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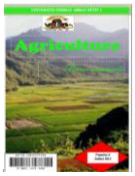

Irrigated farm management in semi-arid area East Algeria

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RESUME

La recherche présentée dans cet article se concentre sur l'influence de l'utilisation de l'eau d'irrigation sur la diversité des cultures du système de production en zone semi-aride de l'Algérie. Nous supposons donc que les pratiques de l'irrigation des agriculteurs sont expliquées par des logiques qui doivent être compris au niveau des exploitations. L'étude accentuée sur la diversité de la stratification des exploitations à l'échelle régionale, a été réalisée par la collecte de données exhaustives dans 120 unités choisies au hasard selon le gradient d'aridité du nord vers le sud: la zone supérieure (ZS), la zone centrale (ZC) et la zone inférieure (ZI). Dans une deuxième phase, 16 exploitations agricoles représentatives et 242 parcelles de cultures, y compris les 174 champs de culture de céréales, ont été soumis à un suivi technico-économique au cours de deux années consécutives (CY1, CY2). Nous avons enregistré des périodes et des modes de culturales sur toutes les parcelles et étudié les logiques et les justifications des agriculteurs à marier ces pratiques. La diversification des ressources et cycle de production sont basés sur la disponibilité et l'utilisation de l'eau d'irrigation et de la combinaison de la culture des céréales et de l'élevage avec d'autres spéculations telles que comme les cultures fourragères, les maraîchères et la pomme de terre. Cette diversification est plus ou moins prononcée selon le type d'exploitation et la zone de production. Elle est plus forte en zone centre et inférieure qui se reproduit principalement dans les exploitations moyennes et petites exploitations. L'irrigation a un grand rôle dans l'extension de la diversité des cultures en zone semi-aride.

ABSTRACT

The research presented in this paper focuses on the influence of irrigation water use on crop diversity of the production system in semi-arid area of Algeria. We hypothesis' that farmers' practices irrigation are explained by logics that need to be understood at farm level. The study was accent in farms' diversity stratification on regional cart: the upper zone (UZ), the central zone (CZ) and the lower zone (LZ), was carried out via quantitative data collection in 120 randomly chosen units. In a second phase, 16 representative farms and 242 crop parcels, including 174 cereal crop fields, were subjected to a technico-economic follow-up during two consecutive years (CY1, CY2). We recorded periods and cropping methods on all parcels and investigated farmers' rationale wedding these practices. Resource diversification and production cycles are based on availability and use of irrigation

water and combine cereal and livestock production with other speculations such as: feed crops, vegetables and potatoes. This diversification is more or less pronounced according to farm type and area. It is stronger in the central and lower semi-arid area mainly occurring on medium-sired and small farms. Irrigation has a big role in explaining of crop diversity in semi-arid area.

1. Introduction

In semi-arid region more than in other regions it is of some necessity to stave for sustainable farm production. This sustainability aims at securing a stable income in combination with sustainable use of (scarce) natural resources that are mobilized to ensure income growth (Sydorovych and Wossink, 2008).

Previous studies of management practices (Kropff, et *al.*, 2001; Kara et *al.*, 2007) in Setif heightens cereal farming in eastern Algeria's semi-arid area, highlighted the various climatic, structural and socio-economic constraints that limit production (Benniou, 2008). These constraints condition producers' interventions and have a direct incidence on choice of cereal species grown (Benniou, 2008; Hubert, 1999; Debaeke 2004). The logic response of farmers to these constraints results in a combination of practices aiming at decreasing risk (economic, climatic...). Among these practices there are: (*1*) extensive farming, esp. in cereals; and (*2*) the mixed cropping to cover for climatic variations (cereal and ruminant livestock farming); according to Millar and Photakoun, (2008), animal husbandry can play a paramount role in ensuring livelihood sustainability; (*3*) crop's diversification within the cereal system; and (4) water mobilization for irrigation. Improved articulation between mixed farming and livestock can guarantee farm income and as a result farm sustainability (Benniou, et *al.*, 2003; Dufumier, 1996). This requires new more indicate organization forms and various production strategies (Dufumier, 1996; Benniou et Brinis, 2006; Meul et *al.*, 2009) as a best set of practices; (*5*) farmers can case fallow land for grazing herds, and (*6*) establish grain reserves over several years for home consumption and seeds.

The present study focuses on irrigation water use for improved production system diversity and great resistance for semi-arid area farms. Farms were monitored during two campaigns targeting all farm crops and especially cereals. We tried to understand technique mode in cropping system management in each farm type. The typology describes the forms of organization and meaning farms is managed before monitoring on field. This typology is based on structural (agricultural land, agricultural equipment, workforce, building, planted crop, livestock…) and environmental factors (Benniou et *al.*, 2003; 2006; Benniou 2009; Brisson and Casals 2005).

2. Material and methods

2.1 Study area

The work was carried out in the Setif High Plains area (SHP) of north-eastern Algeria (36_11 North, 5_25 East). The area is flat and covers 6,550 Km². SHP are characterized by three agro climatic areas: the upper zone (UZ) which on average receives 400 to 500 mm/ year of rain; the central zone (CZ, 300 to 400 mm/ year); and the lower zone (LZ, 200 to 300 mm/ year). In these areas, risks of characterisation drought are the limiting factor for agricultural production (Bourbouze, 2001; Hazell and *al.*, 2001; Millar and Photakoun, 2008). Average rainfall figures over the years show remarkable inter-annual differences precipitation variability. Precipitation during the first year (2001/2002: CY1) and united to 180 mm -266 mm below long-term average. The second year (2002/2003: CY 2) had a total rainfall of 462 mm a variation of 16 mm above long-term average. The north (UZ), there are profound soils with strong water retention capacity; they are black to gray. In both CZ and LZ areas, soils are more or less superficial, light or reddish limestone charge. Their texture is light (Batouche and *al.*, 1993).

2.2 Hypothesis: In areas subject to various climatic, the production choices and farming practices are linked to several determinants such as the production unit structure, the conditions climatic in which agricultural activity takes place and the possibility of irrigation water mobilization.

2.3 Field research

The work focused on the farms development across cropping systems and farmers logic to choose cropping system according to their structuring degree (Kara and *al.*, 2007, Benniou, 2009). One seeks to understand the arrangements made by farmers based on farm structure and organization through crop management (Doré and *al.*, 2007; Clergue and *al.*, 2005).

The farms diversity characterized by a regional typology (table 1), was carried out by quantitative investigations into 120 agricultural units: 48 units in UZ (upper zone), 25 units in CZ (central zone) and 49 units in LZ (lower zone). The sample exploitations results from a choice of zones according to the factors regarded as important of area variability (relief, accessibility water irrigation, enclave region). The investigation objective is not to make sweep in the statistical logic, but rather to retain representative of agricultural unit's; cases of regional diversity (Jouve, 1989; Simon and al., 2000 ; Dounias and *al.*, 2004) in the Mitchell track (Grigera, 2007). The criterion proposed at functions types work depend at agro-ecological area, structural factors (UAA[1], farm equipment, buildings, hand work, use irrigation water) and at productions implemented (Mitchell, 1983). As for cropping cereal diversity methods is characterized by a technical itinerary typology. Technical itinerary was analyzed by a follow-up of practices in sixteen representative farms according to regional typology. The follow-up concerned 242 cultivated parcels including 174 of cereal, during two consecutive years (2001/2002 noted CY1 and 2002/2003 noted CY2). We proceeded to practices recording (dates and modes of culture) on all parcels and to investigations with farmers into these practices reasons.

Table 1. Crop management itinerary by exploitation type in CY1.

					T4												
					T5												
					T5												
LZ		T5			T4					T5							T5
		T4			T3					T3							T4
		T4			T3					T3		T5					T3
	T5	T3	T1		T1				T4	T1		T1					T1
	T1	T3	T1	T3	T1	T5			T5	T1		T1					T1
		T5				T4			T5								
CZ	T5	T5				T5			T5								
	T5	T5				T4	T5		T5		T5	T5					T5
	T5	T3			T5	T3	T5		T4	T3	T4	T4		T5	T4		T5
												T5		T5			
	T5										T5	T5					
UZ	T5	T5				T5					T5	T5					
	T4	T5				T5	T5		T5	T5	T4	T4					
	T3	T4				T4	T4		T4	T4	T3	T3		T4			
	T3	T3			T5	T3	T3	T3	T3	T3	T3	T3		T3		T5	
Stages	L1	L2	L3	L4	1	2	3	4	Lines	Stolen	TSP	Nitrogen	Fu	Ch	Ml	A.	C.
	Ploughing				**R-crossing**				**Sowing**		**Fertilization**			**Treatment**		**Irrigation**	

Legend: L1: early ploughing, **L2**: autumn ploughing, **L3**: late ploughing, **L4**: late ploughing without recovery, **1, 2, 3, 4**: number de recovery, **TSP**: super triple phosphate, **Ch.**: chemical, **Mi**: manual, **A**: supplement, **C**: continue, **Fu**: manure.

3. Results and discussion

3.1 Farmers' diversity regional

The principal components extraction shows two factors groups which accumulate 71 % of total variance (Benniou and Brinis, 2006). The first flap, structural and environmental, known as "explanatory" expresses sustainable of farming activities (Gafsi, 2006) using economic directives (cereals-ovine breeding). This first flap represents a 51 % share. The second flap, with 20 % as variance, expressed more unusual situations underlining economic dynamism through irrigation and animal Breeding. The graphic analysis APC layouts let's appear five exploitations types per economic guideline:

- T1: small-scale farms diversified with an ovine or bovine breeding;
- T2: small-scale farms diversified having a mixed breeding (ovine and bovine);
- T3: average farms "cereals-livestock" and diversify-breeding;
- T4: large farms cereals-breeding with or without potato;
- T5: large farms "mixed-farming-breeding.

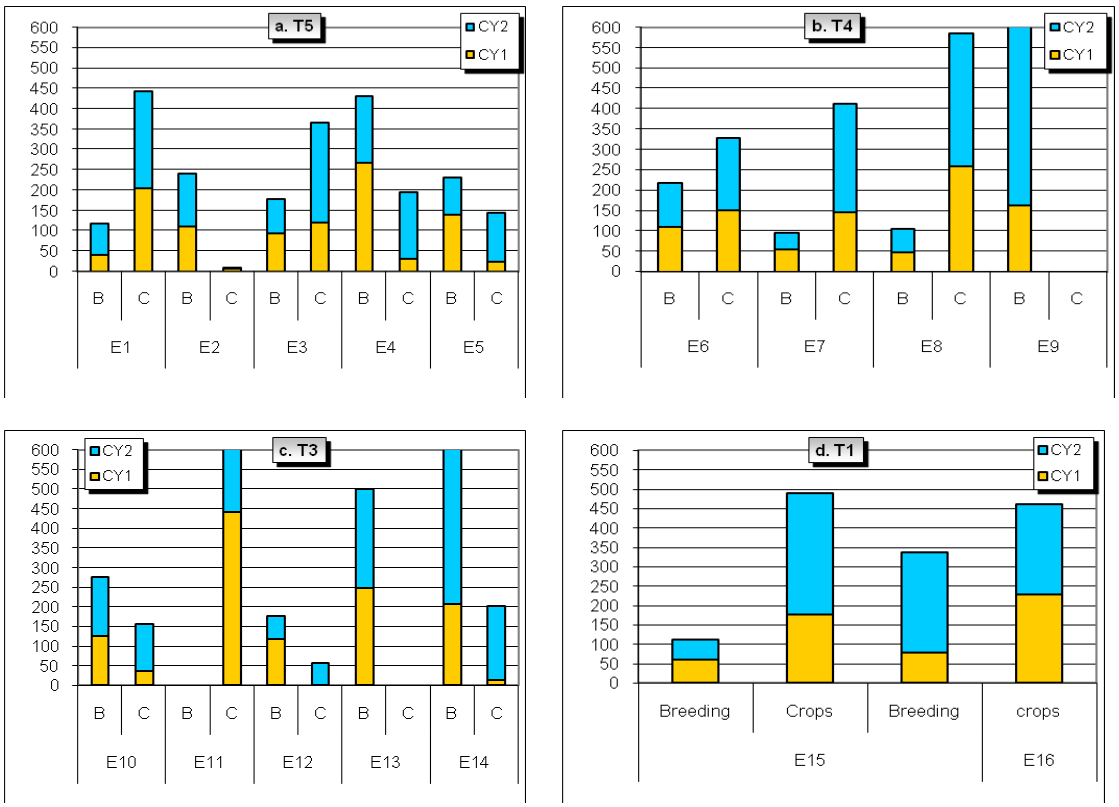
For tillage operations, farms of types T1 and T2 are entirely dependent on the outside. Farm's types T3 and T4 have a partial dependency, then that farms of types T5 are independent (Benniou and Brinis, 2006).

[1] ***UAA:*** usable agricultural area

Overall, the mixed farms income (having an association between the vegetable production and livestock) was maintained each year with an elevated level of climatic constraints. The livestock plays a hand of shock absorber in low rainfall years unfavorable, but not on the Irrigated crops production (Malzieux and Mouster, 2005). He will allow exploitation continuity in more abundant rainfall conditions. The mixed farming and stockbreeding system, contributes more to the benefit of farm economic region. The speculations as irrigable substantially legumes, potatoes and cereals even when they receive a supplemental irrigation (wheat, fodder crops). The mixed crop-livestock system of T5 type in three stages maintained overall good results while support livestock production by: (1) use of the products and under farm products, (2) beginning consumption with products before buying (3) the cereal surfaces by places were used to support, by pasture in the crop course and feed crop stocks; in CY1 with an almost null grain harvest. The cereal crops release as one expected it profits appreciably higher in normal conditions rain (CY2), which is not case for breeding, where income appears stable between the climatic years. We note that in bad cereal harvest case (CY1), the contribution to trading income is guaranteed by atelier fatten up (case of E2, E9, E12 units and E13 as shown in the Fig.1). These units belong on various types and stages (T5 in UZ, T4 in LZ, T3 in CZ and LZ) recorded weak economic profits in crops (exclusively cereal) in CY1 (dryness) and partly in CY2 (hail) compared to those achieved on livestock sales.

It is also noted that in stages CZ and LZ and in spite of the dryness extent in CY1, at certain exploitations especially of small size (exploitations E5, E6, E7, E8, E15 and E16), the share of crops incomes is high compared to breeding. This “favourable” context is owing to irrigation practice on cereals parcels, folder crop and mainly on potato crops and crops market gardening’s (known as speculative crops).

The T5 type’s exploitations and T4 especially record a higher income in crops compared to breeding in three stages in rainy climatic conditions. For T3 type, in region context, breeding contributes positively to trading income; it is higher in dryness event (CY1), case where cereals crops contribute negatively to exploitation global income in particular in stage CZ and LZ. For small-scale farming (T1 type) oriented to irrigated crops (fodder and crop’s legumes) incomes contributions of these crops were higher compared to those of breeding (Mitchell, 1983).



Legend: **B**: breeding, **C**: crops, **CY1**: 2001/2002, **CY2**: 2002/2003, **E**: exploitation

Fig.1: Share of the crops and breeding incomes by exploitation

3.2 Cereal cultivation typology

We retained differentiation criteria which are a priori of major importance, for understanding well production strategies of these crops in semi arid areas: ploughing (temporal position, mode), sowing (temporal position, mode and sowing amount), fertilization (phosphate fertilisation, nitrogen fertilisation), weeding (manual, chemical) and irrigation (supplemental irrigation, continuous irrigation) (tables 1 & 2). In addition, to best understand farms function by connecting these practices to function determinants such as breeding and mechanization by report to climatic stages, to exploitations types and climatic years. These criteria enable us to raise choices coherence; according to Capillon, (1993), it is a genuine key for system definition which exploitation constitutes.

Table 2. Crop management itinerary by exploitation type in CY2

LZ		T5														
		T4							T4							
		T3			T5				T3							
		T3			T4	T5			T3							T3
		T1			T1	T4		T5	T1			T1			T5	T1
	T4	T1			T1	T1	T5	T4	T1			T1	T3		T4	T1
CZ						T5										
						T5										
	T5	T5			T5	T4		T5								
	T5	T5		T5	T5	T4		T5	T5		T5			T5		
	T4	T3	T5	T5	T4	T3	T4	T4	T3	T4	T4			T4	T5	
UZ	T5															
	T5															
	T4					T5		T5		T5	T5		T5			
	T3	T5		T5		T4	T4	T4	T5	T4	T4		T4			
	T3	T4		T3	T5	T3	T3	T3	T3	T3	T3		T3	T5	T5	
Stages	L1	L2	L3	L4	1	2	3	Lines	Stolen	TSP	Nitrogen	Fu	Ch	Man	A	C.
	Ploughing				**Sowing**			**Fertilization**				**Treatment**		**Irrigation**		

Legend: L1: early ploughing, **L2**: autumn ploughing, **L3**: late ploughing, **L4**: late ploughing without recovery, **1, 2, 3, 4**: number de recovery, **Ch.**: chemical, **Mi**: manual, **A**: supplement, **C**: continue, **Fu**: manure.

3.3 Combined typology establishment (ploughing, sowing)

It is noted that if all region farms are concerned by establishment modalities and sowing (combined kits ploughing, sowing), it is not same for cultivation continuation: the maintenance operations (fertilization, weeding, irrigation) are less frequent, more variable and often related to a climatic stage, certain exploitation's types and/or certain climate's years (tables 1 & 2). One highlights in particular intensive cultivation in UZ (early ploughings, many "re-crossing", complete fertilization, weeding). Intensive cultivation in LZ which are different (later ploughings, less "re-crossing", less fertilization, possible chemical weed control, but irrigation, often auxiliary). The full number of operations is variable according to climatic stages and crop years: it varies from 2 to 5 passages with higher located in majority in UZ. respectively, 28 % and 31 % of fallow parcels are ploughed in spring in CY1 and CY2, the remainder (71 % and 69 %) of parcels is ploughed later until November December, to see January.

The small-scale farms never plough in spring, but practically very tardily in autumn. Seven essential "kits" of ground work which join ploughing operations and "re-crossings": the "kits 1.i" gather spring ploughing, the "kits 2.i" autumn ploughing, the "kits 3.i" late ploughing and "Kits 4" only one ploughing with cover-crop.

For cereals installation, flight sowing is observed almost at half of exploitations and almost totality of small-scale farming's of T1 and T2 type. The line sowing remains dominating in CZ and UZ. Twelve "kits" were observed: four "kits" of "early" sowing, four "kits" of "season" sowing, and four "kits" of "late" sowings. The "kits" are subscripted initially according to precocity then sowing density class then modalities. The early ground work early sowing, amount of high sowing and line sowing are more present in UZ according to exploitations types and climatic year. In fact, exploitations majority of CZ and LZ stages of region are concerned by a crop management itinerary with: extensive farming itinerary characterized by a very light ground work and very to diversify species cereal installation (go back to often late sowing, low sowing dose and flight sowing).

This crop logic diversification is accentuated in south (LZ: five "kits" for only, ground work and sowing, compared to north region (UZ: three "kits"). This logic is dependent on global at exploitation function and its principal determinants in particular, mechanization, breeding and water use).

3.4 Combined typology establishment (tillage, sowing), fertilization, weeding and irrigation

This final typology corresponds to diversity cereal control global representation of tillage until irrigation (Table 3). These "kits" remain almost specificity of LZ stage since all exploitations types (of T1 with T5) are concerned. However, theses kits meet more in small one and average exploitation like in low rainfall year (CY1). It is noted that use of water is reasoned thus that fertilization compared to species: irrigation is especially used on second cereals (oats, barley), a little on wheat durum thus on cereals with Fodder crop vocation.

Moreover, irrigation is associated with a great diversity of other techniques. It is thus not an intensification factor automatically associated with a strong fertilization, or a systematic weeding or an early ground work…, as one could possibly expect it and as technical recommendations push there, at least in zones at more strong potential. On the contrary, we meet irrigation rather associated with late tillage dates, with sowing, with stolen and low sowing dose, all elements frequently met in coarse grains with fodder crop vocation. The weak use of nitrogenised fertilization maintains production level, especially on fodder crop surfaces (Dieguez and Hornik, 2001). For farmers, irrigation generally corresponds to an auxiliary irrigation just after plants lifting, therefore a minimum insurance kind, it necessarily does not enter, in intensive farming. Nevertheless for farmers it is a very important technique in production results terms: it is noticed well that certain production stability is thus sought especially on fodder crop cereals.

Table 3. Crop management itinerary illustration starting from the kits of: tillage, sowing, fertilization, weeding and Irrigation.

Kit 1						
Ground work	**T2.2**					
Sowing	**S1E2**	**S2E2**	**S2E1**	**S3E2**	**S2F1**	**S2F2**
Fertilization	**-**	**Fr. N$^-$**	**-**	**-**	**-**	**-**
Weeding	**-**	**-**	**Ds. ch.**	**-**	**-**	**-**
Iirrigation	**I.A**	**I.C**	**I.A**	**I.A**	**I.A**	**I.A**
Type, stage/ year. and number of parcels	**T5S (CY1-1)** *Oats*	**T4I (CY1-1)** *Oats*	**T5C (CY1-2)** *Barley- Oats*	**T2I (CY2-1)** *Oats*	**T5C (CY1-2)** *Durum wheat*	**T4I (CY2-1)** *Oats*
	T2I (CY2-1) *Oats*	**T2I (CY1-2)** *Oats*		**T2I (CY2-1)** *Orge*		**T2I (CY1-2)** *Orge- Oats*
		T5I (CY1-1) *Barley - Oats*				
Tot. Parc.: 15 **Fréq. : 09 %**	02 13	04 27	02 13	02 13	02 13	03 20
Kit 2						
Ground work	**T2.3**					
Sowing	**S3E1**	**S3E2**	**S3F1**	**S3E2**		
Fertilization		**Fr. n$^-$**		**Fr. n**		
Weeding						
Iirrigation	**I.A**	**I.C**	**I.A**	**I.A**		
Type, stage/ year. and number of parcels	**T5I (CY2-2)** *Durum wheat - Oats*	**T4I (CY1-1)** *Durum wheat*	**T5C (CY1-2)** *Barley - Oats*	**T2I (CY2-2)** *Barley - Oats*		
		T4I (CY1-2) *Durum wheat - Oats*				
Tot. Parc. : 09 **Freq. : 05%**	02 22	**03** **33**	02 22	02 22		
	Kit 3		**Kit 4**		**Kit 5**	
Ground work	**T1.2**	Ground work	**T3.3**	Ground work	**T4.0**	
Sowing	**S2E1**	Sowing	**S3E2**	Sowing	**S3E2**	
Fertilization	-	Fertilization	**Fr. n$^-$**	Fertilization	**Fr. n$^-$**	
Weeding	-	Weeding	**-**	Weeding	-	
Iirrigation	**I.A**	Iirrigation	**I.A**	Iirrigation	**I.A**	
Type, stage/ year. and number of parcels	**T5I (CY1-1)** *Durum wheat*	Type, stage/ year. and parcels	**T5S (CY2-1)** *Oats*	Type, stage/ year. and parcels	**T1I (CY1-1)** *Barley*	
Tot. Parc. : 01 **Freq. : 0,6 %**	**01** **100**	**Tot. Parc.: 01 Freq. : 0,6 %**	**1** **100**	**Tot. Parc.: 01** **Freq. : 0,6 %**	**01** **100**	

4. Conclusion

The relation study between cereal crop management itinerary and functional typology such we treated through some major determinants: farm equipment weight, breeding-cattle and diversity weight in production system could allow a real situation agricultural knowledge. In medium term, water mobilization can be a factor of diversity and dynamics in a farm. But in long run, question which remains to be posed in semi-arid area as is it for management of water and of irrigation model?

In this perspective, we finds that work on cultivation methods and economic finer criteria follow-ups by taking of account objectives and exploitations constraints could make it possible to better understand farms function. This objective must necessarily bring together all profession agricultural actors: farmers, vulgarizations popularize public authorities, research institutes and techniques… Finally, what would be good to put in place for more data? The establishment of economic and technical observatory to national scales helped to clarify agricultural sustainability issue in difficult environments.

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