AcademicPres

Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic 1842-4309

Not. Bot. Hort. Agrobot. Cluj 38 (3) 2010, 124-127

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

# Use of Sorghum and Maize Allelopathic Properties to Inhibit Germination and Growth of Wild Barley (*Hordeum spontaneum*)

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**Abstarct**

Herbicidal effects of aqueous extracts of two allelopathic crops, sorghum (*Sorghum bicolor* L.) and maize (*Zea mays* L.) were evaluated against germination and growth of wild barley. Fresh maize and sorghum plants were separated into leaves, stems and roots for vegetative stage. Tissues from each plant parts and mixture of both maize and sorghum parts were soaked in distilled water for 24 h at 24°C in a lighted room to give concentrations of 5, 10 and 15 g of tissue per 100 ml of water. Our results indicated that germination were significantly reduced by extracts of all the test crops. All extracts, except that from sorghum stems and mixture of maize and sorghum stems (MixMSS), significantly reduced hypocotyl length at all concentrations when compared with the water control. Extracts from all plant parts caused a marked reduction in radicle length of wild barley seedlings, ranging between 16 and 47% when compared with the water control. Also all extracts caused emarked reduction in wild barley dry weight at all concentrations when compared with the water control. We concludes that sorghum and maize extracts have significant herbicidal effects on the germination and growth of wild barley.

***Keywords:*** *Sorghum bicolor* L., *Zea mays* L., wild barley, allelopathic crops

## Introduction

Allelopathy is exploit as a weed control strategy, alternative to the commercial herbicide dominated programs(Bhowmik and Inderjit, 2003). Several phytotoxic substances causing germination and/or growth inhibitions have been isolated from plant tissues and soils (Turk and Tawaha, 2003). These substances, collectively known as allelochemicals, are usually secondary plant products or waste products of main metabolic pathways and most of them originate from the shikimic acid and acetate pathway (Rice, 1984; Hall and Henderlong, 1989; Chon and Kim, 2002; Tawaha and Turk, 2003; Turk and Tawaha, 2003). Putnam (1988) reported that allelochemicals are present in almost all plants and in many tissues, like leaves, stems, flowers, fruits, seeds and roots. They are often water-soluble substances that are released into the environment through root exudation, leaching and decomposition of plant residues (Aminidehaghi *et al.,* 2006). Narwal (1994) found that allelochemicals that inhibit the growth of some species at certain concentrations might in fact stimulate the growth of the same or different species at different concentrations. Prvoius research reported that maize and sorghum are a potential allelopathic crops, which possesses a number of allelochemicals at maturity (Lehle and Putnam, 1982). Cheema and Ahmad (1992) observed that sorghum has suppressive effects on different weed species as *Chenopodium album, Phalaris minor, Cyperus rotundus, Senebiera didyma* and *Rumex dentatus.* Kato-Noguchi (1999) found that six substances with inhibitory activity were found in the acetone extract of the maize seedlings, and one substance was higher in light-grown seedlings than in dark-grown ones. One of theses substance was identified as 2,4-dihydroxy-1,4-benzoxazin-3-one (DIBOA). At concentrations greater than 0.03 mM, DIBOA inhibited the growth of roots and hypocotyls of lettuce seedlings (Kato-Noguchi, 1999 ). It is thus essential to identify concentrations at which each specific response occurs if allelopathic interactions are to be used in weed management programmes. In addition, various plant parts may vary in their allelopathic potential (Chon and Kim, 2002; Economou *et al.*, 2002 ; Tawaha and Turk, 2003). The aim of this investigation was to determine damaging effects of maize and sorghum extracts on germination and growth of wild barley.

## Material and methods

*Preparation of extracts*

Maize and sorghum plants were collected from fields in north Jordan during the 2008-2009 growing season. Fresh maize and sorghum plants were separated into leaves, stems and roots for vegetative stage. Tissues from each plant parts and mixture of both maize and sorghum parts were soaked in distilled water for 24 h at 24°C in a lighted room to give concentrations of 5, 10 and 15 g of tissue per 100 ml of water as follow:

After soaking, solutions were filtered through four layers of cheesecloth and the filtrate was then centrifuged (1500 g) for 4 h. The supernatant was filtered again using a 0.2 mm filterware unit to give the final water extract.

Tab. 1. List of treatments and their abbreviations

| Treatments | Abbreviations |
|---|---|
| Maize leaves 5 and 10 and 15g of tissues per 100 ml | ML |
| Maize stem 5 and 10 and 15g of tissue per 100 ml | MS |
| Maize root 5 and 10 and 15g of tissue per 100 ml | MR |
| Mixture of Maize leaves + stem + root 15 g of tissue per 100 ml | MixM |
| Sorghum leaves 5 and 10 and 15g of tissue per 100 ml | SL |
| Sorghum stem 5 and 10 and 15g of tissue per 100 ml | SS |
| Sorghum root 5 and 10 and 15g of tissue per 100 ml | SR |
| Mixture of Sorghum leaves + stem + root 15 g of tissue per 100 ml | MixS |
| Mixture of Maize and Sorghum leaves 5 and 10 and 15g of tissue per 100 ml | MixMSL |
| Mixture of Maize and Sorghum stem 5 and 10 and 15g of tissue per 100 m | mixMSS |
| Mixture of Maize and Sorghum root 5 and 10 and 15g of tissue per 100 ml | mixMSR |

*Seed bioassays*

Two hundred wild barley seeds were surface sterilized with water : bleach solution (10 : 1) and were placed evenly on filter paper in sterilized 9 cm Petri dishes. Ten millilitres of extract solution from each plant part was added to Petri dishes and distilled water was used as a control. All Petri dishes were placed in a lighted room at 24°C. Treatments (extracts from the various plant parts and the distilled water control) were arranged in a completely randomized design with four replications. After 6 days, germination was determined by counting the number of germinated seeds and expressed as total percentage. Radicle and hypocotyl lengths were determined after 8 days by measuring 24 representative seedlings. After measuring the radicle and hypocotyl lengths, the seedlings were separated into hypocotyl and radicle parts. The plants were then dried and their respective dry weights recorded.

*Statistical analyses*

All experiments were repeated twice and pooled mean values were separated using least significant differences (LSD) at the 0.05 probability level following an analysis of variance. Statistical analyses were made with the MSTAT statistical program (Michigan State University, East Lansing, MI).

**Results and discussion**

*Germination*

By contrast, germination of wild barley were significantly reduced by aqueous extracts of all the test species. Germination reductions ranged between 32% and 48%. The degree of inhibition increased for all tissues with increase in extracts concentration from 5 to 15 g per 100 ml of water. The inhibitory potential of the extracts, however, was found to vary with the specific allelopathic species as well as their individual parts used for extract preparation (Tab. 2). Mixture of maize and sorghum leaves had the greatest allelopathic potential at all concentrations (57, 53 and 50% reductions for 5 g, 10 g and 15 g, respectively) and sorghum roots the lowest (65, 61 and 57% reductions for 5 g, 10 g and 15 g, respectively). Mixture of maize and sorghum leaves extract reduced germination by 40, 44 and 47% at concentrations of 5, 10 and 15 g per 100 ml of water, respectively. In general for both species (corn and sorghum) shoot extracts were more effective than root extracts. Al-Saadawi *et al*. (1986) reported that water extracts of different cultivars of sorghum significantly reduced the germination of redroot pigweed (*Amaranthus retroflexus* L.).

Tab. 2. Influence of various concentrations of different aqueous extracts made from maize and sorghum plant parts on the germination of wild barley seeds

| Tissues extracted | Concentration (g per 100 ml of water) | | | |
|---|---|---|---|---|
| | 5 g | 10 g | 15 g | LSD (0.05) |
| Maize leaves (ML) | 59 | 55 | 50 | 4.0 |
| Maize stem (MS) | 65 | 60 | 56 | 3.3 |
| Maize root (MR) | 65 | 57 | 54 | 4.4 |
| Mixture of maize leaves + stems+ roots (MixM) | 61 | 59 | 54 | 3.5 |
| Sorghum leaves (SL) | 61 | 59 | 55 | 3.0 |
| Sorghum stem (SS) | 62 | 56 | 53 | 3.0 |
| Sorghum root (SR) | 65 | 61 | 57 | 3.7 |
| Mixture of sorghum leaves + stem + root (MixS) | 61 | 58 | 56 | 2.9 |
| Mixture of Maize and Sorghum leaves (MixMSL) | 57 | 53 | 50 | 3.0 |
| Mixture of Maize and Sorghum stems (MixMSS) | 57 | 54 | 53 | 2.4 |
| Mixture of Maize and Sorghum roots (MixMSR) | 61 | 56 | 54 | 3.0 |
| LSD (0.05) | 3.0 | 3.2 | 2.9 | |

LSD, least significant differences.Water control = 95. The mixture consisted in mixing equal parts of leaf , stem, flower and root extracts

*Seedling length*

All extracts, except that from sorghum stems and mixture of maize and sorghum stems (MixMSS), significantly reduced hypocotyl length at all concentrations when compared with the water control (Tab. 3). Reductions ranged between 9 and 37%. Aqueous leaf extracts of maize were highly toxic to hypocotyl length of 8-d old of wild barley seedlings compared with other extract. Aqueous extracts of sorghum also exhibited significant phytotoxic activity against hypocotyl length. For all other extracts,

Tab. 3. Influence of various concentrations of different aqueous extracts made from maize and sorghum plant parts on the hypocotyl length of 8-d old of wild barley seedlings

| Tissues extracted | Concentration (g per 100 ml of water) | | | |
|---|---|---|---|---|
| | 5 g | 10 g | 15g | LSD (0.05) |
| Maize leaves (ML) | 4.8 | 4.2 | 3.6 | 0.3 |
| Maize stem (MS) | 5.1 | 4.6 | 4.1 | 0.4 |
| Maize root (MR) | 4.9 | 4.6 | 3.7 | 0.2 |
| Mixture of Maize leaves + stems+ roots (MixM) | 4.7 | 4.5 | 3.9 | 0.4 |
| Sorghum leaves (SL) | 4.9 | 4.4 | 3.8 | 0.3 |
| Sorghum stem (SS) | 5.2 | 5.0 | 4.8 | ns |
| Sorghum root (SR) | 4.9 | 4.3 | 3.7 | 0.3 |
| Mixture of Sorghum leaves + stem + root (MixS) | 5.0 | 4.8 | 4.4 | 0.3 |
| Mixture of Maize and Sorghum leaves (MixMSL) | 4.9 | 4.6 | 4.2 | 0.4 |
| Mixture of Maize and Sorghum stems (MixMSS) | 5.0 | 4.9 | 4.8 | ns |
| Mixture of Maize and Sorghum roots (MixMSR) | 5.2 | 4.7 | 4.3 | 0.3 |
| LSD (0.05 | 0.2 | 0.3 | 0.3 | |

LSD, least significant differences.Water control = 5.7. The mixture consisted in mixing equal parts of leaf , stem, flower and root extracts

Tab. 4. Influence of various concentrations of different aqueous extracts made from maize and sorghum plant parts on the radicle length of 8-d old of wild barley seedlings

| Tissues extracted | Concentration (g per 100 ml of water) | | | |
|---|---|---|---|---|
| | 5 g | 10 g | 15 g | LSD (0.05) |
| Maize leaves (ML) | 4.5 | 4.0 | 3.3 | 0.3 |
| Maize stem (MS) | 5.2 | 4.8 | 4.5 | 0.3 |
| Maize root (MR) | 5.5 | 5.0 | 4.7 | 0.2 |
| Mixture of Maize leaves + stems+ roots (MixM) | 5.1 | 4.8 | 4.5 | 0.3 |
| Sorghum leaves (SL) | 4.0 | 3.8 | 3.2 | 0.2 |
| Sorghum stem (SS) | 5.1 | 5.0 | 4.8 | 0.3 |
| Sorghum root (SR) | 5.2 | 4.9 | 4.6 | 0.3 |
| Mixture of sorghum leaves + stem + root (MixS) | 4.5 | 4.1 | 3.7 | 0.3 |
| Mixture of Maize and Sorghum leaves (MixMSL) | 4.8 | 4.4 | 4.0 | 0.2 |
| Mixture of Maize and Sorghum stems (MixMSS) | 5.0 | 4.7 | 4.2 | 0.3 |
| Mixture of Maize and Sorghum roots (MixMSR) | 4.5 | 4.3 | 4.0 | 0.3 |
| LSD (0.05 | 0.3 | 0.3 | 0.2 | |

LSD, least significant differences.Water control =6.1. The mixture consisted in mixing equal parts of leaf , stem, flower and root extracts

Tab. 5. Influence of various concentrations of different aqueous extracts made from maize and sorghum plant parts on the hypocotyl dry weight of 8-d old of wild barley seedlings

| Tissues extracted | Concentration (g per 100 ml of water) | | | |
|---|---|---|---|---|
| | 5 g | 10 g | 15 g | LSD (0.05) |
| Maize leaves (ML) | 0.96 | 0.93 | 0.83 | 0.05 |
| Maize stem (MS) | 1.20 | 0.92 | 0.89 | 0.04 |
| Maize root (MR) | 1.08 | 0.97 | 0.90 | 0.04 |
| Mixture of Maize leaves + stems+ roots (MixM) | 1.12 | 0.94 | 0.88 | 0.05 |
| Sorghum leaves (SL) | 0.95 | 0.91 | 0.84 | 0.03 |
| Sorghum stem (SS) | 1.08 | 0.97 | 0.94 | 0.04 |
| Sorghum root (SR) | 1.10 | 0.96 | 0.90 | 0.03 |
| Mixture of sorghum leaves + stem + root (MixS) | 0.95 | 0.89 | 0.88 | 0.05 |
| Mixture of Maize and Sorghum leaves (MixMSL) | 0.90 | 0.84 | 0.85 | 0.05 |
| Mixture of Maize and Sorghum stems (MixMSS) | 1.21 | 1.03 | 0.99 | 0.06 |
| Mixture of Maize and Sorghum roots (MixMSR) | 1.20 | 1.13 | 0.89 | 0.04 |
| LSD (0.05 | 0.05 | 0.04 | 0.04 | |

LSD, least significant differences.Water control hypocotyl =1.89. The mixture consisted in mixing equal parts of leaf , stem, flower and root extracts

Tab. 6. Influence of various concentrations of different aqueous extracts made from maize and sorghum plant parts on the radicle dry weight of 8-d old of wild barley seedlings

| Tissues extracted | Concentration (g per 100 ml of water) | | | |
|---|---|---|---|---|
| | 5 g | 10 g | 15 g | LSD (0.05) |
| Maize leaves (ML) | 0.74 | 0.71 | 0.67 | 0.03 |
| Maize stem (MS) | 0.89 | 0.74 | 0.70 | 0.04 |
| Maize root (MR) | 0.88 | 0.74 | 0.72 | 0.03 |
| Mixture of Maize leaves + stems+ roots (MixM) | 0.90 | 0.84 | 0.69 | 0.04 |
| Sorghum leaves (SL) | 0.76 | 0.73 | 0.69 | 0.03 |
| Sorghum stem (SS) | 0.86 | 0.74 | 0.70 | 0.04 |
| Sorghum root (SR) | 0.86 | 0.74 | 0.68 | 0.04 |
| Mixture of sorghum leaves + stem + root (MixS) | 0.78 | 0.71 | 0.68 | 0.04 |
| Mixture of Maize and Sorghum leaves (MixMSL) | 0.73 | 0.66 | 0.64 | 0.05 |
| Mixture of Maize and Sorghum stems (MixMSS) | 0.95 | 0.82 | 0.68 | 0.05 |
| Mixture of Maize and Sorghum roots (MixMSR) | 0.90 | 0.88 | 0.75 | 0.03 |
| LSD (0.05 | 0.03. | 0.03 | 0.05 | |

LSD, least significant differences.Water control radicle = 1.5 g The mixture consisted in mixing equal parts of leaf , stem, flower and root extracts

allelopathicity increased with increases in concentrations. On the other had, root extracts of sorghum were more effective than leaf extracts in the suppression of hypocotyl growth. Earlier, Einhellig and Souza (1992) reported

that root exudates of sorghum reduced the growth of many test weeds. Past research shows that *S. bicolor* contains nine allelochemicals, viz. benzoic acid, phydroxy benzoic acid, vanillic acid, m-coumaric acid, p-coumaric acid, gallic acid, caffeic acid, ferulic acid and chlorogenic acid, which are responsible for its phytotoxic activity against weeds (Cheema, 1988). Netzly and Butler (1986) reported that sorgoleone is an allelochemical exuded from the roots of sorghum that suppresses the growth of weeds. Radicle length was relatively more sensitive to autotoxic allelochemicals than hypocotyls length. Extracts from all plant parts caused a marked reduction in radicle length of wild barley seedlings, ranging between 16 and 47% when compared with the water control. The degree of inhibition increased with the extract concentration. The results were consistent with those previously reported (Chung and Miller, 1995; Turk and Tawaha, 2002) and with our previous studies which showed that water extracts of allelopathic plants generally have more pronounced effects on radicle, rather than hypocotyl, growth. This may be attributable to the fact that radicles are the first to come in contact with allelochemicals.

*Seedling weight*

Both maize and sorghum extracts had similar effects on the hypocotyl and radicle dry weight of 8-d old of wild barley seedlings (Tab. 5 and Tab. 6). All of them caused a marked reduction in wild barley hypocotyl dry weight at all concentrations when compared with the water control, ranging between 35 and 56% (Tab. 5). The response of wild barley radicles was similar to that of hypocotyls, both maize and sorghum extracts causing weight reductions ranging between 36 and 55%. Hypocotyl and radicle dry weight of wild barley was significantly inhibited when extract concentrations increased. These results are in accordance with other studies reporting that inhibitory effects of aqueous extracts of allelopathic grasses viz. *Dicanthium annulatum* Stapf., *Cenchrus pennisetiformis* Hochest, *Sorghum halepense* Pers., *Imperata cylindrica* (L). Beauv. and *Desmostachya bipinnata* Stapf on germination of *P. hysterophorus* (Anjum *et al*., 2005; Javaid and Anjum, 2005).

## Conclusions

The present study concludes that sorghum and maize extracts have significant herbicidal effects on the germination and growth of wild barley. However, further studies are required to identify and isolate the most effective allelochemicals from these two crops and develop natural-product based herbicides to control one of the world's most aggressive weeds.

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