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Yield and quality of dual-purpose barley and triticale in a semi-arid environment in Tunisia

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The semi-arid region of Tunisia is characterized by a low and erratic rainfall. This makes year-round maintenance of pasture and forage production under non-irrigated conditions both costly and difficult. In order to fill the winter feed gap in the livestock cycle; some cereals can be used as dual-purpose. This study aimed at evaluating agronomic performances and grain quality of two dual-purposes cereal crops, Barley and Triticale, cut at the pseudo stem erect stage (C30). The trial was conducted during 2010-2011 and 2011-2012 seasons under a semi-arid environment. Yields did not significantly differ between years and although barley yielded more forage crop than triticale the yield was not significantly different. Crude protein in the plant was significantly higher in barley (18.2%) compared to triticale (17.4%). Defoliation has caused a significant grain yield reduction for both cereals and was about 22% for triticale and 28% for barley; grain yield after forage removal was statistically higher for triticale (3.47 T/ha) than barley (2.85 T/ha). As average for the two seasons of the trial, grain protein was significantly higher after clipping for barley (11.35% for dual purpose and 10.17% for grain production only) and was not affected for triticale (9.38% versus 9.55%). Under Tunisian semi-arid environment, triticale and barley have comparable yields with a small superiority for triticale in grain yield after forage use and higher plant and grain protein contents in barley.

Key words: Cereals defoliation, forage, protein, grain.

INTRODUCTION

In Tunisia, farmers face serious problems of low quantity and quality of forage to feed their animals. The year-round maintenance of pastures and production of forage crops is difficult to achieve in rain fed areas. This is caused by low and erratic rainfall and poor soil fertility conditions, which characterize the semi-arid and arid regions. One of the solutions, used mainly by local and small farmers, is the practice of dual-purpose cereals; these cereals are grazed or cut at a young stage (tillering) and then allowed to re-grow up to grain production. This will provide forage during winter season which is known as a forage deficit, reduce pressure on other feed resources and allow farmers to harvest grain and straw at the end of plant cycle. In Tunisia, dual-purpose use of cereals is commonly practised by Small ruminent breeders. The main crop serving as winter grazing and grain for feed is barley with 45000 ha annually which represents about 20% of total forage area

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(Ouji et al., 2010)

The most frequently used species for dual-purpose cropping in the Mediterranean context are barley, oats and triticale (Epplin et al., 2000). Biomass productivity before grazing and grain yield after regrowth define the suitability of these cereal species to dual-purpose practice. Researches about cereals dual-purpose for seeds and forage have given widely varying results according to the climate, to fertilization to the specie, to seed rate and date and to the cut or grazing stage. In fact, the practice of first use by cutting or grazing helps to gain a certain amount of nutritious forage, but may reduce straw and grain production particularly when conducted in late growth stage. This practice is common in Morocco (Belaird and Morris, 1991); Syria (Mazid and Hallagian, 1983) and Tunisia (Amara et al., 1985). In Mediterranean environments, Hadjichristodoulou (1991) reported that grazing affected grain yield of dual-purpose barley in rain fed conditions, while the same effect was not detectable in irrigated conditions. According to the same author, one clipping at tillering stage reduced total dry matter yield by 12 to 64% and crude protein by 30%. Thus, the management of cutting stage influences the forage and grain yield. Royo et al. (1997) have reported that, when cut at the first detectable node stage (C. 31) triticale and barley forage yield was almost double the yield at the pseudo-stem erect stage (C. 30). Defoliation during early growth stages optimizes seed yield and forage quantity and quality (El-Shatnawi et al., 2004). According to Giunta et al. (2015), understanding phenology is critical for the success of a dual- purpose crop as it determines both the duration of the grazing period and affects the recovery period. Decreases in grain yield after clipping have been attributed to a reduced number of spikes/m² at harvest in barley (Scott et al., 1988) and triticale (Royo et al., 1993) and also to a reduced grain number (Bonachela et al., 1995) and kernel weight (Royo et al., 1994).

Other studies have reported a grain yield increase after a cutting or grazing during green stage. This increase has been associated to the decrease of lodging (Droushiotis, 1984). Other results showed also that a properly managed grazing does not reduce grain yield in the dual-purpose system. It shows that the stocking pressure and number of cuts have been shown as important factors that influence the subsequent grain yield (Arzadun et al., 2003; Hossain et al., 2003). Epplin et al. (2000) and Hossain et al. (2003) also suggested that an optimal choice of planting date and density is crucial if cereal is to produce high forage and grain yields.

Other studies dealt with the influence of dual-purpose cereals on quality traits (Royo et al., 1994; Garcia del Moral et al., 1995; Royo and Pares, 1996; Royo et al., 1997; Royo and Tribó, 1997; Khalil et al., 2002b). With the exception of kernel weight, Khalil et al. (2002b) did not find detrimental effects of dual-purpose management on wheat grain protein or on dough strength parameters, nor was grain protein content affected by forage removal in barley and triticale (Royo et al., 1997). Royo et al. (1993) reported that triticale was seen to be good for forage production compared with other cereals, and barley had the highest crude protein content. The results also showed that different varieties of the species investigated had different behaviors with respect to their dual-purpose capacity. This result was contrary to that found by Khalil et al. (2002a) who found no significant differences among wheat cultivars due to the management system.

The objective of this study was to investigate the effect of defoliation on grain production and quality of two dual-purpose species, triticale and barley under rainfall conditions in a semi-arid region of Tunisia.

MATERIALS AND METHODS

The present study was carried out over 2 years (2010-2011 and 2011-2012) in el Kef region, in the experimental field of the higher Institute of Agriculture Kef (36° 11' 9'' N, Longitude 8° 42' 59'' E ; Altitude 652 m). The trial was carried out in a clay-sandy-loamy soil with about 25 cm ploughable soil and with low organic matter content (1.8%). The climate is Mediterranean, with rainfall concentrated in the autumn and winter. The average annual rainfall is 419 mm on the basis of 20 years.

Monthly rainfall as well as maximum and minimum temperatures of the two seasons of trial are reported in Figure 1. Rainfall from October to June was 496 mm in 2010/2011 and 508 mm in 2011/2012, which is above the annual average (419 mm). Both seasons had a wet winter (December, January and February) with 167 mm during first year and 244 mm for the second year. But greater rainfall was registered during March and April of the second year (143 mm) compared to same period of the first year (51 mm). It supposes that the regrowth of tested cereals will be better during 2011/2012 season.

The experiment assessed the response of two cereal species to winter clipping. Triticale (*triticosecale* Wittmack) variety Tcl 83 and barley (*Hordeum vulgare* L) variety Martin. In Northwest region of Tunisia, Triticale has been introduced as an alternative to barley by local farmers during last decade. The two chosen cultivars, Martin for barley and Tcl 83 for Triticale are very common in Tunisia. They are used for forage or for grain. Ben Youssef et al. (2001) and Ouji et al. (2010) have reported that Martin cultivar is good to be used in dual-purpose management.

The experimental design was a split plot with four replications and each plot measured 6 m² in which the main factor was the species and the secondary one the treatment. The two management systems (treatments) experimented were: (i) control plots which were only clipped at plant maturity in order to estimate the grain yield and (ii) dual purpose plots which were clipped first time and harvested as forage at the stem erect stage (C30) and then let regrowth up to plant maturity. For both treatments the whole plant was hand harvested at maturity and straw and grain yields (SY and GY) were estimated. Sowing was carried out early October (06 October 2010 and 08 October 2011 respectively for the first year and second year of the experiment) at a density of 300 viable seeds/m². The soil was chisel plowed in September and just prior to sowing. Pre-sowing fertilization rates for all plots were 46 kg P/ha and 18 kg N/ha. During growth cycle 2 fertilizations were provided: 40 Kg N/ha in 3 leafs stage and 50 kg N/ha after clipping for dual-purpose treatments and in elongation stage for grain only use treatments. Weeds and diseases were chemically controlled.

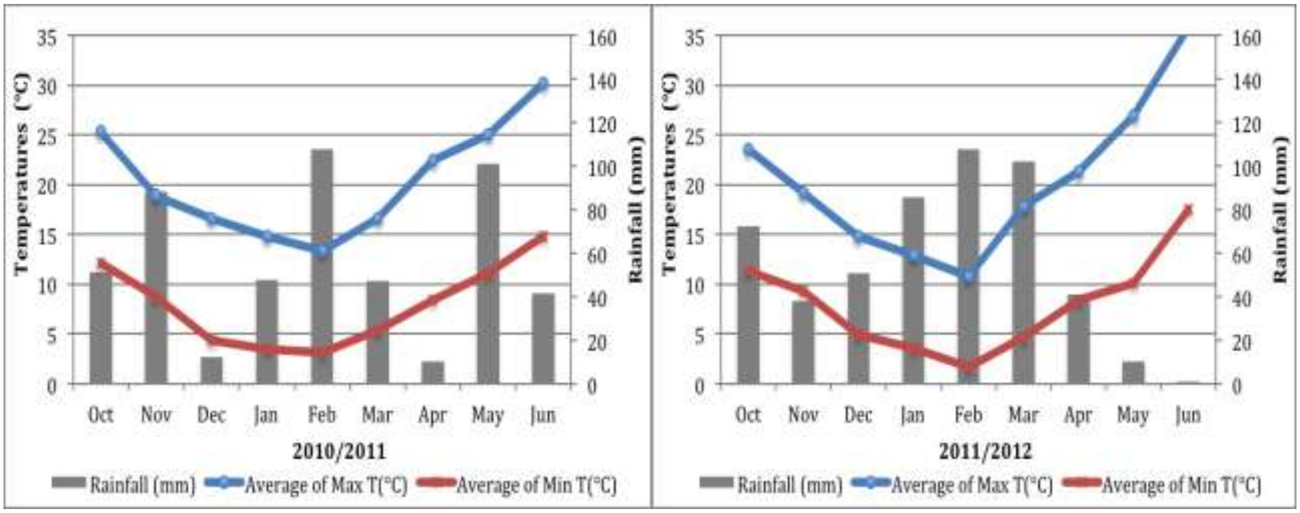

Figure 1. Rainfall and average of monthly maximum temperature and minimum temperatures during 2010/2011 and 2011/2012 in the location of trials.

Forage harvest was done on 13 February 2011 and 19 February 2012 for barley and 24 February 2011 and 26 February 2012 for triticale respectively for the first year and second year of the experiment. Plants were cut about 12 cm above ground level. Grain harvest was made at plant maturity on 28 June 2011 and 01 July 2012 for both species.

Fresh biomass production from each dual-purpose plot was determined at harvest and it's reported in tones of dry matter per hectare (TDM/ha). A 500 g sample was also taken for chemical analysis. The samples were dried to constant weight at 65°C in a forced-air oven. Milk feed units (MFU) were calculated after the energy production equations of Chase (1981). Forage and grain crude protein content were evaluated by means of the standards micro-kjeldahl procedure. Grain yield (GY), number of spikes/m² (NS/m²), number of grains per spike (NG/Sp) and thousand-kernel weight (TKW) were determined for each plot at seed maturity. Analyses of variance (ANOVA) were performed using (1985) and means were separated using Duncan Test.

RESULTS

Influence of defoliation at C30 stage and species on grain yield, straw production, yield components and forage production

Results of forage quantity harvested in C30 are shown in Table 1. Forage yield did not depend on the species. Barley and triticale has given comparable quantities of forage and only a slight superiority was noticed for barley compared to triticale, respectively 2.45 and 2.3 t/ha as average of the two years of trial. For both species, herbage dry matter was superior during the first year of the experiment (2010/2011) but without being statistically different.

The results of the analysis of variance for grain yield and its components are shown in Table 1. Cutting at the green stage (C30) has caused reduction of grain yield for dual-purpose use comparing to grain use only management system. This reduction was more pronounced for barley (-28 and -27% respectively for 2010/2011 and 2011/2012) than for triticale (-19 and -23% respectively for 2010/2011 and 2011/2012). For both species this reduction was statistically significant (*P* <0.01). In the other hand, when they were not cut in C30 stage, barley and triticale had similar yields, which were not statistically different (3.92 t/ha for barley and 4.41 t/ha for triticale as average yields for the two years). For dual-purpose management system, triticale seems to be more adapted and has given a grain yield of 3.47 t/ha which is significantly higher (*P* <0.05) than barley grain yield (2.85 t/ha). The interaction treatment x species was significant (*P* <0.05) for grain yield.

The spike number/m² increased from 330 to 394 spikes /m² for barley and from 310 to 332 spikes/m² for triticale as average for the two years of experiment. This range of variation was statistically significant (*P* <0.05). In the other hand, spike fertility was significantly affected only by treatment (*P* <0.05). Number of grains/spike has decreased after clipping by 30% for barley and 20% for triticale. The third yield component, thousand-kernel weight, was a very stable variable, being similar for both treatments. It was not significantly affected by forage use neither by the species.

Straw quantity is also important for cereals producers in general and for animal keepers in particular, as it constitutes an alternative nutrition resource mainly during deficit period. With this trial, it appears that triticale gives more straw quantity in both managements systems (*P* <0.01). Clipping has affected significantly straw production, and reduced it by (33%) for barley and (28%) for triticale (*P* <0.05). For both cereals, this reduction was more pronounced during the second year of the experiment 2011/2012. The interaction between species

Table 1. Forage yield, straw production, grain yield and related components in different managements systems of dual-purpose barley and triticale.

Forage yield	Year	Forage DM (T/ha)	SY (T/ha)	NS/m²	NG/Sp	TGW (g)	GY (T/ha)
Barley one use (grain only)	2010/2011	-	4.83 [b]	333 [cb]	27 [ab]	40.05 [a]	3.85 [a]
	2011/2013		5.14 [ab]	327 [cb]	31 [a]	40.20 [a]	4.01 [a]
Barley dual-Purpose	2010/2011	2.43 [a]	3.12 [c]	401 [a]	20 [c]	39.42 [a]	2.74 [c]
	2011/2013	2.46 [a]	3.43 [c]	487 [a]	22 [c]	39.18 [a]	2.95 [c]
Triticale one use (grain only)	2010/2011	-	5.88 [a]	304 [c]	34 [a]	40.66 [a]	4.38[a]
	2011/2013		5.62 [a]	314 [c]	32 [a]	40.81 [a]	4.44 [a]
Triticale dual-Purpose	2010/2011	2.29 [a]	4.31 [c]	305 [c]	25 [b]	39.95 [a]	3.45 [b]
	2011/2013	2.35 [a]	3.97 [c]	357 [b]	28 [ab]	40.08 [a]	3.48 [b]
CV (%)		5.76	8.43	7.45	8.45	7.17	6.68
Species		NS	**	NS	NS	NS	*
Treatment		-	*	*	*	NS	**
Year		NS	NS	*	NS	NS	NS
Treatment x Year		NS	NS	NS	NS	NS	NS
Treatment x Species		NS	*	NS	NS	NS	*
Species x Year		NS	NS	NS	NS	NS	NS
Treatment x Year x Species		NS	NS	NS	NS	NS	NS

Distinct letters in the row indicate significant differences according to Duncan test (*P ≤ 0.05, ** P ≤ 0.01, NS: not significant).SY: Straw yield; NS/m²: Number of spike per m²; NG/Sp: Number of grains per spike; Number of grains per spike NG/Sp and TKW: Thousand-kernel weight; GY: Grain yield.

and harvesting treatment was significant (*P* <0.05). The higher straw quantity was obtained with triticale used for grain only.

Influence of defoliation at C30 stage and species grain and forage protein content

Results of this study indicated that forage barley has ahigher protein content (182.6 g/kg DM) than forage triticale (174.2 g/kg DM) when it is cut at C30 stage. Analysis of variance has shown that this difference is significant (*P* <0.05) (Table 2).

This experiment has also shown that in two years of trial, dual-purpose cultivation affected positively the grain protein content of the two tested species. Clipped plant in C30 stage has given grain more rich in protein: 113.56 g/kg DM Vs 101.76 g/kg DM for barley and 95.57 g/kg DM Vs 93.88 g/kg DM for triticale. This increase of grain protein content between treatments was significant only for barley (*P* <0.05). The forage nutritional value, expressed as MFU/kg DM, was on average 0.78 MFU/kg DM for triticale and 0.68 MFU/ kg DM for barley and showed statistical variation linked to the specie (*P* <0.05).

DISCUSSION

Winter cereals were grown for the dual-purpose of forage and grain as an alternative to grain production only in a semi arid climate. The objective was to produce forage during winter (a season of scarce forage supply in the area) and to evaluate effects of clipping on grain production, which have been usually observed (Hadjichristodoulou, 1991; Royo et al., 1997; El-Shatnawi et al., 2004; Droushiotis, 1984).

In our experiment, triticale and barley have given similar forage production, between 2.29 and 2.46 DM t/ha for both species and during the two experimental years. This could be attributed to the fact that the cutting stage (C30) is too early and that different species could not express differences in biomass production. Specific traits for each species will be more observable after cutting with regrowth. Royo et al. (1997) have reported, under Mediterranean conditions, similar forage yields in first detectable node stage for triticale (2.03 t/ha) and barley (2.11 t/ha).

Yield components were differently affected by dual-purpose treatment. Thus, Clipping at C30 stage has enhanced spike number production barley and triticale. This is explained by the removal of the apical domination during final stage of the tillering period. In fact, with defoliation the predominant apex is eliminated and then tiller production restarts again and could drive to a higher number of productive tillers per plant (Briske and Richards, 1994). Bonachela et al. (1995) have also found that forage use during winter makes the tillering period

Table 2. Forage crude protein, milk feed units in green forage and Grain Crude protein in relation to management system.

Forage yield	Year	FCP (g/kg DM)	MFU/kg DM	GCP (g/kg DM)
Barley one use (grain only)	2010/2011	-		99.45 [b]
	2011/2012			102.82 [b]
Barley dual-Purpose	2010/2011	181.1 [a]	0.67 [b]	111.52 [a]
	2011/2012	183.5 [a]	0.70 [b]	114.97 [a]
Triticale one use (grain only)	2010/2011	-		93.58 [c]
	2011/2012			94.17 [c]
Triticale dual-Purpose	2010/2011	176.2 [b]	0.79 [a]	95.07 [c]
	2011/2012	173.7 [b]	0.77 [a]	95.90 [c]
CV (%)		9,2	8.21	8,79
Species		**	**	*
Year		NS	NS	*
Treatment		-	-	*
Treatment x species		-	-	NS
Treatment x Year		NS	NS	NS
Treatment x Year x Species		NS	NS	NS

longer and then capacity to make fertile tiller and spike greater. Compared with cereals species grown in temperate regions, triticale and barley cultivars adapted to Mediterranean climates have relatively short life cycles, especially in the phases before terminal spikelet (Kirby, 1991), Thus a longer life cycle before the stage of maximum spikes number could increase tillering potential and, thereby, spikes number.

As for the number of grains per spike triticale and barley showed smaller grain number under dual-purpose treatment. The decrease in grain number in the clipped treatment can be explained by a reduction in the carbohydrate supply to the developing ears between clipping and anthesis, decreasing the number of of fertile tillers (Dunphy et al., 1982; Winter and Thompson, 1990).

The current study confirmed the shortage of grain yield for both cereals when they are used in dual-purpose compared to grain only management as found by Hadjichristodoulou (1991) who has reported a reduction in barley grain yield under rain fed conditions. Royo and Tribó (1997) found a reduction in grain yield ranging from 7 to 70%, by comparison to losses of triticale of 8 to 24%. Bonachela et al. (1995) recorded a grain yield reduction of 11% in Southern Spain, averaged over cultivars and 3 years. Royo et al. (1997) has reported, for barley, similar reduction of 23% when forage was cut at stage C30 and 42% when forage was cut at stage C31.

Grain yield reduction after forage removal is attributed, in our trial, to the reduction of spike fertility, thus the grain number per spike in both cereals was statistically reduced after forage removal. The good rainfall conditions during February and March have allowed a good restart of tillering and then more spikes per plant, which was associated with a reduction of grain number per spike.

In our study, protein produced in forage was superior in Barley compared to Triticale and averaged 182.3 g/kg DM for barley and 174.9 g/kg DM for triticale and This is in accordance with Royo et al. (1997) results who have measured around 172 g/kg DM for triticale cut in C30 and C31 stages and around 189 g/kg DM for barley cut at same stages. In the contrary, triticale forage has shown better energy content than triticale 0.78 MFU/kg DM vs 0.68 MFU/kg DM. In the other hand, grain protein content was positively affected by defoliation for both species. The significant increase of grain protein after defoliation in C30 stage could be attributed to the dilution effect, since the grain yield was decreasing after clipping and the number of spikes per plant was higher. The higher content of grain protein for dual-purpose use could also be explained by a higher consumption of nutrients than in only grain use. This conclusion joins results of Francia et al. (2006) who have reported also an increase of grain protein content after clipping during green stage for barley and oat.

Conclusions

Of the two crops studied, triticale demonstrates clear superiority in the grain yield, milk feed units value and straw production over barley in the dual-purpose system in the semi-arid region of Tunisia. Triticale has shown good regrowth after clipping in green stage and reduction of grain yield did not exceed 22%, although barley grain yield was reduced by 29% after forage removal during tillering stage. In the other hand, barley has given grain and forage more rich in protein than triticale and this for both management systems.

Triticale has specific morpho-physiological traits that make it more suitable to dual-purpose cultivation than other cereals. It is highly efficient in the utilization of water and nutrients in limiting conditions, a good capacity for tillering, and high capacity for regrowth after forage use; that, in addition to its capacity to compete, enables a fast and large accumulation of biomass. Further research which study the economic impact of dual purpose management of Triticale compared to only grain use may aid to make the choice for the dual or single use of triticale and barley.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Amara H, Ketata H, Zouaghi M (1985). Use of barley (*Hordeum vulgar* L.) for forage and grain in Tunisia. Rachis 4(2):28-33.

Arzadun MJ, Arroquy JI, Laborde HE, Brevedan RE (2003). Grazing pressure on beef and grain production of dual-purpose wheat in Argentina. Agron. J. 95(5):1157-1162.

Belaird A, Moris ML (1991). Wheat and barley production in rainfed marginal environment of west Asia and North Africa; problems and prospects. CIMMYT Econ. Working paper 91/02 CIMMYT Mexico, D.F., Mexico.

Ben Youssef S, Chakroun M., El Felah M, Omri N (2001). Aptitude à la double exploitation de génotypes d'orge en région Subhumide de Tunisie. Fourrages 168:509-521.

Bonachela S, Orgaz F, Fereres E (1995). Winter cereals grown for grain and for the dual-purpose of forage plus grain. I. Production. Field crop Res. 44:1-11.

Briske DD, Richards JH (1994). Physiological responses of individual plants to grazing: Current status and ecological significance. Ecological implications of livestock herbivory in the west. Soc. Range Management, Denver, CO, pp. 147-176.

Chase LE (1991). Energy prediction equations in USA at NY DHAI Forage laboratory. Production Agricultural Training School, Ithaca, NY.

Droushiotis DN (1984). The effect of variety and harvesting stage on forage production of barley in a low-rainfall environment. J. Agric. Sci. 102(02):289-293.

Dunphy DJ, McDaniel ME, Holt EC (1982). Effect of forage utilization on wheat grain Yield. Crop Sci. 22:106-109.

El-Shatnawi MKJ, Ghosheh H, Shannag H, Ereifej K (1999). Defoliation time and intensity of wall barley in the Mediterranean rangeland. J. Range Manage 52:258-262.

El-Shatnawi MKJ, Ghosheh H, Shannag H, Ereifej K (1999). Defoliation time and intensity of wall barley in the Mediterranean rangeland. J. Range Manage 52:258-262.

El-Shatnawi MKJ, Ghosheh HZ (1999). Effect of clipping on wall barley (*Hordeum murinum* L.): tillering and forage production. Afr. J. Range For. Sci. 15:92-96.

Epplin FM, Hossain I, Krenzer Jr EG (2000). Winter wheat fall–winter forage yield and grain yield response to planting date in a dual-purpose system. Agric. Syst. 63(3):161-173.

Francia E, Pecchioni N, Nicosia OLD, Paoletta G, Taibi L, Franco V, Odoardi M, Stanca AM, Delogu G (2006). Dual-purpose barley and oat in a Mediterranean environment. Field Crops Res. 99(2):158-166.

Garcia del MLF, Boujenna A, Yanez J, Ramos JM (1995). Forage production, grain yield, and protein content in dual-purpose triticale grown for both grain and forage. Agron. J. 87:902-908.

Giunta F, Motzo R, Fois G, Bacciu P (2015). Developmental ideotype in the context of the dual-purpose use of triticale, barley and durum wheat. Ann. Appl. Biol. 166(1) :118-128.

Hadjichristodoulou A (1990). Self-regenerating pasture barley. Rachis, 9(2):13-17.

Hossain I, Epplin FM, Krenzer Jr EG (2003). Planting date influence on dual-purpose winter wheat forage yield, grain yield, and test weight. Agron. J. 95:1179-1188.

Khalil HI, Carver BF, Krenzer EG, MacKown CT, Horn GW (2002a). Genetic trends in winter wheat yield and test weight under dual-purpose and grain only management systems. Crop Sci. 42:710-715.

Khalil HI, Carver BF, Krenzer EG, MacKown CT, Horn GW, Rayas-Duarte P (2002b). Genetic trends in winter wheat grain quality with dual-purpose and grain only management systems. Crop Sci. 42:1112-1116.

Kirby EJM (1991). Cereal development in Mediterranean developments. In: Acevedo E, Fereres E, Gimenez C, Srivastava JP.(Eds.). Improvement and management of winter cereals under temperature, Drought and Salinity Stresses. Proceedings Of a ICARDA-INIA Symposium, 1987 at Cordoba, Spain, pp. 66-84.

Mazid A, Hallajian M (1983). Crop-livestock interactions. Information from a barley survey in Syria. Res. Rep. 10:28.

Ouji A, Rouassi M, Ben Salem L (2010). Comportement Varietale de l'orge (*Hordeum vulgare* L.) en double exploitation. Annales de l'INRAT. 83:103-117

Royo C, Insa JA, Boujenna A, Ramos JM, Montesinos E, Garcia Del ML (1994). Yield and quality of spring triticale used for forage and grain as influenced by sowing date and cutting stage. Field Crop Res., 37:161-168.

Royo C, Lopez A, Serra J, Tribó F (1997). Effect of sowing date and cutting stage on yield and quality of irrigated barley and triticale used for forage and grain. J. Agron. Crop Sci. 179:227-234.

Royo C, Montesinos E, Molina-Cano JL, Serra J (1993). Triticale and other small grain cereals for forage and grain in Mediterranean conditions. Grass Forage Sci. 48:11-17.

Royo C, Pares D (1996). Yield and quality of winter and spring triticales for forage and grain. Grass Forage Sci. 51:449-455.

Royo C, Tribó F (1997). Triticale and barley for grain and dual-purpose (forage + grain) in Mediterranean-type environment. II. Yield, yield components, and quality. Aust. J. Agric. Res. 48:423-432.

Scott WR, Hines S, Love G (1988). The effect of grazing on components of grain yield in winter barley. New Zealand J. Exp. Agric. 165:313-319.

Winter SR, Thompson EK (1990). Grazing winter wheat: I:response of semidwarf cultivars to grain and grazed production systems. Agron. J. 82:33-37.