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The role of Dryland Agricultural Research Institute in drought mitigation in Iran

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Abstract. Although drought is a natural hazard, the term drought management and action plans imply that human intervention can reduce vulnerability and impacts. To be successful in this endeavor, many disciplines must work together in tackling the complex issues associated with detecting, responding to, and preparing for the inevitability of future events. Disaster management, of which drought management is a subset, requires scientists and policy makers to focus on both the protection and recovery/rehabilitation of drought. In the past, the emphasis in disaster management has been placed largely on the response and recovery portion of drought management, with little or no attention to mitigation, preparedness, and prediction and monitoring. The Dryland Agricultural Research Institute (DARI), in Iran mainly focused on the breeding crops for drought tolerance, soil management to conserve moisture (minimum tillage, crop rotation, etc.), supplementary irrigation, water harvesting, and agro-ecological zoning considered as basic activities that should be strengthened to cope with drought in the future.

Keywords. Drought – Mitigation – Crop rotation – Supplementary irrigation – Agro-ecological zoning.

Le rôle de l'Institut pour la Recherche Agronomique en Zones Arides concernant l'atténuation de la sécheresse en Iran

***Résumé**. Bien que la sécheresse soit un aléa naturel, les termes gestion de la sécheresse et plans d'action impliquent que l'intervention humaine peut en réduire la vulnérabilité et les impacts. Pour y réussir, plusieurs disciplines doivent travailler de concert pour aborder les questions complexes liées à la détection, pour réagir et se préparer à l'inévitabilité des événements futurs. La gestion des catastrophes, dont fait partie la gestion de la sécheresse, nécessite que scientifiques et décideurs se focalisent à la fois sur la protection et la récupération/réhabilitation lors de la sécheresse. Dans le passé et dans le cas de la gestion des catastrophes, l'accent était largement placé sur le volet de réponse et de récupération à la sécheresse, en n'accordant qu'une attention réduite ou nulle à l'atténuation, la prévention, et la prévision et surveillance. L'Institut pour la Recherche Agronomique en Zones Arides (DARI), en Iran, est principalement axé sur l'amélioration des cultures pour la tolérance à la sécheresse, la gestion du sol pour conserver son humidité (labour minimum, rotation des cultures, etc.), l'irrigation d'appoint, la collecte d'eau, et le zonage agro-écologique, considérés comme activités fondamentales devant être renforcées pour lutter contre la sécheresse dans le futur.*

***Mots-clés.** Sécheresse – Atténuation – Rotation des cultures – Irrigation d'appoint – Zonage agro-écologique.*

I – Introduction

As part of a wider regional weather phenomenon which has affected a number of countries in South Asia and the Near East, a prolonged drought has seriously affected crop and livestock production in Iran. Actually, drought is a matter of fact and part of life in most part of Iran. According to Ghaffari *et al.* (2004), from 28 agro-climatic zones of country, six zones (arid-cool winter-warm summer, arid-cool winter-very warm summer, arid-mild winter-very warm summer, semi arid-cold winter-warm summer, semi arid-cool winter-warm summer, and semi arid-cold winter-mild summer) occupy nearly 90% of Iran. Therefore, since arid and semi arid zones covers a very large areas, drought is much more important than other natural stresses.

The incidence of drought in Iran is becoming increasingly common with substantial consequences on food security, livestock production, environment and natural resources. It has been estimated that the drought in 1999-2001 affected some 37 million people (over 50 percent of Iran's total population), according to a United Nations report of August 2000 (UN,2000), and has been felt in at least 25 out of the 28 provinces of the country. The two largest provinces of Sistan Baluchistan and Khorassan were the worst hit provinces. Also, the latest droughts in 2007-2009 were the worst droughts in the past forty years.

Rangelands and pastures' productivity was drastically reduced in many areas, resulting in malnutrition of livestock. An estimated 800,000 animals were reported to have been seriously affected while living conditions of people in many parts of the country were also worsening due to the drought. Iranian farmers and herders have lost important numbers of their livestock whereas production of wheat and barley was reported to have reduced by 35-75% depending on the provinces. Orchard production was also severely impacted. According to experts, agriculture and livestock sector losses to around USD 2.5 billion annually due to drought. The cold in 2007 and subsequently drought in 2008 produced an estimated USD 15 billion damage to agriculture sector.

The Government responses have mostly concentrated on relief interventions through provision of water, food and feed. A major part of the 2008 budget was allocated to the Agricultural Bank in order to provide loans to drought mitigation projects (e.g. on-farm soil and water conservation, maintenance of damaged traditional irrigation canals, etc.). Financial resources were also allocated to increase the capital of the Agricultural Product Insurance Funds. Globally, the severe drought conditions led to devastating social, economic and environmental impacts; and the responses were often more costly remedies, with little focus on drought preparedness and management policy.

The major farming system practiced in the dryland areas in the Islamic Republic of Iran is cereal (wheat and barley), food and feed legumes (chickpea, lentil and some forage crops) (Table 1). The most important constraint of rainfed farming in Iran is the shortage of water. Average annual precipitation of the country is about 250 mm, with erratic distribution; early drought and terminal drought are predominant. The temperature is the second major constraint that affects the rainfed agricultural productions. It varies from –35℃ (abs. min) in high altitudes to 54℃ (abs. max) in littoral zone. Pest and diseases are also the important factors affecting the rainfed crops productions. In addition to aforementioned factors, lack of suitable machineries and production technology, dissemination of agricultural information to the farmers, inefficient fertilizer and herbicides use and lack of technologies on water conservation and its efficient use hamper productivity severely in rainfed areas. Agricultural output is unstable and usually low, due to land degradation and unpredictable droughts. Increasing water scarcity and frequent drought occurrence is observed in recent years. Dryland farmers are generally poor. Irregular rainfall on poor-vegetated hill slopes results in severe soil erosion, downstream flooding and sedimentation. The major causes for land degradation are conversion of rangelands to rainfed agriculture, ploughing up- and down the slope especially on steep slopes, irrigation on sloping land, untimely and overgrazing. The degradation of the resource base certainly contributed to the relative poverty of the rural communities and to the high rural-urban migration rate.

Table 1. Area and production of major crops in Iran (2007)

Crops	Area (10^6 ha)		Yield (kg/ha)	
	Irrg.	Rain.	Irrg.	Rain.
Wheat	2.39	4.01	4878	1181
Barley	0.62	0.89	3229	1017
Chickpea	0.02	0.62	1074	434
Lentil	0.01	0.21	1094	484
Oil seed crops	0.16	0.09	1740	1366
Forage crops	0.69	0.10	13430	6975

During last two decades the Dryland Agricultural Research Institute (DARI) carried out numbers of research projects in different agro-ecology zones to find appropriate technology. The purpose of this paper is to explain the result of such projects and recommended technologies which adopted over a large cultivated area in dryland farming of Iran.

II – Material and methods

A farm survey conducted in 1995 in East-Azarbaijan (cold environment) and Kermanshah (moderate environment) provinces revealed several factors that hinder crop productivity. Farmers were mainly growing local crop varieties which gave low yields because of the lack of tolerance to biotic and abiotic stresses. There was, therefore, great scope for testing and subsequently disseminating improved crop varieties, along with improved technologies through on-farm verification and demonstration trials.

Following the farm survey, research experiments were designed to provide solutions to problems identified. Specific activities have included: (i) introduction of improved crop varieties and testing them on farmers' fields; (ii) on-farm fertilizer trials to identify crop response in different locations and create awareness among policy makers; (iii) sowing methods to compare recommended practices with traditional farmer practice; (iv) studies on chemical weed control; (v) effects of supplementary irrigation, sowing dates, seed rate and weeding on yields; (vi) monitoring the perception of farmers regarding the new technologies; and (vii) the agroclimatic zones map of Iran has been produced to develop an agroecological zones framework for targeting germplasm to specific environments, formulating land use and land management recommendations, and assisting development planning. In view of the very diverse climates in Iran, an agroclimatic zones map is of vital importance to achieve this objective.

III – Results and discussion

Farming systems in the surveyed region showed:

(i) Wheat-fallow rotation mainly in rainfed farming (90%) in the colder dryland region (Maragheh-Hashtrood).

(ii) Wheat-chickpea and barley-chickpea cropping, mainly in rainfed farming in the milder region (Kermanshah).

(iii) Cereal/livestock integration in both regions.

(iv) Forages under irrigated conditions.

(v) Local or old improved varieties with low yields.

(vi) Variable seed rates for wheat (75-200 kg/ha) and low seed rates for chickpea and lentils.

(vii) Improper tillage practice during fallow in cold areas (late and infrequent), and moderate areas (50% of farmers apply only one tillage by mouldboard).

(viii) Improper seedbed preparation (big clods).

(ix) Planting is done mostly (60-90%) by hand broadcasting and covered by mouldboard in 50% of the cases.

(x) Chickpea, the second important crop after wheat in Kermanshah, is planted mostly in late spring with very low seed rates and very low yields.

(xi) Fertilizers are not sufficiently available though their importance is very well known by farmers.

(xii) Weed control is not applied by about 75% of the farmers.

(xiii) Fertilizer use, lack of machinery and time of initial-tillage are the most important factors affecting farmers' production as they ranked. Also, poor transfer of improved technologies due to an absence of effective research-extension-farmer interaction.

Therefore, on-farm trials were designed in both locations for the following purposes:

(i) Wheat variety demonstrations in farmers' fields.

(ii) Wheat and barley under different seed rates.

(iii) Fertilizer on-farm trials to create awareness among the decision makers.

(iv) Fertilizer trials to identify the crop response in different locations combined with the soil analysis.

(v) Time and frequency of tillage.

(vi) Sowing methods to compare recommended and farmers practice.

(vii) Chemical weed control *vs* weedy check in wheat crop.

(viii) Introduction of forage crops into the crop rotation for livestock in the farming systems (for winter and spring sowing in farmers fields).

(ix) Monitoring of farmers perception of the new technologies and their adoption levels.

Initial results were impressive. After seeing the crop productivity in the demonstration farms, farmers have widely, adopted the technologies on their own farms. New technology included station and on-farm experiments, whose results (Anonymous, 2002, 2003a,b, 2004, 2005) are summarized as:

(i) 4 varieties of bread wheat (Zagross, Azar 2, Niknejad and Kohdasht) and one durum wheat (Saimareh) have been released for commercial cultivation in different ago-ecological regions of the country.

(ii) In soil fertility and fertilizer trials on the main cereal, results showed that 60 kg N and 30 kg P were effective in improved wheat variety.

(iii) Micro elements survey showed that applying 20 kg/ha Zn, and Mn application increased wheat yield in research station and farmers fields.

(iv) Water productivity analysis indicated that the use of improved chickpea varieties (Arman and Azad) and fall planting resulted in high water productivities and good farm incomes. Chickpea cultivation makes farm production more sustainable by encouraging legume-cereal rotation in the farming system.

(v) In supplemental irrigation, just one time 50-70 mm irrigation in early October highly increased (over 50%) local and improved wheat varieties yield; and applying additional 100 mm in spring almost doubled the wheat yield. Consequently water productivity was also increased.

(vi) In crop rotation trials, different crops based on wheat production were studied with fallow systems, and cereal-legume rotation was found to be much productive; the study on forage and oilseeds rotation is going on.

(vii) Suitability of local and imported machinery has been studied and some modifications have been made for fertilizer placement (9 cm below seed) which had high effect on yield increase.

(viii) The best seed rate and row spacing were determined and proper seed drills were introduced to farmers.

(ix) A study on pest and diseases for the main crops was carried out and different control techniques were applied in the station and on the farmers' fields.

(x) Chemical and mechanical weed control systems were surveyed and joint experiments by extension service carried out across the provinces.

(xi) In agro-techniques, some tillage experiments were carried out for moisture conservation and no tillage systems there after founding were extended to farmers fields. No significant differences were found among fall activities (sub-soiler, chisel and no tillage) on moisture conservation in 0-15, 15-30 and 30-60 cm soil depth of fallow years. Significant differences found between first spring tillage on moisture conservation in fallow years. Mouldboard provided higher moisture conservation in different depths than ducks foot. Chemical weed control provided significantly higher moisture conservation than ducks foot in second spring tillage. However fallow techniques relatively affected soil moisture conservation, but they had no effect on seed germination of cultivated wheat. Therefore no significant differences were found for wheat yields in the cultivated years (Jam-e-Jam, 1994). This is because of the same time of tillage application in early spring. The difference comes with the early tillage by any implement compared with the late (June) tillage applied by most of farmers.

In the 2003/2004 season, the recommended technologies were adopted in more than 500,000 ha in five provinces as opposed to 85,000 ha in the previous season and the 4000 ha of crop season of 2001-2002. On-farm results showed 53% wheat grain yield increase compared to farmers fields in 2001-2002 (1-2.5 t/ha in traditional farming and 2-4 t/ha in farms with improved technology), 60% in 2002-2003, and 65% in crop season 2003-2004 (Table 2). Similar results were observed for other crops, including chickpea, lentil, oilseed crops and barley in this region and other provinces. The participation of farmers, researchers, and extension workers in the testing, demonstration and dissemination of improved technologies has led to better awareness of the technology and to its adoption by a large number of farmers.

Table 2. Effects of improved practices at large scale on wheat yield (t/ha)

Year	Practices	Provinces†				
		E. Azar.	Koh.	Kord.	Lor.	Kerm.
2001/02 (~4,000 ha)	Recom. tech.††	1.91	2.43	1.11	–	2.72
	Farmers field	1.19	1.35	0.90	–	1.87
	Dif.†† (%)	60	80	23	–	46
2002/03 (~85,000 ha)	Recom. tech.††	3.22	3.18	1.69	1.61	2.00
	Farmers field	1.80	1.73	1.33	1.24	1.50
	Dif.†† (%)	79	83	27	30	33
2003/04 (~500,000 ha)	Recom. tech.††	3.65	3.47	1.95	2.35	2.20
	Farmers field	2.15	1.90	1.24	1.45	1.50
	Dif.†† (%)	70	83	57	62	47

†E. Azar. = East Azarbaijan; Koh. = Kohgiloieh va Boir Ahmad;
Kor. = Kordestan; Lor. = Lorestan; Kerm. = Kermanshah.
††Recom. tech. = Recommended technology; Dif. = Difference.

IV – Conclusion

The reform of the agricultural price policy for inputs and outputs during last 10 years, has contributed to encouraging farmers to adopt new agricultural technologies relevant to main crops. Therefore, policy makers and planners have achieved their goal of stimulating farmers to adopt modern wheat and other main crops technologies. Using high-yielding varieties, chemical fertilizers, weeds, pest, and diseases control, good management practices, together with enough rain during crop season, caused wheat production in Iran to exceed demand for the first time since 1960. Not only wheat production increased from 9.46 million tones in 2001 to 14 million tones (48%) in 2004 (wheat self-sufficiency was reached), but also other main crop productions increased in this period, including: maize from 1.06 to 2 million tones (89%); colza from 30.3 to 115 thousand tones (280%); and sugar from 837 to 1350 thousand tones (61%).

The dryland areas are playing an important role in Iran's economy and hold a tremendous potential for increasing agricultural production. With the adoption of new technologies the production of most crops can be doubled. Appropriate technologies will help in sustainable agricultural production and restrict environmental degradation. Drought effects should be mitigated for the future through appropriate forecasting methods and management measures. Optimal use of rainfed areas and expansion of supplementary irrigation techniques helps to increase yield in many water available areas.

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