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Selection of two triticale varieties for forage-end use in Tunisia

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Abstract. Two new released triticale varieties (one spring type Tc1821 and one winter type, G41) were evaluated for their dry matter yield and nutritive value at three harvesting stages (first node detectable, Z31, late boot, Z50 and soft dough stage, Z85). Both genotypes confirmed their high dry matter yield potential at all stages. The winter triticale was more productive than the spring genotype at all growing stages. G41 presented a prostrate growth habit from emergence to first node detectable stage (Z31) and took much more time to reach that stage. Among the two cultivars, it was the best to be used by grazing or in dual-purpose system at early vegetative growth. At late boot stage (Z50), the winter type produced 9 T DM ha⁻¹ of a high quality forage (CP = 15%; ADL = 3.8%, dOM = 60%). The spring triticale Tc1821 produced an equivalent forage quality but with half the yield potential (5 T DM ha⁻¹). At soft dough stage, the spring triticale Tc1821 was as much productive as the winter genotype G41, but it produced a forage with much higher quality as expressed in terms of CP, ME and fibers. The agronomical meanings of the three key harvesting stages were discussed.

Keywords. Triticale – Forage – Nutritive value – Winter type – Spring type.

Développement de deux variétés de triticale pour une utilisation fourragère en Tunisie

Résumé. Deux variétés de triticale nouvellement inscrites (un triticale de printemps Tc1821, et un triticale d'hiver, G41) ont été évaluées pour leur production fourragère et valeur nutritionnelle à 3 stades de croissance (premier nœud, début épiaison, et pâteux mou désignés respectivement Z31, Z50 et Z85). Les deux génotypes ont confirmé leur haut potentiel de rendement en MS à tous les stades de croissance, avec une nette supériorité de G41 particulièrement aux stades précoces (Z31 et Z50). Ce dernier a présenté une croissance plagiotrope depuis la levée jusqu'au stade Z31 qu'il atteint 3 semaines après Tc1821. Il est le génotype susceptible de mieux valoriser une exploitation du triticale par pâturage ou dans le cadre d'un système de double exploitation. Au stade début émergence des barbes (Z50), G41 a produit 9 T MS ha⁻¹, et donné lieu à un fourrage de très bonne qualité fourragère (MAT= 15%; ADL = 3.8%, dMO = 60%). Tc1821 a également un fourrage d'aussi bonne qualité mais avec moitié du rendement potentiel (5 T MS ha⁻¹). Au stade pâteux mou (Z85), le triticale de printemps Tc1821 a été aussi productif en MS que le triticale d'hiver G41, mais il donne lieu à un fourrage de bien meilleure qualité en terme de MAT, teneur en énergie métabolisable et de lignine. Les significations agronomiques des trois stades clé de récolte ont été discutées.

Mots-clés. Triticale de printemps – Triticale d'hiver – Fourrage – Valeur nutritionnelle.

I – Introduction

Oat constitutes more than 65% of annual forage cultivated area in Tunisia (Chakroun, 2000). It is grown wrongly at all Tunisian environments from the North to central Tunisia although this species performs well only under favorable environments (over 450 mm of well partitioned annual rainfall) or under irrigation and needs deep and fertile soils. In order to diversify forage resources while taking account of climate change and high farmers skill in growing cereals, our choice was made on triticale species which may constitute a part of forage calendar under less favorable bioclimatic zones. To valorize the triticale as an alternative forage resource to fodder oat, a national breeding program have been initiated since 2005. It aimed to select triticale genotypes target-

ed for animal use as a green fodder resource and not as a grain. As other forage cereals; triticale may be used at all stages of growth, from the grazing of small plants early in the grazing season, to harvest of mature whole plant for hay, or silage at the end of the season (Mergoum *et al.*, 2009). The diversity of types and uses of triticale complicates the choosing of varieties and decisions about the crop management. To choose such a genotype for such use, it is necessary to know perfectly the growth mode of the triticale, its forage potential yield, nutritive values at different growth stage and specific crop management needed to harvest the maximum value of the genotype (Fohner, 2002).

This program initiated in 2005 with more than 100 spring, facultative and winter type triticale accessions originated from CIMMYT, and have led to the registration of two genotypes which are described here.

II – Materials and methods

1. Selection procedure

As for our short term breeding strategy we select varieties from the CIMMYT triticale nurseries. The approach adopted was the selection of lines from genetic material, more or less homogeneous, received from the CIMMYT since 2005. Selection criteria included agronomic traits in addition to dry matter yield at soft dough stage. Six years selection has led to the release of two cultivars which are being registered in Tunisian national catalogue. In this paper we would try to characterize these two new genotypes in the aim to choose the type and form in which they are the best to be used.

2. Plant material

Main characteristics of two selected triticale genotypes are presented in Table 1.

Table 1. Main characteristics of two selected triticale genotypes

Genotype	Origin/nurseries	Pedigree	Seed weight (g)	Type
G41	CIMMYT/ TW05M_LAWIN-INC	AN-31	32	Winter
Tcl821	CIMMYT/40 ITYN	ARDI_1//TOPO 1419// ERIZO_9/3/LIRON_1-1/4/ FAHAD_4/FARAS_1/5/ CT775.81/ARDI_1//ANOAS_1..	55	Spring

3. Measured parameters

Agronomic measured traits were: days to each targeted growth stage, plant height in cm (distance from soil surface to spike tips at cutting), dry matter yield at several phenological growth stages: first node detectable, late boot, anthesis, soft dough and seed maturity stages designed in Zadoks scale (Zadoks *et al.*, 1974) as Z31, Z50 and Z85 and Z95, respectively. At each stage, forage yield is measured by cutting 6 x 0.25 m² quadrat from each plot and a sample of 500 g was dried at 50°C then milled. Samples were analyzed for crude protein, neutral detergent fibers (NDF), acid detergent fibers (ADF) and acid detergent lignin (ADL) content (AOAC, 1984). Metabolic energy (ME) and digestible organic matter (DOM) were determined by gas production technique (Menke and Steingass, 1988).

III – Results and discussion

Dry matter yield (DMY). DMY was measured as a function of growing degrees days (GDD) calculated with a base temperature of 0°C (Fig. 1). For each genotype, there was a strong quadratic relationship between DMY and GDD as revealed by high R² coefficient. For both genotypes maximum dry matter was reached at soft dough stage. G41 produced its dry matter yield on a more extended period of time (175 days vs 141). It exhibited a prostrate growth habit from emergence to Z31 and an erect growth habit thereafter. At first node detectable stage (Z31), the winter type triticale (G41) produced 30% more DYM than the spring triticale Tcl821 and took much more time to reach that stage. It should be advantageous to be used by grazing at early stage. At late boot stage, the winter triticale out-yielded spring triticale by 30% (90 vs 52 g DM m⁻²) and was much more later to reach this stage (a gap of 54 days separated the dates on which late boot stage is attained). The stage Z85 is reached one month earlier by the spring triticale, but, both genotypes produced significantly the same DYM of 170 g DM m⁻². DYM of triticale for all harvesting stages was high and was superior to those found in other studies on forage triticale in Spain (Royo and Tribo, 1997) Italy (Delogu *et al.*, 2002) or USA (McCormick *et al.*, 2006).

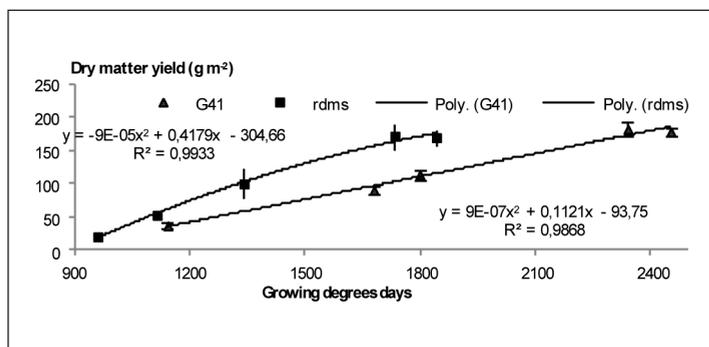


Fig. 1. Variation of dry matter yield with growing degree days.

Crude protein. Maximum crude protein content is registered in Z31 stage for both varieties, and averaged 25.3 and 23.9 for the spring and winter triticale, respectively. At Z50 stage, both genotypes showed significantly the same CP content. In late season, Tcl821 and G41 showed a drastic decrease in their crude protein content which reached 10.3 and 5.2, respectively (Table 2).

Table 2. Chemical composition (CP, NDF, ADF and ADL), ME and dOM of two triticale varieties (G41 and Tcl821) at first detectable node (Z31), late boot stage (Z50) and at soft dough stage (Z85)

Stage		CP (%)		ME (Mj kg ⁻¹ MS)		dOM (%)		NDF (%)		ADF (%)		ADL (%)	
		G41	Tcl821	G41	Tcl821	G41	Tcl821	G41	Tcl821	G41	Tcl821	G41	Tcl821
Z31	Average	23.9	25.1	23.8	25.0	61.1	58.3	53	59.5	22.1	29.7	1.52	–
	SD	0.8	0.6	1.7	0.9	1.7	4.3	24.3	2.5	9.0	0.7	1.0	–
Z50	Average	14.3	15.6	11.8	13.3	49.1	50.7	59.4	55.9	37.1	35.5	4.17	3.8
	SD	2.3	2.5	1.9	2.2	5.1	2.3	1.6	0.7	1.6	0.6	1.09	1.42
Z85	Average	6.5	9.2	6.8	9.2	42.4	49.1	71.5	56.9	40	34.1	6.89	6.06
	SD	1.3	1.8	0.7	4.8	2.7	4.4	9.68	5.69	3.76	4.86	3.6	0.21

Digestible organic matter (dOM). dOM averaged 60%, 50% and 45% at Z31, Z50 and Z85 stages. Both genotypes showed significantly the same dOM at both first node and late boot stage. At soft dough stage, the spring triticale Tc1821 presented a significantly higher dOM than the winter triticale variety (G41).

Fibers. Whatever the genotype, both NDF, ADF and ADL content showed a notable increase between Z31 to Z85 stage. The spring triticale showed a much higher quality indicated by lower NDF, ADF and ADL over all harvesting stages (Table 2). Fibers values still comparable to those obtained by Delogu *et al.* (2002).

Metabolic energy (ME). In general, with respect to the first harvesting stage (Z31) there was an expected drop in the values of metabolic energy registered in Z50 and at Z85 thereafter. At all stages Tc1821 showed the highest ME values (Table 2). However, regarding to dry matter yield, the winter triticale G41 out yielded Tc1821 at all stages in term of energy production per ha. In another hand, the different measures of ME along the lifecycle showed that after a linear decrease began from early vegetative stage, the ME marked a small increase at soft dough stage which is likely to be related to the storage of starch at the grains level (Fohner, 2002). This trend was less obvious for the winter triticale genotype (data not presented).

Although its high cold temperature requirement to initiate heading, G41, showed a good adaptation to local bioclimatic conditions. However, It presented weak grain yield potential ($< 200 \text{ g m}^{-2}$, data not presented). Regarding to its high dry matter yield, G41 should constitute an interesting alternative resource to fodder oat. First node detectable stage, or Z31 is considered as a key stage for using forage cereals by grazing or in dual-purpose system (Royo *et al.*, 1993; Ben Youssef *et al.*, 2000b). It is generally recommended to not exceed this stage to cease grazing or to make forage cut, otherwise, a severe grain or forage yield decrease would be obtained on regrowth. At this stage, G41 showed a great forage yield potential (over 3.6 T DM ha^{-1}) with a high nutritive value and allowed a long grazing period as it reached Z31 in late February after a seeding in november. This yield level is superior to that obtained at the same stage for barley (Ben Youssef *et al.*, 2001); oat (Ben Youssef *et al.*, 2000a) and spring triticale (Benyoussef *et al.*, 2000b). In addition to its initial vegetative prostrate growth habit, G41 seemed to be predestinated for the use by grazing better than the spring triticale Tc1821. Further investigations still be needed to study the genotype behavior under grazing animals. Late boot stage (Z50) marks for cereal species, the limit between vegetative and reproductive growth (Fohner *et al.*, 202). Using triticale in this stage may constitute a compromise between an acceptable level of dry matter yield, and high forage nutritive value. In our study, G41 showed a superiority upon spring genotype concerning all yield and nutritive value traits at this harvesting stage: more forage yield ($10 \text{ vs } 6 \text{ T DM ha}^{-1}$), leafier forage (leaf to stem ration equal to $70\% \text{ vs } 40\%$); richer in dry matter content ($22\% \text{ vs } 15\%$), longer crop height ($133 \text{ vs } 88 \text{ cm}$), more productive in energy ($120\,000 \text{ vs } 84\,000 \text{ Mj ha}^{-1}$) and crude protein ($1460 \text{ vs } 990 \text{ kg CP ha}^{-1}$). It had significantly the same CP content and dMO and ADL as the spring triticale Tc1821. At our knowledge, none of the other forage cereals have been recommended for such end-use in Tunisia. With G41 selection, we have developed a variety which can produce a high dry matter yield of high quality forage at late April which means at a time favorable for hay or silage making. That compromise could not be obtained with the spring type triticale. For cereals, soft dough stage Z85 corresponds to grain physiological maturity. Grains are completely constituted, and rich in starch which constitute an important energetic source while the plant still yet green. As mentioned in figure 1 and table 2, the winter triticale genotype maintained its dry matter yield superiority over Tc1821 ($18 \text{ T MS vs } 16 \text{ T MS ha}^{-1}$). However, its nutritive value is subjected to a great depletion at this stage in comparison to that of the spring type. It is less digestible, poorer in CP ($5.5\% \text{ vs } 9.1$) and ME ($6.8 \text{ vs } 9.2 \text{ Mj kg}^{-1} \text{ DM}$), presented a very higher level of NDF and ADL and seemed to enter in a senescence more precociously than the spring triticale variety. That senescence was evidenced by a very high

dry matter content averaging 47%. That's why, it is strongly recommended not to use this cultivar at this late stage. In general, as regard to its nutritive value, the spring triticale presented a typical chemical analysis constitution as found in other studies (Delogu *et al.*, 2002; Mc Cormick, 2006). Dry matter yield is superior to those commonly found in bibliography suggesting that spring triticale valorize better hotter Mediterranean-type climate. Using the Tc1821 cultivar for silage or hay making at soft dough stage allowed taking maximum value of its nutritive value and forage yield.

IV – Conclusions

Evaluation of forage yield and nutritive value of two triticale genotypes over 3 key harvesting stages allowed to better understanding how to take maximum value of them and to decide the best way in which they should be managed for forage production.

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