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Short communication

Rigid ryegrass problem in wheat and its management in Tunisia

Messaad Khammassi*, Hanene Chaabane[1] and Thouraya Souissi[1]
Institut National des Grandes Cultures (INGC), 120 B.P. Bousalem 8170, Jendouba, Tunisia

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In Tunisia, cereals are important crops and occupy about 1.2 to 1.5 million hectares, of which about 70% is planted with wheat (ONAGRI 2015). Among the weeds, the ryegrass (*Loluim rigidum*) is very competitive in crops especially cereals (Lemerle *et al.* 1996). In Tunisia, ryegrass infested fields was 32%, representing about 1/3 of the total cereal-cropped areas. The weed was found infesting several crops growing on different soil types (clay, loam and sandy). These included wheat, barley, faba bean (*Vicia faba*), chickpea (*Cicer arietinum*), fenugreek (*Trigonella foenumgraecum*), canola (*Brassica napus*), sugar beet (*Beta vulgaris*) and oat (*Avena sativa*) (Khammassi *et al.* 2016). Losses caused by rigid ryegrass varied and became increasingly important under the Mediterranean climate (Gonzalez-Andujar and Saavedra 2003). Rigid ryegrass control in cereal crops relies mainly on selective grass herbicides of the groups of acetyl Coenzyme A carboxylase (ACCase) and acetolactate synthase (ALS) inhibitors. Ryegrass (*Lolium* spp.) is one of the weeds that has developed resistance against eleven grass herbicides products in different countries of the world including France, England, Spain, the USA, Australia including Tunisia (Souissi *et al.* 2004). This study aims to determine the density of rigid ryegrass (*Lolium rigidum* Gaud.) in three climatic regions (sub-humid, superior and lower semi-arid), the correlation between density of ryegrass and losses wheat yields and evaluate the efficacy of grass herbicides, the most used by farmers, on ryegrass.

Surveys were conducted in cereal area of the North and North-West of Tunisia during the 2013-14. All the surveyed regions belonged to the sub-humid and superior and lower semi-arid climatic regions. The areas surveyed were between 36 and 37 degrees to the North and between 9 and 10 degrees to the East and with altitudes that ranged from 7 to 908 m. In each field, 10 samples with one m² quadrate were taken. The density of ryegrass (*Lolium rigidum*) was determined by counting in each sample and was classified according to the climate regions. Field experiment was conducted at 10 locations in the North of Tunisia with different levels of infestation of ryegrass to evaluate the efficacy of 14 herbicides at recommended doses. Experiment was conducted in randomized complete block design (RCBD) with four replications (**Table 1**). The plot area was 40 m² (4 m × 10 m). Wheat variety '*Durum'* was sown in second half of November 2013. Azote fertilizer (33.5%) with three applications of ammonitrate (120, 150 and 100 kg/ha) was applied over three stages of development at 3 leaves of wheat, at tillering and before heading. Fungal diseases were controlled by application of epoxiconazole at 125 g/ha. The spraying of herbicides was done with sprayer calibrated to discharge 200 l/ha at 3 kpa. The efficacy was assessed by percentage of damaged plants of ryegrass compared to an untreated control at 30 days after spray. Experimental data were subjected to analysis of variance (ANOVA) and analysis of the Pearson correlations using SAS statistical package (SAS® 2000).

***Corresponding author:** kh_messad@yahoo.fr
[1]Institut National Agronomique de Tunisie (INAT), 43 Avenue Charles Nicolle, Tunis 1082

Density of rigid ryegrass

The rigid ryegrass (*Loluim rigidum* Gaud.) was recorded in all the climatic regions (sub-humid, superior and lower semi-arid) and in all crops along with other weeds and in different soil types (clayey, loam and sandy). In sub-humid climatic regions, the infestation with rigid ryegrass varied from 4 to 657 plants/m² with an average of 158 plants/m². In the superior semi-arid climatic regions, the infestation varied from 3 to 23 plants/m² with an average of 9 plants/m². The lowest average of 3 plants/m² of ryegrass infestation was recorded in the lower semi-arid climatic regions (infestation from 0 to 9 plants/m²). So, the density of rigid ryegrass increased to the lower semi-arid to the sub-humid climate regions. However, the maximum density (657 plants/m²) of ryegrass was recorded in sub-humid against 9 plants/m² in the lower semi arid. The density of ryegrass increased with increase annual rainfall (**Table 2**). High weed infestations (> 300 plants/m²) were observed in the Northern regions of Tunisia where weather conditions, mainly the rainfall, was more favorable.

Table 1. List of herbicides used in field trials

Trade name	Active substance	Concent. (a.i.)	Recommande rate (ha)
Amilcar OD	Mesosulfuron-methyl + iodosulfuron-methyl-sodium	7.5 g/l + 7.5 g/l	1 l
Amilcar WG	Mesosulfuron-methyl + iodosulfuron-	30 g/kg + 30 g/kg	330 g
Apyros	Sulfosulfuron	75%	26.6 g
Axial	Pinoxaden	45 g/l	1 l
Tolurex	Chlortoluron	500 g/l	4.8 l
Dopler plus	Diclofop-methyl + fénoxapropo-p-ethyl	250 g/l + 20 g/l	2.5 l
Evrest	Flucarbazone sodium	70 %	43 g
Grasp	Tralkoxydim	400 g/l	0.8 l
Illoxan CE	Diclofop-methyl	360 g/l	2 l
Pallas OD	Pyroxsulam	46.6 g/l	0.5 l
Puma Evolution	Fenoxaprop-p-ethyl + iodosulfuron-methyl-sodium	64 g/l + 8 g/l	1 l
Puma Super	Fenoxaprop-p-ethyl	69 g/l	1 l
Topik	Clodinafop-propargyl	100 g/l	0.5 l
Traxos	Pinoxaden + clodinafop-propargyl	22.5 g/l + 22.5 g/l	1.2 l

Densities as low as 10 plants/m² were found in semi-arid regions with an average rainfall of 300 mm. Surveys conducted in Southern Australia revealed the occurrence of rigid ryegrass in 86% of canola crops and 69% of cereal crops (Lemerle *et al.* 1996). As rigid ryegrass originated from the temperate regions of Europe and Asia, temperate climate is very suitable for weed survival thus, explaining its predominance in regions with a Mediterranean climate such as in Tunisia.

Table 2. Density of rigid ryegrass in different climate stages and the average of rainfall

Climatique stages	Density of rigid ryegrass (plants/m²)			Interval of rainfall (mm)
	Minima	Maxima	Average	
Sub-humide	4	657	157.7	600-800
Superior semi-arid	3	23	9	500-600
Lower semi-arid	0	9	2.6	400-500

Effect of density of rigid ryegrass on yield of wheat

Wheat yield loss increased with increase of the density of rigid ryegrass. Correlation study showed a highly significant correlation between losses in yield and the density of rigid ryegrass ($r = 0.92847$ and $p = 0.0001$) and an exponential equation $y = 109, 56\ e^{-0,001x}$ was determinate. When the density was 300 plants/m², the losses in yields were in order of 20 to 30%, but when density exceeded 1000 plants/m², the losses in yields were in the order of 70% (**Figure 1**). Reeves (1976) reported that losses in the yield due to rigid ryegrass may vary with density, sowing date and seed stock. In the field, density with 200 plants/m² may cause losses in wheat yield ranging from 20 to 50% (Porter and Gawith 1999). Moreover, when the density of Italian ryegrass increased from 0.7 to 93 plants/m², the yield loss increased from 0 to 4.1 t/ha (Appleby *et al.* 1976). Thus, with high densities (1500 plants/m²), yield reductions in wheat may ranged from 23.1 to 47.8% (Reeves and Brooke 1977). These high densities of ryegrass can contribute, in addition to crop yield losses (Appleby *et al.* 1976, Palta and Peltzer 2001), to increase the seed stock (Hopfensperger 2007) and to reduce the efficacies of herbicides (El-Sebai *et al.* 2005).

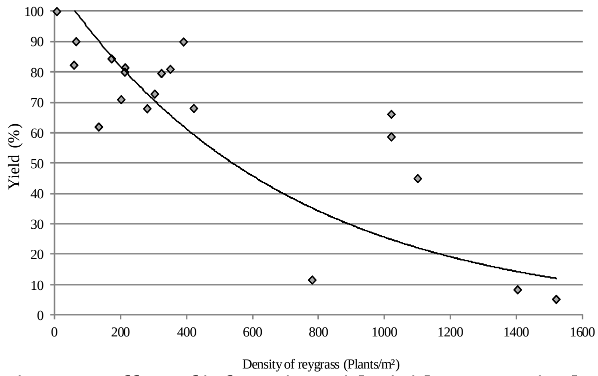

Figure 1. Effect of infestation with rigid ryegrass in the yield of wheat

Efficacy of herbicides on rigid ryegrass

Herbicides (mesosulfuron-methyl 7.5 g/ha + iodosulfuron-methyl-sodium 7.5 g/ha, pyroxsulam 23.3 g/ha, fenoxaprop-p-ethyl 64 g/ha + iodosulfuron-methyl-sodium 8 g/ha and chlortoluron 2400 g/ha) had good control on rigid ryegrass in some locations, but other herbicides showed low to medium effect (mesosulfuron-methyl 9.9 g/ha + iodosulfuron-methyl-sodium 9.9 g/ha, diclofop-methyl 720 g/ha, clodinafop-propargyl 50 g/ha, pinoxaden 27 g/ha + clodinafop-propargyl 27 g/ha, pinoxaden 45 g/ha, diclofop-méthyl 625 g/ha + fénoxapropo-p-ethyl 50 g/ha, tralkoxydim 320 g/ha, sulfosulfuron 75% 26.6 g/ha and flucarbazone-sodium 70% 43 g/ha). At one location (212 plants/m²) all tested herbicides showed lower efficacy except chlortoluron (83.6%). In all locations, herbicides (mesosulfuron-methyl 7.5 g/ha + iodosulfuron-methyl-sodium 7.5 g/ha, pyroxsualm 23.3 g/ha and fenoxaprop-p-ethyl 64 g/ha + iodosulfuron-methyl-sodium 8 g/ha) showed best effect. The best efficacy (97%) was registered with mesosulfuron-methyl 7.5 g/ha + iodosulfuron-methyl-sodium 7.5 g/ha in the location 8, although infestation of rigid ryegrass was high enough (123 plants/m²). However, the efficacies of herbicides were varied from one location to another location and depending on the rate of the infestation with ryegrass and the presence or not of resistance in this weed. The average herbicides efficacies showed good efficacies with chlortoluron

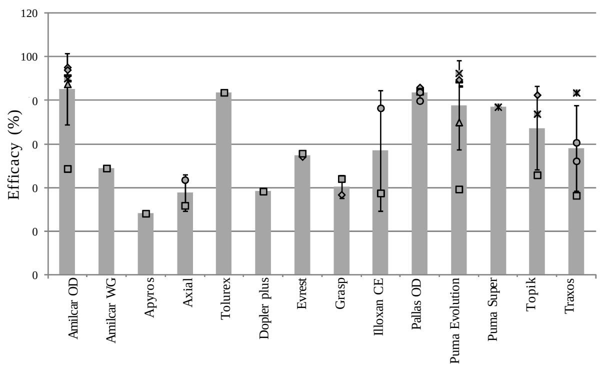

Figure 2. Efficacy of herbicides on rigid ryegrass in 10 locations

2400 g/ha. Factors influencing herbicide efficacy have been documented. These include weed and crop densities (Scursoni *et al.* 2012), which can further be influenced by other factors such as soil type, period of weed emergence and weed growth stage (O'Donovan *et al.* 1985). Low efficacy of herbicides on rigid ryegrass were registered with sulfosulfuron 75% at 26.6 g/ha, pinoxaden at 45 g/ha, diclofop-méthyl at 625 g/ha +fénoxapropo-p-ethyl at 50 g/ha, flucarbazone sodium 70% at 43 g/ha and tralkoxydim at 320 g/ha (ACCase and ALS herbicides inhibitors). Certain herbicides such as mesosulfuron-methyl 9.9 g/ha + iodosulfuron-methyl-sodium 9.9 g/ha, diclofop-methyl 720 g/ha, clodinafop-propargyl 50 g/ha and pinoxaden 27 g/ha + clodinafop-propargyl 27 g/ha have limited the ryegrass populations up to 50%, but this was insufficient to have better yield (**Figure 2**). These results were confirmed with the work of Souissi *et al.* (2004).

SUMMARY

Rigid ryegrass (*Lolium rigidum* Gaud.) is a weed that caused significant losses in yields. The results showed that the density of ryegrass varied depending with the climatic regions and increased with increasing of rain. However, the density of this weed increased to the lower semi-arid to the sub-humid climate regions. Maximum infestation (657 plants/m²) of ryegrass was recorded in sub-humid against 9 plants/m² in the lower semi-arid climatic regions. Study of the correlation showed that the yield losses were highly correlated with density (r = 0.92847 and p=0.0001) with an exponential equation $y = 109{,}56\ e^{-0{,}001x}$. The results of the field trials showed that pre-mix mesosulfuron-methyl 7.5 g/ha + iodosulfuron-methyl-sodium 7.5 g/ha, pyroxsulam 23.3 g/ha and fenoxaprop-p-ethyl 64 g/ha + iodosulfuron-methyl-sodium 8 g/ha and chlortoluron 2400 g/ha controlled ryegrass effectively. At some locations, herbicides ACCase inhibitors (pinoxaden at 45 g/ha, diclofop-méthyl at 625 g/ha + fénoxapropo-p-ethyl at 50 g/ha and tralkoxydim at 320 g/ha) and ALS inhibitors (sulfosulfuron75% at 26.6 g/ha and flucarbazone sodium 70% at 43 g/ha) showed poor efficacy which may be due to the development of resistance in rigid ryegrass in many locations of Tunisia.

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