

Salt-tolerant triticale (X *Triticosecale* Witt) cultivation in Jordan as a new forage crop

Abstract

The impact of climate change and global warming on food and feed crops production is obvious in Jordan; a country where dry areas constitute about 90% of its land. The remaining arable areas (under rainfed or irrigated farming system) are decreasing due to urbanization, land defragmentation, drought, water scarcity, underground water over pumping and salinity. There is an urgent need for more tolerant crops that are capable to stand and cope with adverse climatic conditions and for diversification of crops in the farming systems.

The purpose of this work was to introduce a new forage crop suitable for small holders suffering from soil and/or water salinity. Triticale (X *Triticosecale* Witt) lines were evaluated for salt (soil and water) tolerance at Al-Khaledeya station and the most promising line was introduced to farmers' fields at Azraq saline region (16.7 dS/m, and 2.1 dS/m in soil and water, respectively). Six farmers were trained on the cultivation of the new forage crop for two years (2011 and 2012) through the extension services' programs. The cultivated areas to triticale ranged from 1.8 ha in 2012 to 10 ha in 2014, and the grain and straw yield were compared with barley (the conventional forage crop) in the same region. Protein, fibers, the neutral detergent fiber (NDF) and acid detergent fiber (ADF) percentages were determined chemically for the cultivated triticale. Cultivated triticale in the salty region produced an average of 16 t/ha of dry grains and straw collectively, partitioned as 6 t/ha as dry grains and 10 t/ha dry straw, whereas barley produced 12.1 t/ha of collective dry grains and straw. In salty region, triticale grains NDF percentage was 64.42% and was significantly higher than that of triticale grains under treated waste water. In addition, ADF percentage in the grains of the triticale was 12.54% and was significantly lower than ADF percentage (21.02%) of triticale grains grown under treated waste water. Triticale was adopted as a new forage crop by the farmers and its cultivation was disseminated in the salty regions.

The total cultivated area to triticale in 2011 – 2015 expanded up to 46.6 ha, and this crop became commercialized and part of seed production market in Jordan.

Keywords: Triticale, salt tolerant crops, farmers, extension services, grain yield, chemical composition.

Introduction

During the last decade or so, much experimentation has focused on increasing the output of rain fed cereal crops in semiarid zones. While barley (*Hordeum vulgare* L.), bread wheat (*Triticum aestivum* L. spp *aestivum*) and durum wheat (*Triticum turgidum* L. spp *durum*) are the dominant cereals, attention has centered on triticale (X *Triticosecale* Witt), a crop deemed to have considerable potential in commercial agriculture. Salinity in soil or water is one of the major stresses that limit traditional cereals growth and productivity worldwide. More than 800 million hectares of land throughout the world are salt-affected (including both saline and sodic soil), equating to more than 6% of the world's total land area (FAO, 2011). Triticale (X *Triticosecale* Witt) is one of the most successful man-breed cereals that were crossed to obtain a cereal that combines unique grain quality of wheat (*Triticum* spp.) parent with tolerance to abiotic and biotic stresses of rye (*Secale* spp.) parent (Lelley, 2006). Triticale seems to be an interesting alternative to other cereals, particularly bread wheat, in environments where growing conditions are unfavorable or in low-input systems (Erekul et al., 2006).

In Jordan, the newly-introduced cereal crop is seen as having a complementary role to the major cereals, especially in the semiarid zones. Mergoum et al. (2004) reported that fall planted winter cereals such as triticale produce higher forage biomass than spring types. Kotuby-Amacher et al. (2000) stated one of the very important triticale trials that have been conducted to compare a high salinity-tolerant triticale, with other cereals. Triticale generally tolerated salinity at a higher threshold and responded well to soil salinity at 6.1 dS/m ECE, i.e. up to 100% yield in comparison to corn (grains) at 2.7 dS/m, Rye at 5.9 dS/m and wheat at 4.7dS/m.

Although grain protein composition depends primarily on genotype, it is significantly affected by environmental factors and their interactions (Zhu et al., 2001). Temperature, moisture and soil fertility, particularly nitrogen, are among the environmental factors that most influences grain protein content in cereal, mainly by affecting grain yield (Rao et al., 1993). There has been relatively limited investigation regarding the influences of salinity on grain quality in cereal crops. Previous research in durum wheat showed differential response of salt tolerant and salt sensitive cultivars to salinity stress in view of grain quality with only salt-tolerant cultivar being significantly affected (Katerji et al., 2005). They found a positive effect of salinity on ash content and SDS sedimentation volume and a negative effect on beta carotene content in grain. On the other hand, Francois et al. (1986) observed a reduction in ash content and protein quality due to salinity by visualizing protein content.

These encouraging results suggested a comparison of triticale and barley crops under saline conditions in irrigated farms conditions. The foregoing trial on a representative salt tolerant triticale in saline soil in Azraq region was both diagnostic and demonstrational.

Materials and Methods

Plant materials and growth conditions

Field records were determined using a traditional crop-barley, during 2011-2012, and 2013 – 2014 growing seasons, barley as a salt tolerant crop was included as control. Plant materials were grown in two growing seasons and separate experiments under salt stressed conditions at the farmer field of Azraq region , 105 km east of Amman, 31°50 N 36°49 E, 530 m asl). The soil at this site is clay loam, typic Badia of the semi-arid area EC= 16.7 dS/m. Mean an annual precipitation was 25.5 mm. Each experiment was conducted, at the salt stressed; irrigated water with an EC of 2.1 dS/m was used until spring season stage. Other two seasonal separate experiments conducted under treated waste water conditions at the farmer field of Hashmyahh region, Jordan (115 km north of Amman, 550 m asl). The soil at this site is silty clay, EC= 3.17 dS/m. Each experiment was conducted, at the treated waste water area; irrigated water with an EC of 1.98 dS/m was used until spring season stage.

Grain and straw forage quality traits

At the harvest maturity of triticale, five random samples were collected to measure forage quality traits. Crude protein %, crude fiber %, neutral detergent fiber % (NDF), and acid detergent fiber % (ADF) were evaluated. The experimental procedures used were the drying of each plant grains and straws. Four grams of dried grains and four grams of dried straw were weighed and tested. Ultimately, the percentage of crude protein, crude fiber, neutral detergent fiber, and acid detergent fiber in the flour was calculated. Each parameter percent was expressed by a mean of two samples from each plant part.

Results and Discussion

Results showed an influence of saline environment, genotype and their interaction on crop yield, a difference was found for triticale collective dry grains and straw among barley for the same location (Table 1). These results confirm the yield superiority of triticale compared to bread wheat in saline soil reported by Ortiz-Monasterio et al. (2002), as well as triticale superiority yield to durum and bread wheat in normal soils. Moreover, (McCartney and Vaage 1994) concluded that triticale out-yielded both barley and oat.

In another study conducted by (Josephides 1992/1993), it was stated that triticale had a similar mean grain yield (3,842 kg/ha) to that of bread wheat, but was significantly higher yielding than barley or durum wheat (5 and 7%, respectively). The trials showed that, for yield, triticale performed very well in comparison with barley. In addition, Mergoum et al. (2004) reported that fall planted winter cereals such as triticale produce higher forage biomass.

The crude protein and fiber percentages of triticale as well neutral detergent fiber (NDF %), and acid detergent fiber (ADF %) were evaluated under irrigated conditions at the National Center for Agricultural Research and Extension (NCARE) laboratory, Amman. It was compared with analysis of output trial in other non- saline soils. Data for the above parameters in Azraq area are presented in table 2.

The second trial had different soil salinity. Both locations appeared to perform differently. This was exemplified by a soil salinity of 3.17 dS/m at the second site. The chemical composition of triticale in saline area trial had significantly greater neutral detergent fiber (NDF %) and significantly lower acid detergent fiber (ADF %) in grains than the other site. Moreover, Azraq saline soil site trial was significantly lower than the second trial for crude protein and fiber percentages components measured. Greater NDF and ADF of ensiled triticale versus barley and oat silages have been previously observed by (McCartney and Vaage 1993). Similarly confirmed results of crude protein digestibilities were observed and were greater for barley silage versus triticale and oat silages.

Table 1: Collective dry grains and straw yield of harvested triticale in Azraq, and Hashmyahh trial sites during 2011-2012, and 2013-2014

<i>Growing Season</i>	<i>Crop</i>	<i>Azraq Yield (ton/ha)</i>	<i>Hashmyahh Yield (ton/ha)</i>
2011 - 2012	Triticale	16 *	12
2013 - 2014	Triticale	16 *	13
2011- 2012	Barley	12.2	11
2013 - 2014	Barley	12	9.3
<i>Sig *</i>	<i>Between Triticale and Barley</i>	<i>Sig</i>	NS

Table 2: Crude protein, crude fiber, NDF, and ADF percentages for triticale in Azraq, and Hashmyahh trial locations 2011- 2012.

<i>Location</i>	<i>Replication</i>	<i>Sample</i>	<i>CP %</i>	<i>CF %</i>	<i>NDF %</i>	<i>ADF %</i>
Azraq	1	Triticale Grains	6.1	9.53	64.8 *	12.34
Azraq	2	Triticale Grains	6.53	9.6	64.04 *	12.74
Hashmyahh	1	Triticale Grains	10.5 *	19.61 *	52.25	20.93*
Hashmyahh	2	Triticale Grains	10.5 *	19.61 *	52.27	21.1 *
<i>Sig *</i>	--	<i>Between locations</i>	<i>Sig</i>	<i>Sig</i>	<i>Sig</i>	<i>Sig</i>
Azraq	1	Triticale Straw	1.74	34.66	69.94	38.26
Azraq	2	Triticale Straw	1.74	35	70.14	38.37
Hashmyahh	1	Triticale Straw	3.35 *	38.05 *	74.36 *	40.71 *
Hashmyahh	2	Triticale Straw	3.49 *	38.13 *	74.05 *	41.04 *
<i>Sig *</i>	--	<i>Between locations</i>	<i>Sig</i>	<i>Sig</i>	<i>Sig</i>	<i>Sig</i>

Conclusions

Triticale grown in saline soil performed very well, and on the basis of yield and chemical composition, produced suitable forage source for neutral detergent and acid detergent fibers. However, on the basis of analysis for crude protein, triticale grown in saline soils was less acceptable than barley, and less acceptable than triticale grown under treated waste water. The results of this study were based on growing new suitable crop for saline areas may be more pronounced, and disseminated to whole country. Adoption practiced in 2013

via Farmers' Field Schools (FFS) also. It was recommended that a further research is required to determine the relationship between forage quality and livestock uses of triticale as a feed crop.

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