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in

Saxena M.C. (ed.), Cubero J.I. (ed.), Wery J. (ed.).
Present status and future prospects of chickpea crop production and improvement in the Mediterranean countries

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 9

1990
pages 145-150

Winter chickpea: status and prospects

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SUMMARY - Progress in winter chickpea selection during the last 6 years in Morocco is summarized. Potential yield in regular years is close to 2.0 t/ha for winter chickpea, compared to 0.6 t/ha for spring chickpea. That means a 210% relative gain. Earliness improvement is of 25 to 45 days, depending on planting date and variety. However, the expression of genetic potential is highly influenced by the environment. Certain problems of winter chickpea cultivation as well as research priorities are also discussed in this study.

RESUME - "Le pois chiche d'hiver: présent et futur". Les progrès réalisés en 6 années en matière de sélection du pois-chiche d'hiver au Maroc sont résumés dans cette publication. Le rendement potentiel en années normales est de près de 2.0 t/ha pour le pois-chiche d'hiver comparé à 0.6 t/ha pour le pois-chiche de printemps; soit un gain relatif de 210%. Le gain en précocité est de 25 à 45 jours selon les dates de semis et les variétés. Cependant, l'expression du potentiel génétique est hautement influencé par l'environnement. Certains problèmes de la culture du pois-chiche d'hiver ainsi que les priorités de recherches sont également discutés dans cette publication.

Introduction

Legumes occupy an important place in agricultural systems in areas so called favorable and of medium pluviometry (350-450 mm). This role is on the one hand linked to the enrichment of soil in nitrogen, and on the other hand to their economic and nutritional importance. Chickpea in particular, can play a significant economic role, although current production levels are rather low.

Being chickpea a spring crop, it is often subject to climatic and parasitary hazards. In fact, water stress and sudden high temperatures are quite frequent at the end of the cycle, which as a consequence limit the yield level of this species. In Mediterranean climates, it is quite frequent that the climatic demand at the end of the cycle be higher than the plant supply.

From that time on, stomata regulation takes unavoidably place, independently from the water reserve stored in the soil during the humid season. It is thus established that one of the best strategies to improve water efficiency is to grow the plant in the period when evapotranspiration is minimal, that is, in winter (Hawtin, 1975). The first trials in this direction were started by ICARDA in 1978 and positively exploited by INRA from 1979 (Kamel, 1983).

Growing conditions

Winter chickpea sowing takes place between 10 and 30 November. Nevertheless, this shift of the growing cycle imposes new ecological conditions on the plant, different from those in spring. Actually, high relative humidity in winter is a favorable factor for the development of ascochyta blight (*Ascochyta rabiei*), dreaded enough disease during usual spring growing (Janati and Schluter, 1979). Low temperatures and risks of frost require as well that varieties be adapted to these new conditions.

It is therefore essential, from the genetic viewpoint, that winter chickpea be resistant to ascochyta blight and tolerant to cold. Evidence of genetic variability for these two traits has been shown for chickpea (Singh *et al.*, 1983 a, b).

Potentiality of winter chickpea

The results of comparisons between winter and spring chickpea for 3 seasons at 4 sites (Douyet, Merchouch, Settat and Jemaa shaim) are summarized in Table 1. These results show that yields of winter chickpea are around 2 t/ha as an average compared to 0.6 t/ha for usual spring crops, allowing for a relative gain of over 210%.

However, the expression of this genetic potential depends upon climatic conditions. In particular, the results presented in Table 2 show that with a well distributed pluviometry of 550 mm average potential yield is 2.2 t/ha. Nevertheless, the difference is only of 17% with respect to spring. With 370 mm rainfall, yields were of 1.5 t/ha, but the relative gain of winter chickpea is 197%.

These data suggest that the genetic potential of winter chickpea is further expressed in average years and in arid areas. Planting dates may also have the same effects and therefore it is advisable to proceed to early sowing to obtain the maximum profit from this crop.

Table 1. Potencial yield (kg/ha) of winter chickpea as related to spring chickpea (year x location).

Cultivars	1982/1983		1986		Average		
	Winter	Spring	Winter	Spring	Winter	Spring	%
ILC 195	1832	327	1780	980	1806	653	+176
ILC 482	1797	334	2390	1020	2093	677	+209
ILC 484	1667	340	2600	1110	2133	725	+194
ILC 3279	1590	300	2360	840	1975	570	+246
PCH 46	1246	264	2110	1678	507	507	+230
Average	1626	313	2248	940	1937	626	+211

Advantages and limitations of this crop

Winter chickpea cultivation presents several advantages with respect to spring cultivation that are worth mentioning:

1) Significant yield increase, up to 200% and over.

2) Harvesting 25 to 45 days earlier according to regions and planting dates.

3) Better utilization of rain water that is lost simply by evaporation between November and April with spring cultivation.

4) The possibility of chickpea cultivation in more arid areas.

5) Mechanical harvesting becomes easier because winter chickpea is a much taller and more erect plant.

Table 2. Incidente of rainfall on winter and spring chickpea yield (kg/ha).

Cultivars	550mm			370mm		
	Winter	Spring	%	Winter	Spring	%
ILC 72	2780	2430	+14	1500	570	+160
ILC 194	3100	2510	+23	1270	530	+140
ILC 195	2680	3010	-10	1920	530	+260
ILC 200	3530	3000	+17	1980	400	+395
ILC 202	3430	2460	+39	1480	510	+190
ILC 482	4000	2900	+37	1750	510	+240
ILC 484	4100	3380	+21	1520	570	+160
ILC 1407	3760	2760	+36	1460	530	+170
ILC 2548	2910	3840	-24	1640	560	+190
ILC 2555	3720	2850	+30	1370	630	+117
ILC 3279	3270	2240	+45	1520	440	+240
Local	2000	2700	- 4	990	410	+140
Average	3323	2840	+17	1533	515	+197

6) Early tillage can be performed immediately after harvest.

7) Certain potentially important diseases or parasites for spring chickpea can be under certain conditions, reduced for winter chickpea, such as the leaf miner in case of hard winters.

Conversely, this crop is much more exposed to ascochyta blight than the spring crop. The endemic effects of this disease are much more important since the causal agent is variable and the existence of physiological races is not an excluded possibility (Amezian, 1977; Reddy *et al.,* 1983). From the genetic viewpoint this means that the varieties of winter chickpea should at best have a non- specific or stable resistance, which in practice is not easy to achieve due to certain genetic barriers.

Resistance to ascochyta blight

In order to achieve this purpose, that is, stable resistance, a selection program started in 1977 in cooperation with FAO (Pieters, 1985). Significant progress has been made although certain lines show sensitivity to some strains of blight (Table 3). At the same time, considerable progress has been achieved in selecting new kabuli chickpea cultivars, and in obtaining vertical or specific resistance to blight (Tables 4 and 5). This program has been developed in collaboration with ICARDA since 1979. Nevertheless, it should be mentioned that there are no large seeded varieties (weight of 100 seeds > 45 g) showing blight resistance.

Table 3. Chickpea lines selected within the horizontal resistance project.

Lines	Resistance to ascohyta blight[a]		Average
	1984	1986	
79103	4.5	5	4.75
79154	3.7	3	3.35
79161	1.2	3	2.10
79177	3.5	1	2.25
79252	4.3	9	6.65
79255	3.2	3	3.10
79256	4.5	3	3.75
79258	3.2	3	3.10
79266	3.0	1	2.00
79298	2.7	1	1.85
79302	4.2	3	3.60
79305	4.2	3	3.6
79324	5.1	3	4.05
79332	4.2	–	–
79362	5.0	3	4.00
79430	4.2	3	3.60
79467	4.7	3	3.85
79484	3.9	3	3.45
79496	2.2	3	2.60
79497	5.0	1	3.0
79500	5.0	7	6.0
79501	4.0	–	–
79503	3.5	3	3.25
79518	4.5	3	3.75
79537	5.0	1	3.00
C6	4.5	5	4.75

[a]/ ICARDA scale; 1: resistant, 9: susceptible

In the short run, a sound combination of "genetic resistance x chemical treatment" against ascochyta is advisable. DACONIL is a product that was tested in our trials to control ascochyta, and gave better results than DITHAN M45. In practice we could recommend the use of variety ILC 482, tolerant to ascochyta, together with 1 or 2 treatments with DACONIL, according to the intensity of the attack. This solution could also be considered for the new varieties at present being registered in the catalog, and having the same resistance level as ILC 482, especially: 82-72C, 82-128C, 82-293C, 82-93C, 81-57W, 825C, 82-245C and 82-164C.

Varietal mixtures could as well be envisaged as a solution to stabilize the incidence of this disease. Our trials have shown that these mixtures delay the appearance of the disease and can assure protection against ascochyta if there is in the mix a 60% of the resistant component (Table 6). The response depends however on the genetic composition and the phenotype of the mixture.

Table 4. Progress in selection for resistance to ascochyta blight.

Year	Total genotypes tested	No. of genotypes with the score[a]				
		1	3	5	7	9
Before 1978						
Kabouli	67	0	1	2	6	58
Desi	26	0	6	1	2	17
Total	9	0	7	3	8	75
1981-82						
Desi	55	0	32	3	4	16
Total	142	0	51	7	12	72
1985-86						
Kabouli	88	0	39	34	8	7
Desi	25	0	12	11	1	1
Total	113	0	51	45	9	8

[a]/ ICARDA scale; 1: highly resistant, 3: resistant, 5: tolerant, 7: susceptible, 9: highly susceptible

Table 5. Kabuli chickpea cultivars with stable resistance to *Ascohyta rabiei* in Morocco.

Cultivars	Origin	1983-84		1985-86	$\bar{x}$ [a]	b[b]
		Merchouch	Douyet	Aïn N'zegh		
ILC 182	USSR	3,5	3,5	4,5	3,6	0,67
ILC 202	USSR	2,0	2,5	3,0	2,5	0,62
ILC 2506	USSR	2,5	4,5	5,0	4,0	1,51
ILC 2956	USSR	3,0	3,5	4,0	3,5	0,62
ILC 3856	MOROCCO	3,0	3,0	4,5	3,5	0,97
FLIP 82-2C	ICARDA	4,0	3,0	4,0	3,6	0,05
FLIP 82-3C	ICARDA	4,5	4,5	4,5	4,5	0,00
FLIP 82-64C	ICARDA	2,0	3,0	4,7	3,2	1,69
FLIP 82-68C	ICARDA	3,5	4,5	4,2	4,0	0,40
FLIP 82-99C	ICARDA	3,0	4,5	4,0	3,8	0,56
FLIP 82-259C	ICARDA	2,0	4,0	4,2	3,4	1,32
FLIP 81-41W	ICARDA	2,0	2,5	4,5	3,0	1,59
FLIP 81-75C	ICARDA	2,0	4,0	5,0	3,6	1,83
ILC 482	TURKEY	5,5	5,5	5,5	5,5	0,00
ILC 195	TURDEY	2,0	2,5	6,5	3,6	2,88
Population average		2,9	3,6	4,5	3,6	1,00

[a]/ $\bar{x}$: average
[b]/ b: regression coefficient

Other potential parasites and diseases

As mentioned at the beginning, the changes in cultivation conditions of chickpea necessarily imply a profound modification of the epiphytotic balance established between the plant and the different parasites. We could even advance the hypothesis that given the large amount of varieties with natural tolerance to cold, the germination of chickpea at low temperatures, the way plantlets emerge, the area of origin and the plasticity of the species, chickpea was in its origins cultivated in winter, and that the endemic evolution of certain diseases or parasites has perhaps progressively shifted the cycle towards spring. This aspect should thus be regarded as extremely important.

In the South, in arid and semi-arid areas with temperate winters, important attacks of *Fusarium* and *Stemphyllium* on chickpea have been observed.

The attacks of leaf miner (*Liriomyza cicerina*), although less serious than in spring, are strong enough to cause considerable losses in case of drought at the beginning of the cycle.

Orobanche, although rarely observed in our trials, is a parasite whose evolution deserves closer attention.

Genetic considerations

From the genetic standpoint, the shift in the cycle implies that it should be also necessary to update the objectives as new data are gathered.

Should spring chickpea be forgotten to center the interest exclusively on winter cultivation?. This strategy seems to be a mistake because of the role, as an economic buffer, that chickea plays in farming systems.

The selection of "double season" chickpea cultivars, therefore adapted both to winter and to spring, could be a convenient strategy to improve the chickpea in the future. This type of genetic material would provide the farmer with a greater flexibility concerning adjustment of the crop to climatic variations. The stability of yield of this kind of genetic material would also be a major asset in arid and semi-arid areas. This requires further studies on genotype x environment interaction as well as the setting of new breeding strategies on the basis of genetic data explaining both the specific and the broad adaptation of the species.

Table 6. Effect of mixture proposals on the incidence and intensity of ascochyta blight attack, 1985-86.

Mixture (% resistant)	Intensity[a]				Incidence[b]
	9/03/86	27/03/86	10/04/86	28/04/86	
90	1.0	1.6	1.6	2.0	1
80	1.0	1.3	2.0	2.6	8
70	1.0	1.0	1.0	2.6	10
60	1.0	1.6	2.6	4.3	12
50	1.6	3.6	4.6	6.0	50
40	2.3	4.6	5.3	6.6	51
30	1.6	2.3	2.6	6.0	35
20	1.6	4.0	5.0	7.3	61
10	1.0	2.6	2.6	6.6	60
00	9.0	9.0	9.0	9.0	86

[a]/ Intensity from 1 to 9; 1-4: low, 5-6: moderate, 7-9: high
[b]/ Index (%) of tissue attacked

Table 7. Selection criteria for chickpea.

Selection criteria	Justification
- Yield stability	. Flexibility to choose the cropping season . Adaptation to arid and semi-arid areas
- Non-specific resistance to *Ascochyta* - Resistance to *Fusarium* and leaf miner	. Better water use . Yield stability
- Large grain (>40 g/100 seeds) and rough kabouli type	. Consumer preference . Economic reasons
- Semi-erect habit	. Better soil coverage . Better pod setting . Early maturing
- Photoperiod independence	. Early flowering . Possibility of off-season cropping for seed multiplication

Agronomic aspects

It is evident that the cultivation of winter chickpea inevitably means a certain number of quite deep changes concerning management under these new conditions. It is not question in this document to cover all agronomical aspects, but rather to advance some guidelines for future actions.

Weeding

The abundance of weeds in the crop becomes something unavoidable due to the shift in the cycle. It is well known that weeding is one of the methods to maximize water efficiency, particularly in arid and semi-arid areas. At a difference with cereals, and given that legumes are weeded crops, two techniques can be considered for this purpose:

- Chemical weeding with possibilities for mechanical sowing in narrow rows;

- Second ploughing, together with other sowing methods.

Whichever the chosen technique, research on both of them should be carried out although a priori the first one seems to have more possibilities for success since it does not differ very much from that used for cereals.

Trials carried out on weeding did show promising results with IGRAN (El Brahli, 1986).

Application of fertilizer

Research on fertilization carried out in Morocco and abroad has successfully tried to establish universal recommendations for a a certain number of species. Experiments performed in the USA, especially on cereals, and adopted for these crops in the frame of the Moroccan program for cultivation in arid areas (Soltanpour *et al.*, 1986) have shown that the best approach to solve the problem is the calibration of N and P fertilizer method for each type of soil. This method permits to make recommendations according to the crop, the type of soil, and to both the preceding crop and the residues left in the soil. This kind of research must of course be done out of season, in representative farms in what concerns soils of the areas under study. Finally, and because of the specific characteristics of legumes, these type of trials must be closely linked to trials on *Rhizobium* inoculation and its status in the soil. Our research in farms has shown that in marginal areas characterized by the absence of inoculation, yields are hardly over 0.3 t/ha. This aspect of symbiotic fixation is of outmost importance for cereals in arid and semi-arid areas.

One more factor to be taken into consideration, especially in the "calcixirall" vertisols of Sidi El Aïdi, is iron deficiency.

Water storage and efficiency

This problem is of particular interest for arid and semi-arid areas where water is the limiting factor. Hence the need to study techniques that will maximize efficiency and improve water storage.

As the preceding crop is usually cereals, it is useless to talk about techniques that will permit water transfer from a season to the next. On the contrary, it is necessary to make sure that chickpea will not have a dessicating effect for the following crop. A series if trials is being carried out to study this aspect.

The techniques that will permit a better water use during the cropping season have to be studied. In this sense, every method and tool allowing for a reduced tillage without profile disturbance and a better handling of residues (stubble of cereals) would be the most appropriate one.

It also seems necessary to explore crop establishment techniques that favor plant coverage at the beginning of the season in order to minimize losses by evaporation.

Conclusion

Winter chickpea is an innovative technique whose success has not yet been capitalized. The advantages from the agronomical and economic standpoints are clear and surpass by far those of the spring crop. It is however necessary to look into any aspect linked to this crop and to the consequences for farming systems and work research programs in order to get the maximun rate of progress.

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