmers for both winter and spring chickpeas, as well as average yields in the 2005/06 season in Zones 1 and 2, are summarized in Table 6. Manual harvesting was applied by 48% of winter chickpea growers compared to 93% for spring growers. About 41% used an ordinary harvesting combine for winter, compared to 3% for spring chickpea. About 56% of farmers in Idleb used a combine for winter chickpea harvesting compared to 40% in Aleppo and 35% in Al-Ghab. No farmers in Dara'a province used a harvesting combine for either winter or spring chickpeas.

The majority of farmers harvested their chickpea during the first half of June (Table 6), and some delayed to the second half of June. About 15% of growers harvested their winter-sown chickpea during the second half of May.

In the 2005/06 season, winter chickpea growers in Zone 1 obtained average yields of 2.1 t/ha compared to 1.5 t/ha for spring chickpea; in Zone 2, average yields were 1.2 and 0.86 t/ha, respectively. Thus, winter chickpea growers had 37% higher yields per hectare than spring growers.

Table 6. Harvesting time and methods

	Winter chickpea	Spring chickpea
Harvesting methods (% of farmers)		
Hand	48.3	93.0
Mechanical	8.7	.6
Combine	40.9	2.9
More than one method	2.1	3.5
Harvesting time (% of farmers)		
1st half of May	3.7	4.5
2nd half of May	14.1	2.8
1st half of June	45.7	47.1
2nd half of June	22.4	22.2
1st half of July	13.5	19.4
2nd half of July	0.6	4.0
Yields in 2005/06 season (kg/ha)		
Zone 1	2082 (768)*	1520 (505)*
Zone 2	1187 (541)*	865 (512)*
Chickpea prices at harvest time (SYP/kg)		
Grain	28.1 (4.4)*	31.7 (5.4)*
Straw	3.2 (1.7)*	3.2 (1.5)*

* Figures in parentheses are standard deviations

7. Contribution of Chickpea Production to Farmers' Livelihoods

In the dry areas of the CWANA region, rural livelihoods and agriculture are closely interlinked. A livelihood comprises the assets, activities, and access to these as mediated by institutions and social relations; together they determine the living gained by individuals or households. The construction of a livelihood is an ongoing process with constantly changing elements, and alterations in the quality and quantity of natural resources. These elements affect crops that farmers can grow and have direct implications on the livelihoods of those who depend on them. In the short term such changes in resources and crops grown have a great effect on people's livelihoods.

7.1. Household assets

Households usually use a variety of resources as inputs into their production processes as they attempt to meet and extend their needs. These can be classified as human, financial, physical, natural, and social capitals, as popularized in the sustainable livelihoods approach (Carney 1998). Five capital assets were used to ensure that all components of the livelihood assets were addressed and summarized (Table 7).

Natural capital is very important for rural communities because they derive all or part of their livelihoods from resource-based activities. Farm size is a major determinant of financial status of a farmer, land holdings also play an important role in family labor employment and income, and production per unit area may also depend on farm size. The average total holding area in this study was 10.7 ha with range 2.5-160 ha, but generally most were small farmers (50% had < 6 ha) and only some had access to irrigation.

Physical capital is vital for societal development, as it comprises the basic infrastructure and producer goods that support livelihoods. Many assessments have found that a lack of particular infrastructure is a core dimension of poverty. Without adequate access to public services such as water and energy, human health deteriorates and long periods are spent in non-productive activities (DFID 2001). Ownership of livestock, a tractor, a pick-up, and other items all affect household welfare; and these physical assets were available to some households (Table 7).

Human capital usually represents the skills, knowledge, and availability of labor and health status that together enables people to pursue different livelihood strategies and achieve their objectives. The household head remains the main driving force behind any household livelihood strategy. Characteristics of household

Table 7. Household assets

	Average
a. Natural Capital	
Total holding area (ha)	10.7
Total owned area (ha)	8.8
Having irrigated land (%)	36
Using the water resource to irrigate chickpea (%)	8.5
Distance between the house and paved road (m)	83
b. Physical Capital (% of farmers)	
Having a tractor	32
Having a well	29
Having agricultural equipment	25
Having a shop	15
Having a car	11
Having a pick-up/lorry	20
Having a motorcycle	32
Having a bus	2
Availability of public school	98
Availability of public clinic	81
Availability of telephone in the house	69
Availability of electricity in the house	96
c. Human Capital	
Family size (persons)	9
Experience in agriculture (years)	25
Having other skills (%)	25
Having work opportunities outside (%)	21
Farmers' education (%)	
- Illiterate	6
- Read and write	27
- Preliminary	26
- Secondary	22
- University	19
Classification of livelihood by farmers' perception (%)	
- Very poor	1
- Poor	13
- Moderately well-off	67
- Well-off	19
d. Financial Capital	
% of off-farm income	12
% of income from chickpea	21
Average annual income	SYP 403,000/household
Saving money last year (%)	29
Using credit for farm needs (%)	19
Having sheep and/or goats (%)	20 (average 25 head)
Having cattle (%)	10 (average 3 head)
e. Social Capital (% of farmers)	
Cooperative availability in the village	95
Cooperative membership	45
Perception of household member to be active in any collective action in the community	
- Leader	6
- Very active	25
- Somewhat active	63
- Not active	6
People generally trust one another in matters of lending and borrowing	51

heads were documented to understand decisions to adopt a particular livelihood strategy. Household head education, experience, and age strongly influenced decisions regarding crops, livestock management, and farm investments. Household endowments of different livelihood assets were included in the analysis, where farmers classified themselves into different welfare groups. Most farmers classified themselves as moderately well-off, and a small proportion classed themselves as poor or very poor. The variables that represent household human capital are summarized in Table 7.

The availability of cash or equivalents that enable people to adopt different livelihood strategies is defined as financial capital. Available stock and savings may not be cash, and is sometimes livestock in dry areas. Livestock animals are considered a stand-by asset as part of a strategy to reduce vulnerability. Alternative sources of income, especially from non-farm activities, are likely to have a greater poverty-reducing effect. Facilitating finance to farmers and intermediary agencies is important in improving livelihoods in rural areas, by improving the delivery of inputs to farmers and introducing liquidity into output marketing. Moreover, delivery of credit can be linked to savings as the other important element in rural finance. Financial assets available to the households in the target areas are shown in Table 7. The percentage of households who saved money in the previous year was notably low. Farmer access to credit was low (29%), and income from non-farm activities was only 12%.

The social capital of any society is very important, as mutual trust and connectedness assists in coping with shocks and vulnerability, particularly for the poor. However, in this study, due to availability of agricultural cooperatives, farmers had potential to cooperate in commonly beneficial development schemes. There is a strong need to develop mutual trusts and organization of the community to develop and utilize the available resources for sustainable livelihoods. Most farmers indicated the availability of agricultural cooperatives in their communities, but only 45% were members of these cooperatives.

7.2. The wealth index

The wealth index, based on the status of household assets, was used for ranking households in the sample. In the wealth ranking, variables important in distinguishing households from each other were identified by Principal Components Analysis. Wealth quartiles were used to explore patterns of income distribution in households. Five main elements were hypothesized to represent household well-being; the human, natural, financial, physical, and social capitals presented in the previous section. Several variables were selected and used to represent each element. The variables used to create the wealth index were total holding area, goat numbers, family size, having other skills apart from knowledge in agriculture,

Table 8. Household characteristics by wealth quartile

	Wealth Quartiles			
Variables	**Lowest 25%**	**25-50%**	**50-75%**	**Highest 25%**
Total holding area (ha)	5.0	6.6	7.1	22.2
Goat numbers (head)	0.2	0.4	0.7	2.2
Family size (persons)	7	8	9	10
Having other skills apart from knowledge in agriculture (1 = Yes, 0 = otherwise)	0.03	0.17	0.38	0.42
People generally trust one another in matters of lending and borrowing (1 = Yes, 0 = otherwise)	0.19	0.50	0.71	0.70
Owned area (ha)	4.4	5.8	6.2	17.6
Having car (1 = Yes, 0 = otherwise)	0.01	0.03	0.12	0.26
Farmer age (y)	59	52	48	47
Distance between the house and paved road (m)	27	37	73	178

people generally trusting one another in matters of credit worthiness, owned area, having a car, farmer's age, and the distance between the house and a paved road.

To use indices for assessing welfare status, wealth index, which was calculated based on factor analysis, was used to sort wealth categories and classify households into four welfare quartiles (Table 8).

7.3. Importance of chickpea in household income

Households in the target areas have diversified livelihoods, grow several crops, keep different types of animals and participate in diverse off-farm and non-farm activities. The livelihoods of farmers in the area depend mainly on crop production, which represents about 75% of household income (Fig. 4). Mixed farming is practiced and farmers make income from crops. There are also some people who make a living from off-farm activities as laborers or government employees.

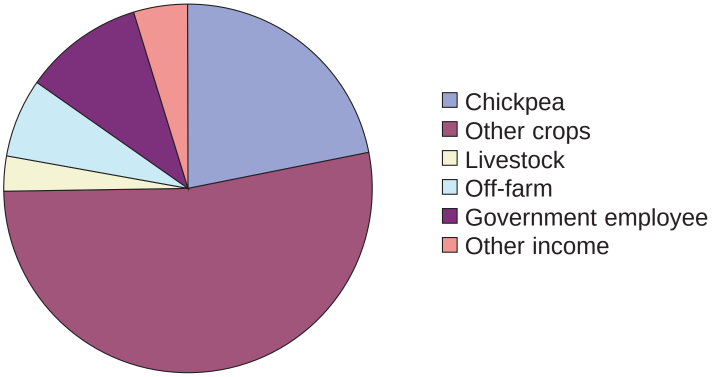


Figure 4. Sources of household income

Table 9. Contribution of chickpea to average household income (%)

Group	**Income from chickpea (SYP)**	**Average household income (SYP)**	**Contribution of chickpea (%)**
Type of chickpea grown			
Winter only	107,311	453,672	24
Spring only	72,195	370,091	20
Winter and spring	206,946	924,388	22
Wealth quartiles			
Lowest 25%	61,970	266,940	23
25-50%	70,336	330,979	21
50-75%	86,133	397,429	22
Highest 25%	196,241	934,831	20
Average	103,927	482,194	22

$P < 0.05$ between income from chickpea and type of chickpea grown
$P < 0.01$ between average household income and type of chickpea grown
$P < 0.001$ between income from chickpea and wealth quartiles
$P < 0.001$ between average household income and wealth quartiles

Crop production, as mentioned, is the dominant source of income for most farmers. Wheat, barley, chickpea, and lentil are the most important crops. On average, chickpea sales contribute about 20% to total household income; with 22% for winter and 19% for spring chickpea growers (Table 9).

Income from chickpea is relatively more important for poor households. The analysis indicated that the contribution of chickpea to household income was 23.2% for the lowest quartile in the wealth index scale, compared to 19.6% for the highest quartile (Table 9).

8. Adoption of Improved Varieties and Management Practices

Any innovation or new technology has two components; the hardware and software. These components are clear in computer technology, where the machine is hardware and the program is software. This is true in other technologies including agricultural technologies (Van den Ban and Hawkins 1988), where the new varieties are hardware and other techniques such as land preparation, weed control, fertilization, and irrigation are software. For this reason we will study adoption of winter chickpea varieties first, and then we will examine the components.

8.1. Indicators used to measure adoption

Three adoption indicators were used to measure winter chickpea adoption:

- Adoption rate, which represents the percentage of farmers adopting the technology
- Degree of adoption, which represents the proportion of land under the new technology
- Intensity of adoption, which equals adoption rate multiplied by degree of adoption.

An adopter is defined in this study as 'a farmer who grew winter chickpea in the 2005 season and continues to grow winter chickpea in 2006'. Table 10 shows these indicators by zones, provinces, and wealth quartiles. Adoption of winter chickpea expanded in Zone 2, which is drier than Zone 1, and not traditionally a chickpea production area. As a result, Aleppo province that covers part of Zone 2 also showed a high intensity of adoption compared to other provinces. Dara'a is a traditional chickpea production area; however, due to the lack of extension sup-

Table 10. Adoption rate and adoption intensity of winter chickpea varieties

	Adoption degree (%)	Adoption rate (%)	Adoption intensity (%)
Zone			
Zone 1	65.7	64.0	42.0
Zone 2	65.8	72.7	47.8
Province			
Aleppo	85.6	75.0	64.2
Idleb	67.8	66.2	44.9
Hama/El Ghab	68.1	63.8	43.4
Dara'a	37.8	43.6	16.5
Wealth quartiles			
Lowest 25%	56.6	56.5	32.0
25-50%	64.7	64.6	41.8
50-75%	66.0	67.5	44.5
Highest 25%	65.7	73.3	48.1
Average	65.7	66.0	43.4

port to farmers, adoption was relatively low. It is also evident that the intensity of adoption was highest for well-off farmers. Poorer farmers are sensitive to risk associated with early adoption of any new technology, and take time to observe positive effects before increasing adoption.

The Syrian Agricultural Extension Directorate provided farmers with a full package of recommendations and it was the farmers' decision whether to take up individual components or the full package. The results indicated that only three farmers adopted the full package and most farmers adopted one or a few technology components in addition to a winter chickpea variety. Table 11 summarizes adoption rate for the main and optional technology components associated with winter-sown chickpea varieties by zones. In addition to a new variety, > 50% of farmers adopted planting date, seed treatment, and fungal and weed control. These results are consistent with previous adoption studies that showed a clear tendency of farmers to adopt individual technological components rather than the full package. Therefore, adoption rate is expected to increase with time as farmers acquire knowledge of other package components, learn from experience, and derive additional benefits from adopting other components.

8.2. Farmers' perceptions of winter chickpea

Farmers' assessments of new varieties provided insights into their adoption decision behavior. Understanding the criteria that farmers use to evaluate new crop varieties allows breeders to effectively set priorities and target different breeding strategies to different communities. For this purpose, farmers were asked to rank factors affecting productivity of winter chickpea technology. It is important to note here that these farmer assessments were not facilitated by any agricultural professional; hence they were independent views of individual farmers, based on

Table 11. Adoption rate of winter-sown chickpea components by zones (% of farmers)

Component	Zone 1	Zone 2	Both zones
Main components			
Seed rate	38.7	13.6	32.7
Planting date	53.6	40.5	50.7
Seed treatment	49.0	63.6	52.4
Fungal control	69.9	50.6	65.5
Weed control	98.0	79.2	93.6
Full package	1.1	0	0.9
Optional components			
Reliable seed source	72.1	61.0	69.1
Using drill	64.1	57.3	62.5
Applying super phosphate	70.3	44.2	64.2
Applying 100 kg/ha of super phosphate	22.5	23.3	22.7
Using herbicide before planting	29.2	11.7	28.2
Using mechanical weed control	8.7	0	6.7
Using 2-3 sprayings against Ascochyta	18.9	7.8	16.4
No. of observations	253	77	330

Table 12. Factors affecting productivity of winter chickpea (% of farmers)

Factor	No Effect	Low	Moderate	High
Variety	14.9	6.0	43.4	35.8
Previous crop	18.0	17.4	39.6	25.0
Time of tillage	14.9	17.4	46.5	21.2
Equipment of tillage	18.9	15.8	45.1	20.2
Date of sowing	4.7	5.6	39.4	50.3
Method of sowing	14.9	13.6	43.7	27.8
Seed rate	6.3	8.5	43.9	41.4
Seed treatment	8.2	12.3	30.4	49.1
Phosphorus application	21.5	10.9	29.3	38.3
Nitrogen application	35.2	22.0	30.6	12.2
Insects and diseases	3.8	5.8	19.9	70.5
Weeds	2.2	5.0	27.1	65.6
Ascochyta blight	4.2	8.0	15.7	72.2
Method of harvest	17.3	19.2	44.2	19.2
Lack of labor	27.0	22.0	32.9	18.1
Credit	29.1	15.2	32.1	23.5
Marketing	24.5	15.4	28.1	32.0
Machinery availability	25.8	15.9	38.0	20.3

their own judgments of variety performance and their preferences. Ascochyta blight, insects and diseases, and weeds were the most important factors affecting productivity of winter-sown chickpea (Table 12). Variety was an important factor but was ranked as moderate by farmers. Therefore, the provision of technical support and information to farmers about types of pesticides, insecticides, and herbicides to be used for effective control, and their supply through input distribution channels will increase the chances of high productivity and benefits from the crop.

The ranking of winter compared to spring chickpea varieties was done by farmers who planted the varieties and observed their yield performance and other attributes. Farmers indicated that winter chickpea had better characteristics than spring chickpea, except for grain size, color, and price received (Table 13). Further research on winter chickpea may focus on improving grain size and color to increase the competitiveness of these varieties with spring-sown varieties.

Farmers were asked to evaluate the performance of the winter chickpea project using a five-statement scale: very good, good, average, poor, and very poor. Some farmers reported that they had no idea, since they had not received seed from the project, however, the majority rated project performance as good (Table 14).

8.3. Adoption of winter-sown chickpea varieties

One of the preconditions for technology adoption is awareness of the technology itself. After being aware of the existence of technologies, farmers assess the feasibility of adopting them based on predetermined criteria. Hence, it is logical to assess farmers' level of awareness of winter chickpea varieties before discussing

Table 13. Comparing characteristics of winter and spring chickpeas (% of farmers)

Characteristic	Winter is better	Spring is better	No difference	No idea
Frost resistance	64.2	8.3	6.1	21.3
Ascochyta resistance	48.9	16.9	11.4	22.8
Drought resistance	38.2	21.2	13.2	27.4
Heat resistance	27.1	23.4	14.8	34.7
Salt resistance	14.9	9.0	16.7	59.4
Disease resistance	35.4	13.4	19.9	31.3
Insect resistance	29.4	4.6	37.1	28.9
Yield under marginal conditions	54.7	7.4	9.9	28.0
Early maturity	72.3	6.1	2.5	19.0
Needs more weeding	54.6	8.7	17.9	18.9
Ease of manual harvest	14.0	44.1	21.2	20.7
Ease of mechanical harvest	71.0	1.8	5.6	21.5
Ease of threshing	17.5	22.4	36.6	23.5
Resistance to shattering	27.6	12.4	30.9	29.1
Ability to store under local conditions	14.0	4.7	47.7	33.7
Tillering	29.1	19.0	18.4	33.5
Grain size	11.0	69.1	4.1	15.9
Grain color	14.5	53.7	11.9	19.9
Grain yield	66	7.9	6.1	20.1
Straw yield	34.6	21.0	19.4	24.9
Cooking time	30.4	11.6	13.4	44.6
Price of grain	14	58.4	9.2	18.4
Price of straw	8.8	22.7	37.9	30.7
Taste	15.6	26.8	20.8	36.9
Consumer demand	23.5	39.3	14.0	23.2

Table 14. Evaluating the performance of the winter chickpea project

Farmer response	Frequency	%
Very good	38	8.1
Good	227	48.3
Average	96	20.4
Poor	24	5.1
Very poor	7	1.5
No idea	78	16.6
Total	470	100.0

adoption. The survey showed that 73% of interviewed farmers were aware of winter chickpea varieties (Table 15).

About 77% of the farmers interviewed in Aleppo and Idleb provinces were aware of winter chickpea varieties, compared to about 55% in Dara'a. Chickpea variety Ghab 3 was known by more than half of respondents, while Ghab 4 and Ghab 5 varieties were known only by farmers who received seeds either from ICARDA or the Agricultural Extension Directorate. Awareness of winter chickpea varieties was also significantly influenced by participation in extension activities related to winter chickpea technology development.

Table 15. Awareness and adoption rate of winter chickpea varieties

	Awareness of winter chickpea varieties (%)	Adoption rate (%)
Zone		
Zone 1	72.3	64.0
Zone 2	74.0	72.7
Province		
Aleppo	77.5	75.0
Idleb	77.0	66.2
Hama/El Ghab	65.0	63.8
Dar'a	55.0	43.6
Wealth quartiles		
Lowest 25%	65.4	56.5
25-50%	71.0	64.6
50-75%	73.6	67.5
Highest 25%	78.5	73.3
Average	72.9	66.0

Adoption of technology refers to continued use of the technology on an area of land sufficiently large enough to economically contribute to household income. Farmers who planted winter chickpea varieties and continued growing at least one of the varieties are considered to be adopters. Those farmers who never adopted and those who discontinued using improved varieties are categorized as non-adopters. The empirical survey showed that the rate of adoption was 66%. It was higher in Aleppo and Idleb (75 and 66%, respectively) than in the other two provinces (Table 15). Rate of adoption was higher in Zone 2 than Zone 1 (73 and 64%, respectively), supporting the hypothesis that winter sowing may encourage chickpea cultivation in drier areas where the crop was not previously grown.

The relationship between socioeconomic status of households and rate of adoption was examined; the parameter used was wealth index quartiles. The chi-square test, used to assess any statistically significant association between socioeconomic status and probability of adoption of winter chickpea, showed no significant association. In other words, all types of farmers benefited from winter chickpea technology. However, adoption rate for the highest quartile was significantly higher at 75%, compared to 57% for the lowest quartile.

Some points related to expansion of winter chickpea cultivation in Syria should be mentioned:

- Winter chickpea is normally planted in relatively wet areas (Zone 1) in Aleppo and Idleb provinces. It is also grown in Al-Ghab, on limited areas – further expansion is difficult because of farmers’ land allocation priorities.
- Farmers' decisions to plant winter chickpea should be made in December-January, unlike spring chickpea. The criteria used are different in the two cases.

- In Aleppo and Idleb, winter chickpea has been cultivated for 10 years. Winter chickpea occupies about 50% of the total chickpea area in Idleb, and about 20% in Aleppo province.
- Winter chickpea area can be influenced by the following factors:
  - The price of lentil and cumin
  - Crop rotation, i.e. introduction of legumes to improve soil fertility
  - The increased age of olive trees that were introduced into farming systems 10 years ago, means that many farmers decide not to grow winter or spring chickpea between trees.
- The importance of winter chickpea has increased in the fertile land of Zone 2 in both Aleppo and Idleb provinces in the last five years. The area of winter chickpea has noticeably increased, especially in the Al Ma'arra area of Idleb and in Jarablos area of Aleppo.
- Farmers' decisions to plant spring chickpea in Aleppo and Idleb basically depend on rainfall:
  - If rainfall is low, the land in kept fallow
  - If rainfall is medium, the farmers plant spring chickpea
  - If rainfall is high, most farmers prefer to plant water melon or rainfed crops such as okra or snake cucumber.
- Chickpea area in Al-Ghab is relatively low (< 500 ha per year) and is mostly winter chickpea. Many farmers harvest it while still green and sell it for 7500-10,000 SYP/ha at the beginning of May. Then farmers plant a summer crop, such as cotton or sugar beet, which increases income by 50-65,000 SYP/ha. Holding sizes in this area are small, therefore cultivating winter chickpea is useful to increase household income.
- Although chickpea is planted in 25,000 ha of Dara'a province (80% of this area is Zone 2), the new winter chickpea varieties are still used in limited amounts. The seed sold by GOSM in 2004/05 did not exceed 11.5 t, which would only cover 100 ha.

8.4. Adoption of improved practices

Chickpea in Syria is grown as a cash crop in all provinces. The Agricultural Extension Directorate provides a full technology package for winter chickpea; farmers decide whether to adopt individual components or the full package. Only three farmers adopted the full package. Most adopted one or a few technology components in addition to a winter chickpea variety (Table 16). About two-thirds of farmers adopted two or three components of the package.

The recommended seed rate for winter chickpea is 120 kg/ha. Only 37% of farmers used the recommended seed rate. About 60% used a higher rate. Adoption of recommended seed rate varied by province (Table 17). In Aleppo, farmers tended to use more seed, while in Dara'a they used less. Chi-square test showed significant differences among provinces and adoption patterns.

Table 16. Number of components adopted by farmers

No. of components	Frequency	%
0 (only variety)	7	2.1
1 + variety	64	19.4
2 + variety	101	30.6
3 + variety	103	31.2
4 + variety	52	15.8
5 + variety	3	0.9
Total	330	100.0

Table 17. Adoption rates of main winter chickpea technology components

Component	Aleppo	Idleb	El Ghab	Dara'a	Average
Seed rate	20.8	45.3	59.6	20.5	36.8
Planting date	61.3	48.7	57.4	33.3	52.0
Seed treatment	68.0	37.9	54.5	63.2	52.4
Fungal control	32.1	43.3	19.1	2.6	31.9
Weed control	46.2	79.3	72.3	25.6	62.0

The research recommendation for winter chickpea planting date is the first half of January. About 52% of farmers adopted this component, while 32% planted before, and 16% after the suggested date. Most farmers in Aleppo and Al-Ghab provinces adopted the recommended planting date, while farmers in Dara'a tended to sow winter chickpea before January.

A protective spray against fungi during the second half of March was a main component in the recommended package; the adoption rate of this was lower than for other components (Table 17). The highest adoption rate was 43% in Idleb Province, but in Dara'a province it was very low at 3%.

The weed control component was the component most adopted by farmers (62%). The adoption rate was significantly higher in Idleb and Al-Ghab compared to Aleppo and Dara'a (Table 17). This is due to the weed problem facing chickpea producers in Idleb and Al-Ghab.

The adoption rates of optional technological components by province are summarized in Table 18. In all provinces, most farmers adopted a reliable seed source. About 63% of farmers used a drill, and this proportion was higher in Aleppo and Idleb provinces compared to Dara'a. Application of super phosphate fertilizer was adopted by 64% of farmers, but only 40% in the Al-Ghab area because available P in soil is very high due to long-term use of phosphate fertilizer. The adoption of other components, such as using herbicides before planting, mechanical weed control, and spraying 2-3 times against Ascochyta was very low (Table 18).

Table 18. Province adoption rates (% of farmers) of optional winter chickpea technology components

Component	Aleppo	Idleb	Hama/ El Ghab	Dara'a	Average
Seed rate	20.8	45.3	59.6	20.5	36.8
Reliable seed source	54.3	71.8	86.0	86.4	69.1
Using drill	79.4	78.4	15.9	8.1	62.5
Applying super phosphate	60.4	73.3	40.4	48.8	64.2
Applying 100 kg/ha super phosphate	16.9	25.3	17.0	28.2	22.7
Using herbicide before planting	30.1	23.8	31.2	16.2	28.2
Using mechanical weed control	14.6	2.7	4.7	2.7	6.7
Using 2-3 sprayings for Ascochyta	18.4	20.1	9.3	2.7	16.4

Table 19. Reasons for not growing winter chickpea in the following year (% of farmers)

Reasons	Zone 1	Zone 2	Total
Crop rotation	47	24	43
Affected by diseases or Ascochyta	10	14	11
Low grain yield	6	3	6
Bad season, shortage in rainfall	6	28	9
No experience in growing winter compared to spring chickpea	3	-	3
No guarantee of protection from theft at green stage by passing people	3	-	3
Availability seeds from formal sector	6	17	8
Not accepted for economic reasons (lower market price, high weeding costs)	18	14	17
Total	100	100	100
No. of observations	162	29	191

It is clear that adoption was selective, and that not all technology components were adopted at the same rate. Planting date, seed treatment, weed control, use of seed drill, and pest control were more widely adopted than other components.

8.5. Reasons for discontinuing adopting varieties

Not all farmers adopted or continued planting winter chickpea. These farmers were asked to give their reasons for discontinuing. The main reasons for discontinuing planting were crop rotation (43%), susceptibility to drought (9%) and no guarantee of protecting the field from theft (3%) (Table 19). The major reasons for non-adoption were the effects of Ascochyta blight or other disease (11%), lower market price and weeding costs (17%), seed availability from formal source (8%).

The analysis indicated significant and positive relationships between planting winter chickpea in the next season and having grown it in the past (Table 20). There was a significantly higher percentage of farmers in Zone 2 who continued to grow winter chickpea than in Zone 1, while the relationship between continuing to

Table 20. Farmers who intended to grow winter chickpea in 2005/06 (%)

	Planting winter chickpea in 2005/06	
	Yes	**No**
Grew winter chickpea in 2004/05		
Yes	88	12
No	56	42
Grew spring chickpea in 2004/05		
Yes	22	78
No	42	58
Type of chickpea grown in 2004/05		
Winter only	70	30
Spring only	25	75
Winter and spring	47	53
Province		
Aleppo	61	39
Idleb	55	45
Al-Ghab	51	49
Dara'a	48	52
Zones		
Zone 1	51	49
Zone 2	70	30

Chi-square test showed significant ($P < 0.001$) differences among groups except among provinces

grow winter chickpea and provinces was not significant. This suggests farmers are likely to continue growing winter chickpea varieties.

8.6. Determinants of adoption

The ultimate effect of technology on producers and consumers depends on many factors, such as household resources, markets, social assets, and institutional context. The existence or absence of effective extension mechanisms, markets, favorable credit systems, and social assets greatly determine the uptake of the agricultural technology and thereby determine their ultimate effect on well-being of producers and consumers. Economic gains from a technology among different social groups may vary depending on their control of resources and access to information, credit, and markets. At early stages of introduction of a new technology, the poor may not adopt the technology until they are sure that adoption involves only minimal risk. Thus, at initial stages, the benefits of new technology go to wealthier farmers, who can absorb risks associated with the new technology.

Logistic regression (logit model) was applied in the analysis to identify factors influencing adoption of winter chickpea. This technique can be used to estimate the probability of adopting a new technology, given certain conditions. It is a quantitative relationship between adoption and influencing factors, used to predict whether or not a farmer will adopt the new technology based on a series of characteristics of the farm and farmer. The Statistical Package for Social Science (SPSS), which was used to analyze this data, has several facilities for measuring

Table 21. Coefficients of factors in the logit model influencing adoption of winter chickpea

Factor	B	Std. Error	Sig.*	Exp(B)
Zone	1.347	0.447	0.00	3.84
Total holding area	0.064	0.023	0.00	1.07
Having an irrigation source	-0.877	0.317	0.01	0.42
Farmer's age	0.037	0.012	0.00	1.04
Chickpea yield in 2005	0.001	0.000	0.00	1.00
Wealth index	0.685	0.341	0.04	1.98
Participating in field days	0.724	0.377	0.05	2.06
Constant	-6.535	1.188	0.00	0.00

* Significant level of the variable different from zero.

–2 Log likelihood	Cox & Snell R^2	Nagelkerke R^2	Correct prediction
292.747	0.251	0.349	76%

logit model goodness of fit, such as calculating the percentage of cases which are correctly predicted, calculating the –2 log Chi-square of the estimated model compared to a 'Best' model (Because the likelihood is a small number and less than 1, it is usual to use –2 times the log of the likelihood), and also show a measure of goodness of fit equivalent to R^2, such as Cox & Snell R^2 and Nagelkerke R^2.

The zone, total holding area, having an irrigation source, farmer's age, chickpea yield obtained in 2005, score on the wealth index, and participation of the farmer in field days were the most important factors influencing farmers' decisions to adopt winter chickpea technology. All these factors were significant and positively affected farmer decisions to adopt winter chickpea technology, except having access to an irrigation source. The coefficients of these factors in the logit model are summarized in Table 21.

8.7. Diffusion of winter chickpea

The time dimension is essential in the diffusion process, and is an important aspect of any communication process. Researchers have shown that innovation adoption when plotted against time is often normally distributed (Rogers 1983, CIMMYT 1993). If the cumulative number of adopters is plotted over time, the resulting distribution is an S-shaped curve, and a logistic curve is most commonly used to represent it.

Based on time-series data of the number of adopters of winter chickpea varieties gathered in this study, the coefficient values of the logistic functions which best fitted the time-series data were estimated. The actual and predicted cumulative percentages of adopters are shown in Fig. 5. Adoption is increasing at an accelerating rate and is expected to reach 90% by 2015.

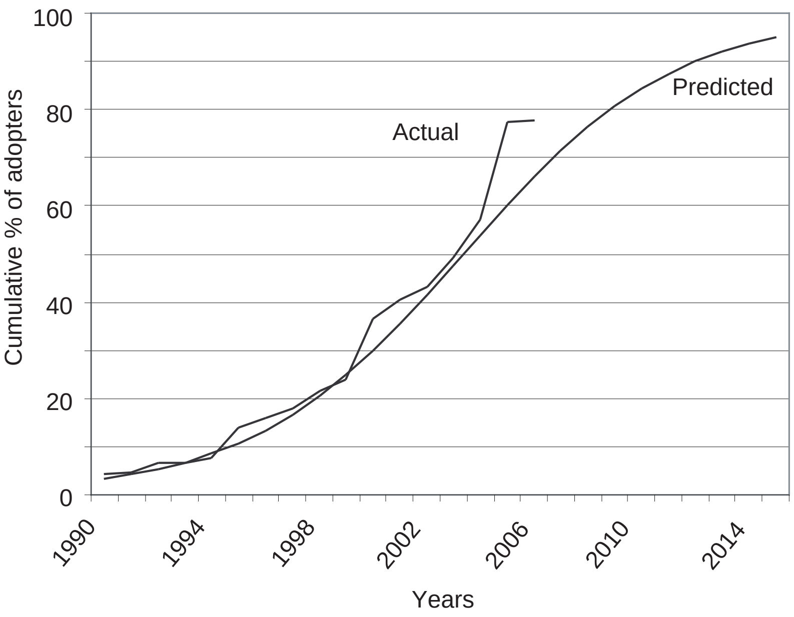


Figure 5. Diffusion of winter chickpea varieties

Traditionally, impact is assessed by measuring the effect of new technology on productivity and profitability. Recently, other indicators have been used to measure impact, such as impacts on productivity, profitability, household income, poverty reduction, labor requirements, and water productivity.

9. Impact of Chickpea Technologies

Impact assessment of research is a special form of evaluation and deals with effects of research output on target beneficiaries (IFPRI 2004). In general it attempts to look at both intended and unintended effects. Basic concepts of impact assessment are causality, attribution, and incrementality. The typical impact chain starts from the set of inputs and activities of a project or program to the most highly aggregated results, such as productivity, profitability, poverty reduction, food security, and environmental protection. The chain also specifies all the main intermediate steps: the project activities, the output, the use that others make of the output, the direct and possible indirect effects, and the implications of the use of outputs on the ultimate beneficiaries. Impact also refers to measurable effects of outputs and outcomes on the well-being of the ultimate beneficiaries of the research and development efforts, namely the poor, the food-insecure, under-nourished households, and the environment. Most socioeconomic impacts and developmental impacts fall in this category (IFPRI 2004).

9.1. Impact on productivity

Agricultural productivity is a widespread indicator for impact assessments of new technology. Successfully increasing the productivity of resources devoted to crop production will increase real income of farmers. A simple measurement, specifically grain yield per unit area, was used in this study to measure changes in factor productivity.

The winter-sown chickpea technology had a positive effect on crop productivity. Yields obtained by farmers, in both Zones 1 and 2, who adopted the full or some components of the technological package were higher compared to non-adopters during good, normal, and dry years (Fig. 6). The range of yield increases of winter compared to spring chickpea obtained by farmers were 33-54% in Zone 1, and 9-61% in Zone 2, and depended on rainfall and other climatic conditions. Improved varieties were an important component in increasing yields; the spatial distribution of yield due to the change to winter production using improved varieties, increased average yield by 32% in Zone 1, and 18% in Zone 2.

A multiple linear production function was estimated for chickpea in Syria. The dependent variable was grain yield obtained by farmers in the 2005/06 season. The independent variables included rainfall, variety, seed rate, use of supplemental irrigation, amount of super phosphate applied to winter chickpeas, use of pest control, and total labor needed per hectare. All these variables positively and significantly affected yield (Table 22). In terms of productivity effect, the coefficient on the winter-sown variety adoption dummy variable was positive and significant ($P < 0.01$).

Table 22. Estimated multiple linear production function for chickpea in Syria

Variable	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	P
Constant	-624.184	169.038	0.000
Rainfall in 2005/06	2.990	0.271	0.000
Variety (dummy variable) 1 = use winter-sown variety	379.941	60.960	0.000
Seed rate (kg/ha)	4.004	0.867	0.000
Use of supplemental irrigation (dummy variable)	379.952	104.944	0.000
Amount of super phosphate applied on winter chickpea	1.070	0.369	0.004
Using pest control once	100.936	64.331	0.117
Using pest control twice	549.896	97.016	0.000
Total labor needed per hectare	5.019	0.836	0.000

Dependent variable: Grain yield in 2005/06
Adjusted R^2 = 0.456 F(493, 7) = 51.22***

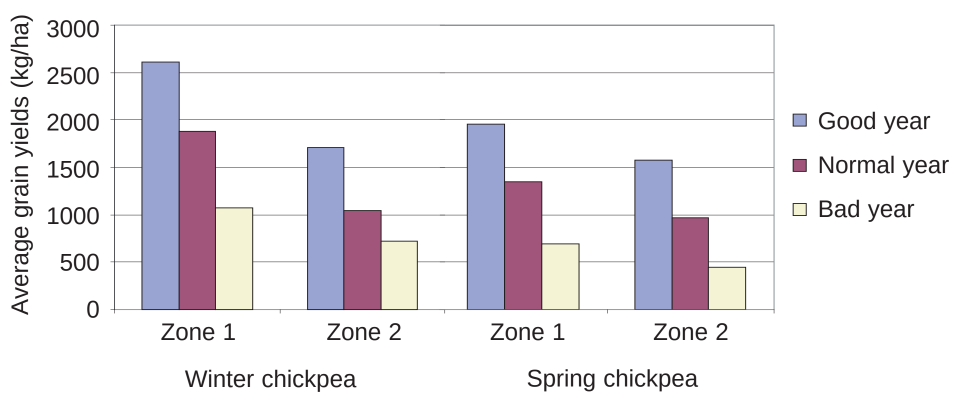


Figure 6. Estimated average chickpea yields in good, normal, and dry seasons

All types of farmers, poor and more wealthy, obtained higher yields when growing winter compared to spring chickpea (Fig. 7).

9.2. Impact on profitability

Winter chickpea was profitable, and can increase the farmer's net revenue compared to spring chickpea by at least SYP 10,500 per ha (equivalent to US$220). The ratio of net revenue increase to the additional costs was approximately 320% (Table 23).

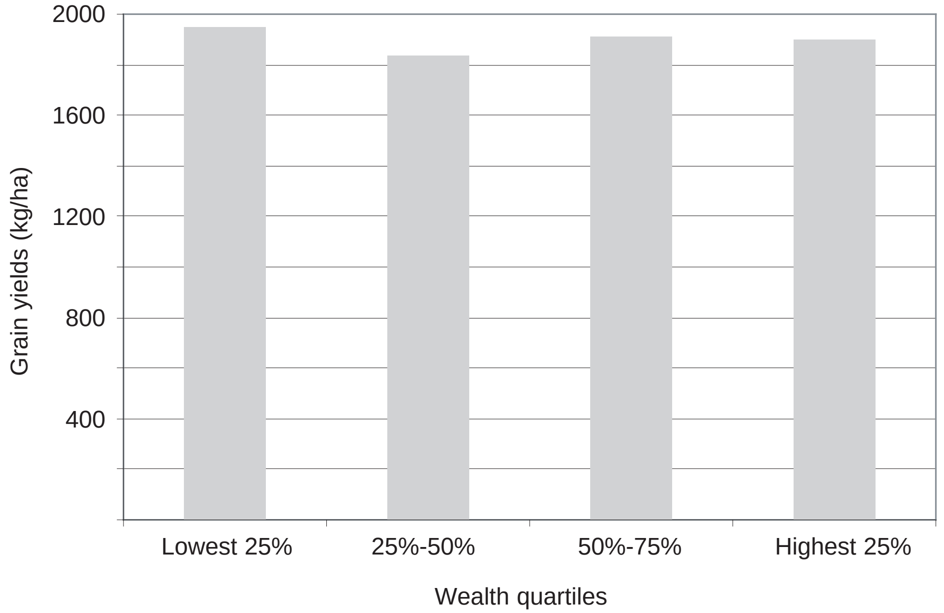


Figure 7. Average grain yields of winter chickpea by wealth quartile, 2005 season

All categories of farmers (i.e. very poor, poor, moderate, and well-off; Table 24) obtained higher net revenues from winter compared to spring chickpea. This result provides evidence of the appropriateness of the technology for all farmers.

9.3 Impact on household income

Income is widely used as a welfare measure as it is strongly correlated with the capacity to acquire items associated with an improved standard of living. Income gains are a valid indicator of impacts because productivity gains attributable to adoption of technologies should logically be reflected in income gains.

Households and farmers in the target areas had many activities contributing to their livelihoods. Average annual household income in the sample was estimated at US$13,900. The contribution of chickpea in the total household income was about 21%, distributed between winter and spring chickpea (14 and 6%, respectively). The contribution of chickpea was higher for farmers who grew winter chickpea, and for poor compared to more wealthy farmers (Fig. 8).

Table 23. Profitability of spring and winter chickpea (SYP/ha)

	Spring			Winter		
Item	**Zone 1**	**Zone 2**	**Average**	**Zone 1**	**Zone 2**	**Average**
Grain value	48,624	26,355	43,465	64,133	39,266	58,701
Straw value	3,482	3,110	3,396	1,980	1,982	1,980
Total revenue	52,106	29,465	46,861	66,113	41,249	60,681
Total production costs	15,723	14,829	15,603	20,346	13,755	18,906
Net revenue	36,382	14,636	31,258	45,767	27,493	41,775

Table 24. Costs and revenues of spring and winter chickpea (SYL-ha)

	Spring			Winter		
Wealth quartile	**Total revenue**	**Total prod. cost**	**Net revenue**	**Total revenue**	**Total prod. cost**	**Net revenue**
Lowest 25%	50,288	16,098	34,191	63,122	19,684	43,437
25-50%	45,689	14,641	31,048	58,074	18,818	39,256
50-75%	46,079	15,960	30,119	59,935	18,278	41,657
Highest 25%	46,458	16,569	29,889	62,404	19,204	43,201
Average	47,404	15,839	31,565	60,869	18,974	41,895

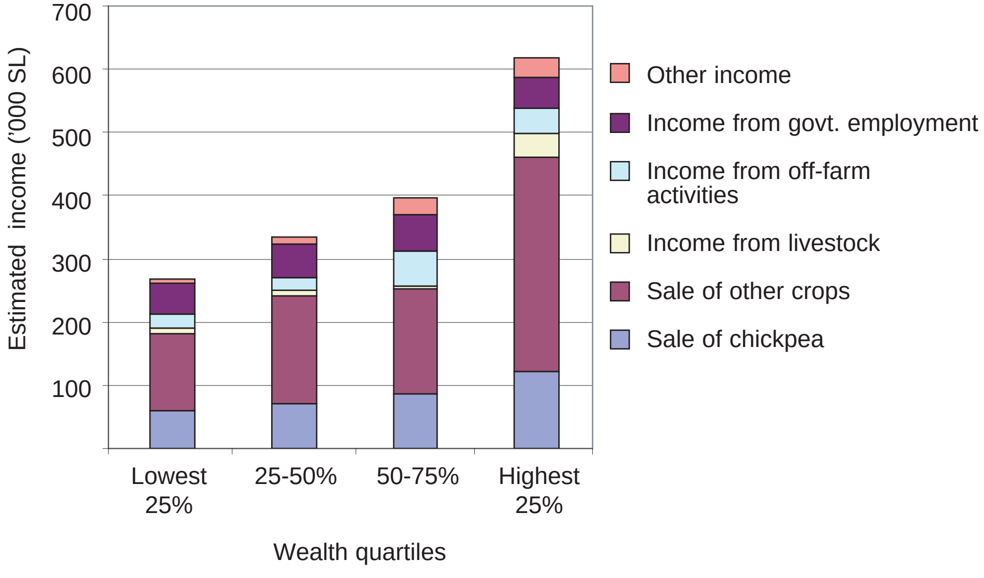


Figure 8. Average annual household income by wealth quartile

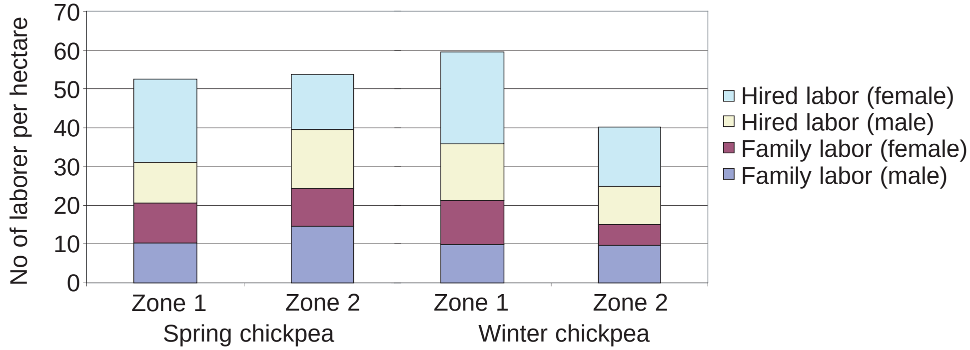


Figure 9. Estimated number of laborers needed per hectare for winter and spring chickpea

9.4 Impact on labor employment

Adoption of winter chickpea technologies generated job opportunities for laborers. Adopter farmers started using hired labor for different farm operations and this generated local job opportunities for rural laborers. The estimated number of laborers needed per hectare by gender for winter and spring chickpea for Zones 1 and 2 in Syria is shown in Fig. 9. Winter chickpea clearly had increased labor requirements for certain operations, such as weeding. Weeding operations are mostly carried out by family and non-family female labor in rural areas, so increased adoption of winter chickpea provides more work opportunities for women.

9.5 Impact on food security

Although there are several definitions of food security, which include notions of availability, access, and nutritional status, this study focused on the contribution of new varieties to improvement in produce availability for consumption. Therefore, it used total production and average consumption per household as indicators of improvement in food security.

Total annual chickpea production per household was 4600 kg for adopters, which was more than twice that of non-adopters at 2100 kg (Table 25), implying that adopters were more food-secure than non-adopters. Average family consumption of chickpea was 122 kg for adopters and 59 kg for non-adopters. Although household food security issue goes beyond the production of a single crop, results indicate clearly that winter chickpea contributes to achieving the food security goal.

Table 25. Average annual chickpea production and consumption (kg/household)

	Average chickpea production	Average home consumption
Adopters	4621	122
Non-adopters	2115	59
Total	3357	104

Table 26. Water productivity by district, 2005/06 season

District	Grain yield (kg/ha)		Rainfall (mm)	Water productivity(kg/mm)	
	Spring chickpea	Winter chickpea		Spring chickpea	Winter chickpea
Izaz	1269	1476	365.4	3.47	4.04
Al-Bab	n.a	1270	286.8	n.a	4.43
Samaan	1400	2013	396.3	3.53	5.08
Efreen	950	2550	385	2.47	6.62
Idleb	1765	2220	413.8	4.27	5.37
Harem	1500	1771	489.3	3.07	3.62
Ariha	1250	1636	549.3	2.28	2.98
El Ma'arra	1650	1696	340.8	4.84	4.98
El Ghab	1676	2741	562.8	2.98	4.87
Mesiaf	2000	n.a	402.7	4.97	n.a
Mhardeh	n.a	2350	478.5	n.a	4.91
Jarablos	n.a	1524	283.5	n.a	5.37
	803	652	298.8	2.69	2.18
Izra'	563	652	244.2	2.30	2.67
El Sanamein	712	1025	243.2	2.93	4.21
Average	1360	1826	378.7	3.59	4.82

n.a. Data not available

9.6 Impact on water productivity

The water productivity indicator used in this study is yield of chickpea per unit of rainfall. Based on harvest data from farmers and rainfall data from the Extension Directorate, it is estimated that each 1 mm of rain (equivalent to 10 m^3 of water per hectar) produced 4.8 kg of winter chickpea and 3.6 kg of spring chickpea. This productivity varied according to rainfall and its seasonal distribution. However, water productivity was higher for winter than spring chickpea in all the studied administrative districts (Table 26).

9.7 Net impact

Regression analysis is usually an appropriate technique for assessing the impact of improved cultivars on productivity. The Cobb-Douglas production function is frequently used to estimate the productivity impact of a new technology. The impact of a new technology on the total factor productivity can be estimated by adding a dummy variable to the Cobb-Douglas production function (Lin 1994).

Data from the adoption surveys were used to estimate productivity impacts of improved cultivars. The Cobb-Douglas production function was estimated on the total sample level and for Zones 1 and 2 (Tables 27 and 28) by adding a dummy variable to the function, which had the value one for adopters of winter chickpea and zero for non-adopters. The estimated coefficient of the dummy variable measures the shift in the intercept of the production function due to the new technology. The shift captures the impact of the dummy variable on total factor productivity.

Table 27. Estimated Cobb-Douglas production function

Variables	Unstandardized coefficients B	Unstandardized coefficients Std. Error	Standardized coefficients Beta	*P*
(Constant)	-2.107	0.559	-	0.000
ln Rain	1.042	0.070	0.508	0.000
ln Seed rate	0.565	0.081	0.230	0.000
ln Labor	0.066	0.023	0.101	0.003
Variety (dummy)	0.287	0.040	0.249	0.000
Using supplemental irrigation (dummy)	0.322	0.072	0.149	0.000
Using pest control once	0.059	0.044	0.045	0.182
Using pest control twice	0.237	0.066	0.126	0.000

Dependent variable: ln Grain yield in 2005/06
Adjusted R^2 = 0.484 F(481, 7) = 66.65***

Table 28. Estimated Cobb-Douglas production function by zone

Variable	Zone 1 Coefficients	Zone 1 P	Zone 2 Coefficients	Zone 2 P
Constant	2.509	0.004	-6.638	0.000
ln Rain	0.590	0.000	1.602	0.000
ln Seed rate	0.181	0.063	0.858	0.000
ln Labor	0.076	0.002	0.063	0.189
Variety (dummy)	0.280	0.000	0.163	0.086
Using supplemental irrigation (dummy)	0.210	0.005	0.649	0.001
Using pest control once	0.063	0.175	0.005	0.966
Using pest control twice	0.277	0.000	0.013	0.960
Adjusted R^2	0.278		0.542	

Dependent variable: ln Grain yield in 2005/06

This gives the net effect of adopters relative to non-adopters. Formation of the model was influenced by several hypotheses. Estimated coefficients represent elasticities that measure the percentage increase in output in response to a percentage point increase in the respective inputs. Econometric estimations of the production function confirmed the positive net effect of the improved chickpea technology package on crop productivity.

The spatial distributions of yield gain due to the change from spring to winter production were: 32.3% in Zone 1, 17.7% in Zone 2, and 33.2% over the whole sample.

10. Conclusions

In partnership with the Syrian national program, ICARDA's winter chickpea research has made important contributions to household economies in Syria, and created the conditions for significant additional increases in production of a nationally important crop. Chickpea productivity has been improved by overcoming key constraints that earlier prevented the cultivation of winter-sown chickpea. These efforts have also strengthened national research and extension capacity, and developed strong partnerships with national research organizations. The Syrian research system has benefited from information exchange, technology dissemination, and acquisition of germplasm and advanced materials for its breeding program.

To assess the adoption and impact of winter-sown chickpea technology in Syria, a survey was conducted in early 2006 to collect data from chickpea farmers in the main production areas in four provinces. Winter chickpea technology – hitherto not used in Syria – has been disseminated widely, and cultivation in the study area is still expanding. Ascochyta blight, insects, diseases, and weeds are the most important factors constraining the productivity of winter-sown chickpea in the country. Improved winter varieties have been widely adopted, and most farmers have also adopted some components of the recommended crop management package for these varieties. There was noticeable expansion of the winter chickpea area in Zone 2, where annual rainfal is 250-350 mm.

The analysis indicates that this technology is profitable and appropriate for all segments of the farming community (across all wealth quartiles). All growers achieved higher net returns from growing winter-sown chickpea compared to their traditional spring-sown crop. Household incomes increased correspondingly, and the positive impact was relatively greater among poorer farmers. Adoption of winter chickpea also delivered two other benefits. Water productivity increased, i.e. winter chickpea produced more grain per millimeter of rainfall. Labor demand (mainly for weed control) also increased, representing new employment opportunities, particularly for women.

The spatial impact of shifting from spring to winter production on yield gain was much higher in zone 1 compared to zone 2. However, the use of supplemental irrigation was found to be more effective in increasing crop yield in zone 2. The incremental impact of winter chickpea on farm income is higher for zone 2 compared to zone 1.

11. References

Carney, D. (ed). 1998. Sustainable rural livelihood. What contribution can we make? Department for International Development, London.

CIMMYT (International Maize and Wheat Improvement Centre). 1993. The adoption of agricultural technology: a guide for survey design. CIMMYT Economics Program, Mexico, D.F.

DFID (Department for International Development). 2001. Sustainable livelihoods guidance sheets. DFID, London, UK.

El-Mott, M. 1984. Chickpea production in Syria in Ascochyta Blight and Winter Sowing of Winter Chickpea (M.C. Saxena and R.P. Singh, eds). ICARDA, Aleppo, Syria.

IAEG (Impact Assessment and Evaluation Group). 1999. Impact assessment of agricultural research: context and state of the art. Paper presented on ASARECA/ ECART / CTA Workshop on Impact Assessment of Agricultural Research in Eastern and Central Africa. Entebbe, Uganda, 16-19 Nov. 1999.

ICARDA. 1979. An introduction to agriculture within the Syrian economy. Farming System Research Program, ICARDA, Aleppo, Syria.

ICARDA. 1984. ICARDA annual report, 1984. ICARDA, Aleppo, Syria.

ICARDA. 1987. ICARDA annual report, 1987. ICARDA, Aleppo, Syria.

ICARDA. 1988a. Food legume improvement program annual report for 1987. ICARDA, Aleppo, Syria.

ICARDA. 1988b. ICARDA annual report, 1988. ICARDA, Aleppo, Syria.

ICARDA. 1990. Food legume improvement program annual report for 1989. ICARDA, Aleppo, Syria.

IFPRI (International Food Policy Research Institute). 2004. Monitoring, evaluation, and impact assessment of R&D investments in agriculture. Learning Module (Working Document). IFPRI, Washington, DC, USA.

Kebede, Y., K. Gunjal and G. Coffin. 1990. Adoption of new technologies in Ethiopian agriculture: the case of Tegulet-Bulga district, Shoa province. Agricultural Economics 4 (1990): 27-43.

Lin, J.Y. 1994. Impact of hybrid rice on input demand and productivity. Agricultural Systems 10: 153-164.

Mahajan, V. and R.A. Peterson. 1985. Models for innovation diffusion. Sage University Paper series. Quantitative Applications on the Social Sciences, series no. 7- 48. Beverly Hills and London: Sage Publications.

Pala, M. and A. Mazid. 1992. On-farm assessment of improved crop production practices in northwest Syria: I. Chickpea. Experimental Agriculture 28(2): 175-184.

Shideed, K.H. and M. El Mourid (eds). 2005. Adoption and impact assessment of improved technologies in crop and livestock production systems in the WANA region. The development of integrated crop/livestock production in low rainfall areas of Mashreq and Maghreb Regions (Mashreq/Maghreb Project). ICARDA, Aleppo, Syria.

Rogers, E.M. 1983. Diffusion of innovations, 3rd edition, Free Press, New York, USA.

Van den Ban, A.W. and H.S. Hawkins. 1988. Agricultural extension. Longman Group, UK.