Differential Allelopathic Potential of Three Cereal Species

Oussama Oueslati and Moncef Ben-Hammouda, Laboratoire de Physiologie de la Production des Céréales, Ecole Supérieure d'Agriculture du Kef, Université de Jendouba, 7100 Le Kef, Tunisia

ABSTRACT

Oueslati, O., and Ben-Hammouda, M. 2017. Differential allelopathic potential of three cereal species.Tunisian Journal of Plant Protection 12: 109-120.

Barley is an important cereal cultivated in Tunisia for double purpose, grazing and grain production. Barley is mostly conducted in monoculture or in rotations with other cereals such bread wheat and specially durum wheat. When conducted in direct drilling (DD), residues (stubble, straw) are abandoned on soil surface which could be a source of allelochemicals that may express auto-toxicity or hetero-toxicity detrimental to the yields of a following crop. The differential allelopathic potential of three cereal (barley, bread wheat, durum wheat) mulches and soils cultivated with these cereals was studied, using bioassays (germination, seedling growth). For all bioassays 'Manel' (barley) was the test-variety. Radicle growth bioassay was the most sensitive test to detect allelopathy expressed in the form of auto-toxicity (barley/barely) or hetero-toxicity (bread wheat/barley, durum wheat/barley). Only soil-extracts cultivated with bread wheat, showed a significant effect on barley growth. A differential inhibitory effect was identified within and between studied cereal species. Hetero-toxicity was significantly more pronounced than auto-toxicity. Moreover, stubble-extracts were more inhibitory than straw-extracts independently of cereal species. Results suggest that barley auto-toxicity and bread and durum wheats hetero-toxicity should be considered when applying crop sequencing especially in conservation agriculture (CA) using DD on permanent mulch. Barley monoculture appeared to be a better choice than a rotation of barley with bread or durum wheat.

Keywords: Allelopathy, auto-toxicity, barley, bread wheat, durum wheat, hetero-toxicity, residues

---

Understanding allelopathic potential of crop residues could aid to better manage crop rotation in conservation agriculture (CA). Barley residues expressed an allelopathic effect in the form of auto-toxicity (Ben-Hammouda et al. 2002). Asghari and Tewari reported that extracts of eight barley cultivars inhibited significantly germination and seedling growth of greenfoxtail(*Setaria viridis*) (Asghari et Tewari 2007). Bread wheat and durum wheat responded differently to barley allelopathy, with greater sensitivity of bread wheat (Ben-Hammouda et al. 2001).Water-extracts of durum wheat expressed allelopathic effect in the form of heterotoxicity by inhibiting germination and radicle growth of barley and bread wheat (Oueslati 2003). Straw-extracts of two local Iranian wheat varieties induced a significant inhibition on growth of two corn hybrids (Saffari et al. 2010). Extracts from sorghum stems and maize inflorescences inhibited germination and growth of painted euphorbia (*Euphorbia heterophylla*), showing a degree of inhibition that was

Corresponding author: Oussama Oueslati
Email: oussamaoueslati@yahoo.fr

Accepted for publication 19 December 2017

extract concentration dependent (Ayeni and Kayode 2013).

Mulched plots with barley residues, triticale (*xTriticosecale*) and rye (*Secale cereale*) were behind a low emergence of barnyard grass (*Echinochloa crus-galli*), bristly foxtail (*Setaria verticillata*) and large cabgrass (*Digitaria sanguinalis*) when compared with emergence in mulch-free plots (Dhima et al. 2006-b). Corn sown on barley residues grew with less biomass of weeds such as barnyard grass and bristly foxtail (Dhima et al. 2006-a).Incorporated barley residues in the soil reduced germination, plant height and weight of wild barley (*Hordeum spontaneum*) (Ashrafi et al. 2009).Grains yield of continuous barley after straw incorporation was lower when compared to conventional tillage removed straw and burned straw treatments (Procházková et al. 2002). A nine years field experiment of wheat cultivation showed that direct drilling (DD) or conventional drilling (CD) caused a one third reduction in yield when straw of wheat was burnt prior to wheat sowing (Christian et al. 1999). However, different methods of durum wheat residues management presented an auto-toxicity risk (Ben-Hammouda et al. 2003). Establishment of winter oats (*Avena sativa*) was better when wheat straw was incorporated by tine cultivation when compared to DD (Christian and Miller, 1986). In a no-till maize (*Zea mays*), germination and seedling growth of red root pigweed (*Amaranthus retroflexus*) was particularly affected by rye mulch used as a cover crop (Tabaglio et al. 2013).

Incorporation of fresh barley biomass reduced quack grass (*Agropyrum repens*) germination, plant height and plant weight when compared with a control treatment (Ashrafi et al. 2009). Growth of wild barley was significantly reduced when black mustard (*Brassica nigra*) wasthe prior crop in comparison to its growth in monoculture(Tawaha and Turk, 2003). Soil rhizosphere of wild oat (*Avenafatua*) inhibited wheat seedlings growth (Fragasso et al. 2012). Root exudates of durum wheat, barley and oat affect plant dry weight of bread wheat, with durum wheat making the lowest radicle length while oat minimized all recorded data (Ali 2013).Amended soil with decomposing alfalfa (*Medicago sativa*) and kava (*Piper methystecum*) strongly and continuously inhibited barnyard grass growth during 25 days (Xuan et al. 2005).

The present work aimed to: i) study the allelopathy potentials expressed by residues as straw and stubble and plus soils-extracts among three cereal species (barley, bread wheat, durum wheat), and ii) develop a better understanding of cereal production under CA conditions.

MATERIALSAND METHODS

Plant material and field experiments.

Three cereal crops represented by 5 varieties each [barley ('Manel', 'Martin', 'Momtaz', 'Rihane', 'Souihli'), bread wheat ('Byrsa', 'Haïdra', 'Salambo', 'Tebica', 'Utique') and durum wheat ('Karim', 'Khiar', 'Nasr', 'Oum rabiaa', 'Razzak')were grown at the Experimental Station of the *Ecole Supérieure d'Agriculture du Kef* (NW/Tunisia) during the 2003/04growing season. The site was located in the semi-aridzone. All species were sown after a fallow in a soil slightly alkaline (pH = 7.5) with clay dominance (48% clay, 34% sand, 18% silt) and 2% organic matter. From soil preparation to harvest, appropriate technical package to the semi-arid zone, under rain-fed conditions, was applied. The field lay-out was a Complete Randomized Block Design (CRBD**)** with four replications. Cereal varieties were conducted in 6-row plots of 12 m^2 (10 m × 1.2 m) each. Climatic data were collected from a neighboring meteorological station (Table 1) and plots were irrigated with 40 mm of water when severe wilting was observed.

Table 1. Climatic data* relative to the biological cycle of barley

Month	Rain-fall (mm)	ETP** (mm)	Temperature (°C)
November	13.20	38.20	19.30
December	203.00	27.30	13.10
January	49.10	29.20	13.20
February	16.90	51.20	16.90
March	77.20	71.80	17.60
April	45.20	98.20	19.50
May	47.50	180.00	23.40
Total	452.10	495.90	-
Mean/month	64.58	70.84	17.57

* Source: Meteorological Station of Boulifa/Kef, adjacent to the experimental site.
** Evapotranspiration potential.

Preparation of water extracts

Cereal straw and stubble were randomly collected from field after harvest. Roots from soil were gently washed by tap water, then with distilled water, dried between 2 paper towels before being chopped into 1-cm long pieces and placed in oven at 50°C for 24 h. The extraction followed the procedure reported by Ben-Hammouda et al. (1995).

After harvest, soil samples were randomly collected from plots cultivated with the 3 tested cereals (barley, bread wheat, durum wheat) across a profile of 30 cm, than air dried for 1 day and sieved through 0.3 mm stitches. Soil extraction was done following the procedure described as follow: A sample of 250 g equivalent of dry soil was extracted in 250 ml distilled water then set on a horizontal shaker for 24 h at 200 rpmn (Read and Jensen 1989). Soil suspensions were filtered across Whatman N° 2 filter paper, by gravity then stored at less than 5°C until bioassay.

Bioassays of plant extracts

Extracts of the 3 cereal species were tested for auto-toxicity on germination and seedlings (radicle, coleoptile) growth using ‘Manel’/barley as the test-variety. For germination bioassays, 'Manel' seeds were surface sterilized with a 5% aqueous solution of sodium hypochlorite for 1-min, rinsed 5 times with distilled water and dried between 2 paper towels. Surface sterilized seeds were placed in a standard Petri Dish containing 15 ml of water agar, as growth medium, amended with 20 ml of residues (straw, stubble) or soil extracts. The control was 1.2% distilled water agar. After incubation for 35 h in dark at 25°C, seeds with 2 mm radicle length were recorded as germinated.

For seedlings growth bioassays, the growth medium was similar to what was used for germination bioassays. Surface-sterilized seeds of ‘Manel’ were pre-germinated then set for seedling growth. Data were collected following the procedure described by Ben-Hammouda et al. (2001; 2002). Inhibition of 'Manel' growth was expressed as follow:[(Control - Treatment)/Control] × 100.

Statistical analysis

Bioassays were conducted in a Complete Randomized Design (CRD) with four repetitions. Treatments with a significant main effect were separated by the protected LSD Fisher-test at the probability level of 5% (Steel and Torrie 1980).

The average individual effects of five varieties, as inhibition rate of 'Manel' radicle growth [(Control - Treatment)/(Control)], was used to make a single observation relative to each species. A combined analysis of allelopathic species effects/potential on the test-variety was conducted. In addition, a second combined analysis concerning source of extracts (straw, stubble) among the three tested species was conducted too. Data transformation was operated to reach an acceptable level of coefficient of variation then subjected to analysis of variance using SAS package (SAS Institute 1992).

RESULTS

Germination bioassays

All over the five tested varieties, barley stubble-extracts showed a significant allelopathic/auto-toxic effect on the germination of the test-variety 'Manel', and the same applies for all bread wheat and durum wheat varieties. Only straw-extracts of bread wheat did similar effect to 'Manel' germination. However, soil-extracts of the three cereal species showed no significant effect on germination of the barley test-variety (Table 2).

Table 2. Treatment mean squares for germination of 'Manel' assayed with three sources of extracts (straw, stubble, soil) from three cereals

Source of extract	Barley	Bread wheat	Durum wheat
Straw	104.01 NS	11.90 **	18.54 NS
Stubble	261.10 **	7.22 *	77.20 *
Soil	9.70 NS	46.96 NS	6.56 NS

NS Not significantly different at 5% level of probability.
* Significantly different at 5% level of probability.
** Significantly different at 1% level of probability.

Stubble-extracts, of three ('Moumtez', 'Rihane', 'Souihli') out of five barley varieties, were inhibitory to 'Manel' germination, with 'Moumtez' having the most inhibiting extracts. Straw-extracts of two bread wheat varieties ('Byrsa', 'Haïdra') and stubble-extracts of three varieties ('Byrsa', 'Haïdra', 'Utique') inhibited significantly barley germination. As was the case of bread wheat, stubble-extracts of four durum wheat varieties ('Karim', 'Khiar', 'Oum-rabiaa', 'Razzak') inhibited significantly barley germination (Table 3).

Seedling growth bioassay.

Coleoptile bioassay. Both barley residues (straw, stubble) and soil extracts had no effect on 'Manel' coleoptile growth. However, two (stubble, soil) bread wheat extracts showed a highly significant effect 'Manel' coleoptile growth. For durum wheat, only straw-extracts showed a significant effect on barley coleoptiles growth (Table 4).

Table 3. Effects of straw and stubble extracts of three cereals (barley, bread wheat, durum wheat) on germination (%) of 'Manel' variety

Barley	Stubble	BW††	Straw	Stubble	DW††	Stubble
Control	99.00 a†	Control	96.20 a†	95.30 a†	Control	44.00 a†
'Manel'	96.50 ab	'Byrsa'	93.00 b	91.50 b	'Karim'	31.70 b
'Martin'	90.00 abc	'Haïdra'	92.00 b	92.00 b	'Khiar'	32.70 b
'Moumtez'	78.00 d	'Salambo'	95.50 a	93.00 ab	'Nasr'	37.20 ab
'Rihane'	86.50 bcd	'Tebica'	96.00 a	93.50 ab	'Oum rabiaa'	35.70 b
'Souihli'	82.50 cd	'Utique'	94.00 ab	92.50 b	'Razzak'	34.50 b
LSD $_{(5\%)}$	1.12	-	2.38	2.35	-	6.80

† Means within a column followed by different letters are significantly different at 5% level of probability.

†† BW (bread wheat) and DW (durum wheat).

Table 4. Treatment mean squares for coleoptile growth of 'Manel' assayed with 3 sources of extracts (straw, stubble, soil) of three cereals, independently of variety

Source of extract	Barley	Bread wheat	Durum wheat
Straw	0.01^{NS}	0.02^{NS}	0.18*
Stubble	0.14^{NS}	0.35***	0.18^{NS}
Soil	0.02^{NS}	0.41**	0.08^{NS}

NS Not significantly different at 5% level of probability.

* Significantly different at 5% level of probability.

** Significantly different at 1% level of probability.

*** Significantly different at 0.1% level of probability.

Stubble-extracts of three bread wheat varieties ('Byrsa', 'Haïdra', 'Salambo') inhibited significantly barley coleoptile growth with 'Haïdra' being the most inhibitory. Soil-extracts of three varieties ('Haïdra', 'Salambo', 'Utique') within bread species inhibited coleoptile growth, with 'Salambo' being the most inhibitory. However, straw-extracts of all the tested durum wheat varieties showed a significant inhibition on 'Manel' coleoptile growth, with 'Oum rabiaa' being the least inhibitory (Table 5).

Table 5. Extract effects of bread wheat stubble, bread wheat soil and durum wheat straw on 'Manel' coleoptile growth (cm)

BW††	Stubble	Soil	DW††	Straw
Control	3.22 a†	3.40 a†	Control	3.60 a†
'Byrsa'	2.82 b	3.39 a	'Karim'	3.00 b
'Haïdra'	2.43 c	2.91 b	'Khiar'	3.00 b
'Salambo'	2.89 b	2.68 b	'Nasr'	3.00 b
'Tebica'	3.00 ab	3.33 a	'Oum rabiaa'	3.20 b
'Utique'	3.23 a	2.82 b	'Razzak'	3.00 b
LSD $_{(5\%)}$	0.29	0.38	NA	0.35

† Means within a column followed by different letters are significantly different at 5 % level of probability.

†† BW (bread wheat) and DW (durum wheat).

NA Not applicable.

Radicle bioassay. Barley straw and stubble extracts showed a highly significant effect on barley radicle growth. Straw and stubble extracts as well as soil-extracts of bread wheat showed a highly significant effect too. The pronounced of allelopathy in soils cultivated with bread wheat could be explained by a high release of allelochemicals into the soil by this cereal crop. Straw and stubble extracts of durum wheat showed a significant effect on barley radicle growth. Soil-extracts of barley and durum wheat have no detectable effect on radicle growth of barley (Table 6).

Table 6. Treatment mean squares for radicle growth of ‘Manel’ assayed with three sources of extracts (straw, stubble, soil) of three cereals, independently of variety

Source of extract	Barley	Bread wheat	Durum wheat
Straw	4.15^{***}	0.49^{***}	1.82^{*}
Stubble	5.05^{***}	4.07^{***}	1.82^{*}
Soil	0.09^{NS}	0.81^{***}	0.72^{NS}

NS Not significantly different at 5% level of probability.
* Significantly different at 5% level of probability.
*** Significantly different at 0.1% level of probability.

Due to its elevated degree of significance compared to germination and coleoptile growth bioassays, only radicle growth bioassay will be considered for statistical combined analysis. Straw-extracts of the five barley varieties ('Manel', 'Martin', 'Moumtez', 'Rihane', 'Souihli') inhibited barley radicle growth. 'Moumtez' was the most inhibitor variety. The same happened with stubble-extracts; with 'Rihane' expressing the most inhibitory effect. Straw and stubble extracts of 'Souihli' were the least depressive to barley radical growth(Table 7).

Table 7. Effects of straw and stubble extracts of 5 barley varieties on radicle growth (cm) of ‘Manel’ variety

Treatment	Straw	Stubble
Control	4.71 a†	4.95 a†
‘Manel’	2.69 bc	2.29 c
‘Martin’	2.39 c	2.66 b
‘Moumtez’	1.90 d	2.18 c
‘Rihane’	2.05 d	1.78 d
‘Souihli’	2.89 b	2.72 b
LSD $_{(5\%)}$	0.32	0.35

† Means within a column followed by different letters are significantly different at 5% level of probability.

Straw-extracts of two bread wheat varieties 'Byrsa' and 'Tebica' stimulated barley radicle growth whereas those of 'Salambo' and 'Utique' showed an inhibition. However straw-extracts of 'Haïdra' showed no significant effect. Stubble-extracts of all bread wheat varieties inhibited radicle growth. Soil-extracts of 'Byrsa' and 'Salambo' showed a stimulation of radicle growth while soil-extracts of 'Haïdra' were inhibitory (Table 8).

Table 8. Effects of straw, stubble and soil extracts of five bread wheat varieties on radicle growth (cm) of ‘Manel’

Treatment	Straw	Stubble	Soil
Control	1.58 b†	6.12 a†	4.03 b†
‘Byrsa’	1.87 a	3.63 b	4.83 a
‘Haïdra’	1.47 b	3.78 b	3.59 c
‘Salambo’	1.07 c	3.35 b	4.58 a
‘Tebica’	1.83 a	3.85 b	3.99 b
‘Utique’	1.06 c	3.85 b	4.04 b
LSD $_{(5\%)}$	0.20	0.56	0.36

† Means within a column followed by different letters are significantly different at 5% level of probability.

Except 'Razzak' straw-extracts, those of the remaining durum wheat varieties inhibited radicle growth of barley, with 'Karim' as the most inhibitory. Stubble-extracts of durum wheat were inhibitory except 'Khiar' which showed no significant effect. 'Razzak' was the most inhibitory variety. For the same variety 'Razzek', straw-extracts were inhibitory whereas stubble had no significant effect (Table 9).

Table 9. Effects of straw and stubble extracts of five durum wheat varieties on radicle growth (cm) of ‘Manel’ variety

Treatment	Straw	Stubble
Control	4.00 a†	5.50 a†
‘Karim’	2.40 b	4.30 bc
‘Khiar’	2.60 b	5.00 ab
‘Nasr’	2.90 b	4.20 bc
‘Oum Rabiaa’	2.90 b	4.00 bc
‘Razzak’	3.20 ab	3.70 c
LSD $_{(5\%)}$	0.90	1.20

†Means within a column followed by different letters are significantly different at 5% level of probability.

The effect of cereal species on radicle growth of 'Manel' was very highly significant. Across varieties, the species effect on barley radical was more pronounced than source of extract, either straw or stubble. Also the effect of source of extract was significant due to a highly significant interaction between cereal species and source of extract(Table 10).

Table 10. ANOVA of source of extract and cereal species effects on radicle growth (cm) of 'Manel'

Source of Variation	DF	SS	MS	F value	*P*> F
Total	29	0.38696793			
Source of extract	1	0.02341932	0.02341932	4.79	0.0386*
Species	2	0.18258224	0.09129112	18.67	0.0001***
Source of extract × Species	2	0.06358244	0.03179122	6.50	0.0055**
Error	24	0.11738393	0.00489100		

* Significantly different at 5% level of probability.
** Significantly different at 1% level of probability.
*** Significantly different at 0.1% level of probability.

Bread wheat expressed the highest inhibition (86.19%) of barley radicle growth, followed by durum wheat (85.43%) and barley (69.27%). The difference between the two later species was not significant (Fig. 1).

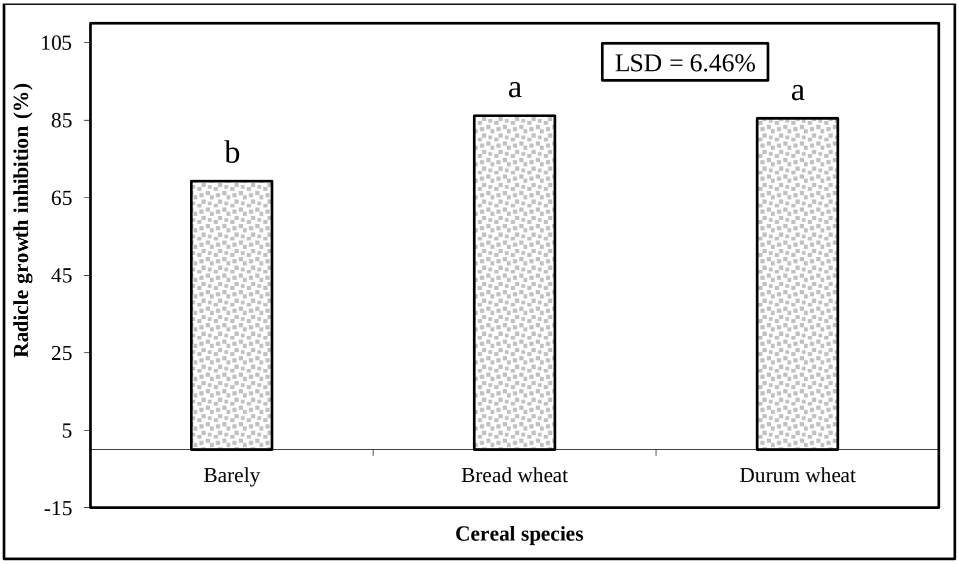

Fig. 1. Effect of cereal species on radicle growth inhibition (%) of the test-variety 'Manel'. Bars with the same letter are not significantly different according to LSD test at 5% level of probability.

Previous results show that hetero-toxicity is more pronounced than auto-toxicity. Regardless the cereal species, straw-extracts expressed the largest inhibition (83.09% *vs* 77.50%) of barley radicle growth when compared to extracts coming out of stubble (Fig. 2).

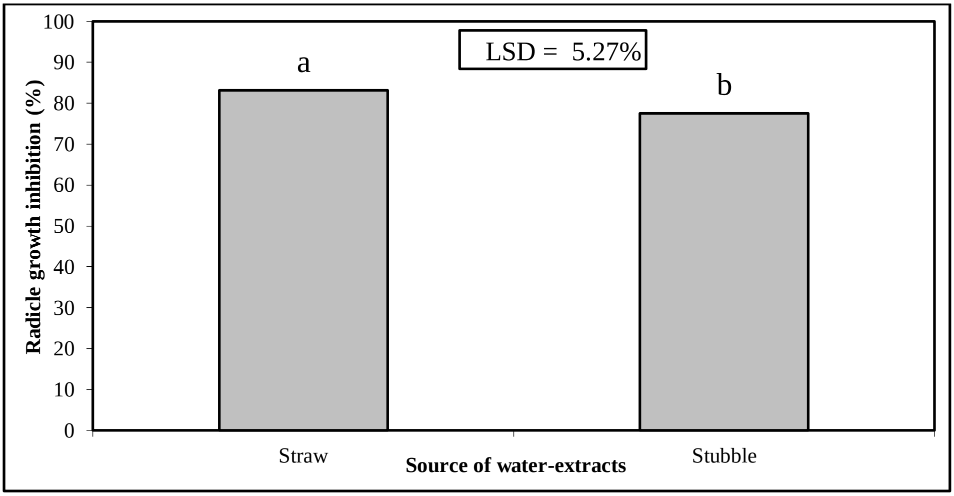

Fig. 2. Effect of source of extracts on radicle growth inhibition (%) of the test-variety'Manel'. Bars with the same letter are not significantly different according to LSD test at 5% level of probability.

DISCUSSION

Allelopathic effect expressed by inhibition of germination was reported with barley and durum wheat plant components (Ben-Hammouda and Oueslati 1999; Oueslati 2003). Both varieties 'Haïdra' and 'Salambo', stubble and soil-extracts expressed an inhibitory effect on 'Manel' coleoptile growth. This was not the case for 'Byrsa' and 'Utique', suggesting that these varieties are not necessarily those which released detectable allelochemicals into the soil by leaching and/or exudation. Similar results were obtained by Oueslati and Ben-Hammouda (2014). Mostly soil extracts of cereals have no detectable effect on germination and seedling growth of barley. In previous work, soil extracts of barley and durum wheat showed a heterotoxic/allelopathic effect (Ali 2013). Once again radicle growth bioassay was the best tool for screening cereal species allelopathy (Ben-Hammouda et al. 2001; 2002; Oueslati et al. 2005).

The carried work showed varietal differences of the allelopathic potential expressed by barley, bread wheat and durum wheat. In fact varietal differences of the three cereals in expressing allelopathy were reported (Asghari and Tewari 2007; Oueslati 2003; Xuan et al. 2005).This potential is expressed under the form of auto-toxicity and hetero-toxicity. Hetero-toxicity was more pronounced than auto-toxicity and straw extracts were more allelopathic than stubble extracts. In contrary, stubble-extracts of barley were shown to be most allelopathic than straw-extracts (Procházková et al. 2002). Residues of the three cereal crop species contain soluble allelochemicals that were in general inhibitory to barley radicle growth. Phenolic acids and two protoalkaloids (hordenine, gramine) are responsible of barley auto-toxicity (Hoult and Lovett 1993; Oueslati et al. 2009). Also phenolic acids, hydorxamic acid and DIMBOA are allelochemicals isolated from tissues of bread wheat (Ma 2005). Total phenolic content is responsible of durum wheat allelopathy (Wu et al. 1998).

The bread wheat variety 'Byrsa' had the lowest inhibitory straw and soil extracts, which make it of great interest for agronomic sequencing with barley.

There were a significant interaction between cereal species and source of extracts (straw, soil, stubble) according to radicle growth inhibition. Similar results were obtained by Oueslati et al. (2005) when working on barley auto-toxicity.

These results should be considered by grower practicing direct drilling in the semi-arid zone especially when arranging crop sequences. Removing straw of the subsequent crop could be a help to minimize inhibitory allelopathic effect.

ACKNOWLEDGEMENTS

We express our appreciations and thanks to: i) the *Fond Français pour l'Environnement Mondial* (FFEM) for financial support to both Scientific Research Program and Extension Program of Direct Drilling in Tunisia and ii) the *Agence Française de Développement* (AFD) for the fluid management of FFEM funds, serving well both introduction and extension of Direct Drilling in Tunisia.

RESUME

Oueslati O. et Ben-Hammouda M. 2017. Potentiel allélopathique différentiel de trois espèces de céréales. Tunisian Journal of Plant Protection 12: 109-120.

L'orge est une céréale importante, cultivée en Tunisie pour le pâturage et la production de grains. L'orge est principalement conduite en monoculture ou en rotation avec d'autres céréales comme le blé tendre et le blé dur. Lors de la conduite de l'orge en semis direct (SD), les résidus (chaume, paille) qui sont abandonnés à la surface du sol peuvent être une source de substances allélochimiques, préjudiciables pour les rendements de la culture suivante. Le potentiel allélopathique différentiel du paillis de trois céréales (orge, blé tendre, blé dur) et des sols cultivés en ces trois céréales a été étudié en se basant sur des bio-essais de germination et de croissance de jeunes plantes. Pour ces bio-essais, 'Manel' (orge) était la variété-test. Le bio-essai de la croissance de la radicule était le test le plus sensible pour détecter l'allélopathie exprimée sous forme d'auto-toxicité (orge/orge) et d'hétéro-toxicité (blé tendre/orge, blé dur/orge). Seuls les extraits du sol avec le blé tendre ont montré un effet significatif sur la croissance de l'orge. Un effet inhibiteur a été identifié parmi et entre les espèces de céréales étudiées. L'hétéro-toxicité était significativement plus prononcée que l'auto-toxicité. En outre, les extraits de chaume étaient plus inhibiteurs que les extraits de paille, ceci indépendamment de l'espèce de céréale. Les résultats suggèrent que l'auto-toxicité de l'orge et l'hétéro-toxicité du blé tendre et du blé dur doivent être prises en considération lors du choix des séquences culturales surtout en cas de conduite en SD (comme moyen d'agriculture de conservation) sur paillis permanent. La monoculture de l'orge semble être un meilleur choix que la rotation de l'orge avec le blé tendre ou le blé dur.

Mots clés: allélopathie, auto-toxicité, blé tendre, blé dur, hétéro-toxicité, orge, résidus

---

ملخص

وسلاتي، أسامة والمنصف بن حمودة. الفرق في المجاهضة الكامنة لثلاثة أنواع من الحبوب.
Tunisian Journal of Plant Protection 12: 109-120.

تتم زراعة الشعير في تونس لغرض مزدوج، الرعي وإنتاج الحبوب. يجرى استعمال الشعير كزراعة أحادية أو بالتداول مع القمح اللين والقمح الصلب. أثناء القيام بالبذر المباشر يتم التخلي عن مخلفات النباتات أي القش والتبن على سطح التربة. هذه المخلفات يمكن أن تكون مصدر لمواد سمية يمكن لها التأثير سلبا على مردود الزراعة الموالية. تمت دراسة الفرق في المجاهضة الكامنة للغطاء النباتي للحبوب الثلاث (شعير، قمح لين، قمح صلب) وللتربة التي زرعت عليها هذه الحبوب باستعمال اختبارات بيولوجية (إنبات، نمو البادرات). بالنسبة لجميع الاختبارات البيولوجية تم اختيار 'منال'

(شعير) كصنف اختبار. كان اختبار نمو جذير البادرات الأكثر حساسية للكشف عن السمومية الذاتية (شعير\شعير) أو السمومية المغايرة (قمح لين\شعير، قمح صلب\شعير). فقط مستخلصات التربة التي زرع عليها القمح اللين أظهرت تأثيرا ملموسا على نمو الشعير. تم اكتشاف فرق في المفعول المثبط ضمن وبين الأنواع الثلاثة للحبوب المدروسة. كانت السمومية المغايرة أكثر تأثيرا على نمو الشعير من السمومية الذاتية. علاوة على ذلك، كانت مستخلصات القش أكثر تثبيطا من مستخلصات التبن. تشير النتائج أنه يجب الأخذ بعين الاعتبار السمية الذاتية والسمية المغايرة عند اختيار تداول الزراعات، خاصة عند تطبيق البذر المباشر على غطاء نباتي مستديم. يبدو أن اختيار الزراعة الأحادية للشعير أفضل من تداول الشعير مع القمح اللين أو القمح الصلب.

كلمات مفتاحية : المجاهضة، السمومية الذاتية، السمومية المغايرة، الشعير، القمح اللين، القمح الصلب، المخلفات النباتية

LITERATURE CITED

Ali, K.A. 2013. Allelopathic potential of some crop plant species on bread wheat *Triticum aestivum* using equal compartment agar method. Journal of Agriculture and Veterinary Science 2: 52-55.

Asghari, J., and Tewari, J.P. 2007. Allelopathic potentials of eight barley cultivars on *Brassica juncea* (L.) and *Setaria viridis* (L.) Beauv. Journal of Agriculture Science and Technology 9: 165-176.

Ashrafi, Z.Y., Sadeghi, S., and Mashhadi, H.R. 2007. Allelopathic effects of barley (*Hordeum vulgare*) on germination and growth of wild barley (*H. spontaneum*). Pakistan Journal of Weed Science Research 13: 99-112.

Ashrafi, Z.Y., Sadeghi, S., and Mashhadi, H.R. 2009. Inhibitive effects of barley (*Hordeum vulgare*) on germination and growth of seedling quack grass (*Agropyrum repens*). Icelandic Agricultural Sciences 22: 37-43.

Ayeni, M.J., and Kayode, J. 2013. Allelopathic effects of aqueous extracts from residues of*Sorghumbicolor* stem and maize inflorescence on the germination and growth of *Euphorbia heterophylla* L. Journal of Plant Studies 2: 1-6.

Ben-Hammouda, M., Kremer, R.J.,and Minor, H.C. 1995. Phytotoxicity of extracts from sorghum plant components on wheat seedlings. Crop Science 35: 1652-1656.

Ben-Hammouda, M., and Oueslati, O. 1999. A germination bioassay to test the allelopathic potential of barley. Rachis 18: 51-54.

Ben-Hammouda, M., Ghorbal, H., Kremer, R.J., and Oueslati, O. 2001. Allelopathic effects of barley extracts on germination and seedlings growth of bread and durum wheat. Agronomie2: 65-71.

Ben-Hammouda, M., Ghorbal, H., Kremer, R.J., and Oueslati, O. 2002. Autotoxicity of barley. Journal of Plant Nutrition 25: 1155-1161.

Ben-Hammouda, M., Oueslati, O., and Ben-Ali, I. 2003. Persistence of the allelopathic potential of durum wheat residues. Pages 245-248. In: Proceeding of the II-nd World Congress on Conservation Agriculture. August 11-15, 2003, Iguassu falls. Parana, Brazil.

Christian, D.G., and Miller, D.P. 1986. Straw incorporation by different tillage systems and the effect on growth and yield of winter oats. Soil and Tillage Res. 8: 239-252.

Christian, D.G., Bacon, E.T.G., Brockie, D., Glen, D., Gutteridge, R.J., and Jenkyn, J.F. 1999. Interactions of straw disposal methods and direct drilling of cultivations on winter wheat (*Triticum aestivum*) grown in a clay soil. Journal of Agriculture Engineering Research 73: 297-309.

Dhima, K.V., Vasilakoglou, B.I., Eleftherohorinos, G., and Lithourgidis, A. S. 2006-a. Allelopathic potential of winter cereal cover crop mulches on grass weed suppression and corn development. Crop Science 46: 345-352.

Dhima, K.V., Vasilakoglou, B.I., Eleftherohorinos, G., and Lithourgidis, A. S. 2006-b.Allelopathic potential of winter cereal cover crop mulches on grass weed suppression and sugar beet development. Crop Science 46: 1682-1691.

Fragasso, M., Platani, C., Miullo, V., Papa, R., and Iannuci, A. 2012. A bioassay to evaluate plant responses to the allelopathic potential of rhizosphere soil of wild oat (*Avena fatua* L.). Agrochimica LVI: 120-128.

Hoult, A.H.C., and Lovett, J.V. 1993. Biologically active secondary metabolites of barley: III: A method for identification and quantification of hordenine and gramine in barley by High-Performance Liquid Chromatography. Journal of Chemical Ecology 19: 2245-2254.

Ma, Y. 2005. Allelopathic studies of common wheat (*Triticum aestivum* L.). Weed Biology and Management 5:93-104.

Oueslati, O. 2003. Allelopathy in two durum wheat (*Triticum durum* L.) varieties. Agriculture Ecosystems &Environment 96: 161-163.

Oueslati, O., Ben-Hammouda, M., Ghorbal, H., Gazzeh, M., and Kremer, R.J. 2005. Barley autotoxicity as influenced by varietal and seasonal variation. Journal of Agronomy and Crop Science 191: 249-254.

Oueslati, O., Ben-Hammouda, M., Ghorbal, H., Gazzeh, M.,and Kremer, R.J. 2009. Role ofphenolic acids in expression of barley (*Hordeumvulgare*) autotoxicity.Allelopathy Journal 23: 157-166.

Oueslati, O. and Ben-Hammouda, M. 2014. Etude du Pouvoir Allélopathique de l'Orge. 1st ed. Presses Académiques Francophones. Saarbrücken, Germany, 70 pp.

Oueslati, O., and Ben-Hammouda, M. 2016. Differential autotoxicity of five cropped barley varieties. Tunisian Journal of Plant Protection. 11: 179-189.

Procházková, B. Málek, J., and Dovrtěl, J. 2002. Effect of different straw management practices on yields of continuous spring barley. Roslinná Výrola 48: 27-32.

Read, J.J. and Jensen, J. H. 1989. Phytotoxicity of water-soluble substances from alfalfa and barley soil extracts on four crop species. Journal of Chemical Ecology 15: 619-628.

Saffari, M., Saffari, V.R., and Torabi-Sirchi, M.H. 2010. Allelopathic appraisal effects of straw extract wheat varieties on the growth of corn. African Journal of Plant Science 4: 427-432.

SAS Institute, Inc. 1992. *SAS Technical Report* P-229, SAS/STAT Software: Changes and Enhancements. Release 6.07, Cary. NC-USA.

Steel, R.G.D. and Torrie, J.H. 1980. *Principles and Procedures of Statistics*, 2nd ed. McGraw-Hillbook, New York.

Tabaglio, V., Marocco, A., and Schulz, M. 2013. Allelopathic cover crop of rye for integrated weed control in sustainable agro ecosystems. Italian Journal of Agronomy 8: 35-40.

Tawaha, A.M., and Turk, M.A. 2003. Allelopathic effects of black mustard (*Brassica nigra*) on germination and growth of wild barley (*Hordeum spontaneum*). Journal of Agronomy and Crop Science 189: 298-303.

Wu, H., Pratley, J.E., Lemerle, D., Haig, T., and Verbeek, B. 1998. Differential allelopathic potential among wheat accessions to annual ryegrass. *In*: 9th Australian Agronomy Conference. July 20-23, 1998, Wagga Wagga, Australia.

Xuan, T.D., Tawata, S., Khanh, T.D., and Chung, I. M. 2005. Decomposition of allelopathic plants in soil. Journal of Agronomy and Crop Science 191: 162-171.

Zuo, S.P., Ma, Y.Q., and Inanaga, S. 2007. Allelopathy variation in dry land winter wheat (*Triticum aestivum* L.) accessions grown on the loess plateau of China for about fifty years. Genetic Resources and Crop Evolution 54: 1381-1393.
