

THE POSSIBLE ROLE OF ALLELOPATHY EXHIBITED BY ROOT EXTRACTS AND EXUDATES OF CHINESE CABBAGE IN HYDROPONICS

Mehmood Akram and Farrukh Hussain*

PCSIR Laboratories, Peshawar

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Aqueous extracts from fresh and dried roots and root exudates of the Chinese cabbage collected on filter papers and in glass vials, besides reducing its own radicle growth, fresh and drymass, also inhibited the growth of mustard (*Brassica campestris*) in various experiments. Extracts from dried roots were more inhibitory than those from fresh root. Mustard was more susceptible than the Chinese cabbage. The inhibitory effects of root exudates or extracts suggested that allelopathy might play a significant role in reducing productivity in hydroponics.

Key words: Roots, Allelopathy, Hydroponics.

INTRODUCTION

Allelopathy is exhibited by many plants [11,17] to render the soil toxic either during the death and decay of plants or parts thereof and/or during their active growth period. Exudation of toxic substance is one of the possible methods in allelopathy. Benedict [2] and Rovira [18] reported inhibitory effects of root exudates. Root exudates from *Lolium* [12], *Dichanthium* [5], *Sorghum* [15], and *Datura* [7] inhibit germination and growth of test species. Root exudates from tobacco seedlings reduced the germination and growth of cultivated plants [6]. Recently more work on allelopathy has been reported [4,9,3,14,17,10].

Seedlings of the Chinese cabbage were raised on stony gravel during a trial experiment on hydroponics to test the working of the unit. Four rows of the unit were arranged in a stair stepway so that nutrients supplied to the topmost row dripped down to the lowermost 4th row in a series (Fig. 1). The plants in the 4th row received nutrient solution after circulation through the 1st, 2nd and 3rd rows. After 15 days the plants growing in the 4th row become yellow and unhealthy (Fig. 2). Every row was provided with 250 seeds and the germination count showed 141, 140, 100 and 81 plants respectively in the 1st, 2nd, 3rd and 4th rows. Since all the physical conditions were seemingly similar, therefore, the authors suspected an allelopathic mechanism in the Chinese cabbage operating through either death and decay of roots and/or its exudates.

Keeping in mind the aforementioned evidences concerning the phyto-toxicity of the root exudates and the observed autotoxicity of the Chinese cabbage, the present

investigation was, therefore, conducted to test the hypothesis whether the Chinese cabbage exhibits allelopathy.

EXPERIMENTAL

1. *Aqueous extract bioassay.* 5 g. fresh or dried roots of the Chinese cabbage were separately soaked in 100 ml distilled water for 24 hrs. at 25°, and filtered and tested against twenty seeds of Chinese cabbage (*Brassica oleracea* Cv. *chinensis*) and mustard (*Brassica campestris*) using our standard technique [8]. There were 5 replicates and seedlings were dried at 65° for 24 hrs. for dry weight determination.

Radicle growth and dry-mass of both test species was reduced by the extracts (Table 1). Growth was reduced

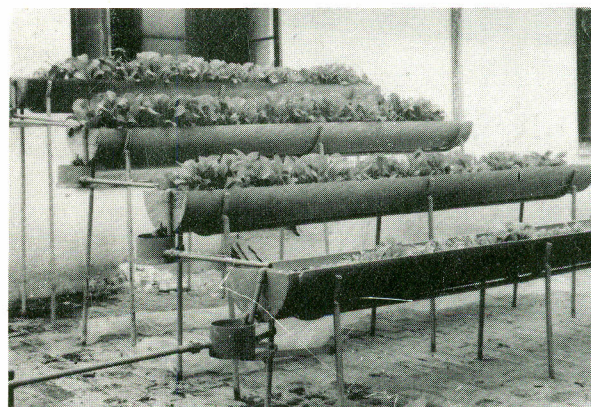


Fig. 1. General view of the set-up of stair-step hydroponic unit showing the flow of nutrients from the first uppermost tray to the lowermost 4th tray through the 2nd and 3rd trays. Compare the number of seedlings, growth and vigour of the Chinese cabbage in the different trays.

*Department of Botany, University of Peshawar, Peshawar.

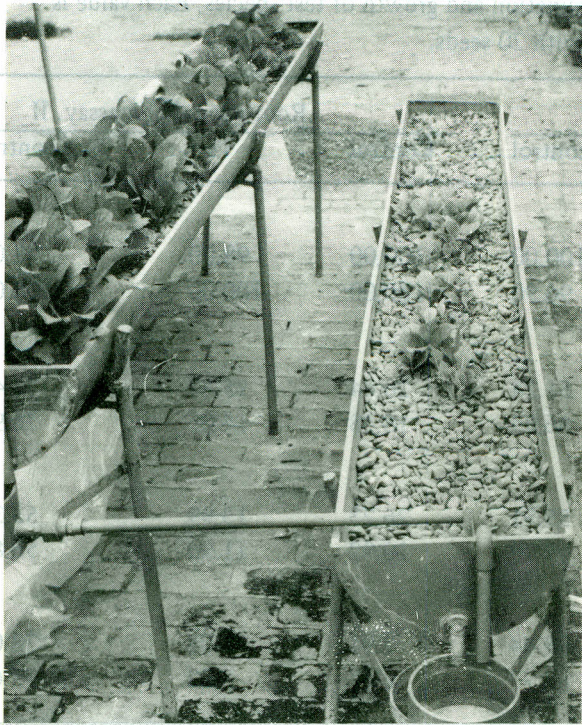


Fig. 2. Close-up view of the Chinese cabbage growing in the 3rd and 4th trays. Notice the inhibited growth of above ground parts in the lowermost 4th tray.

to 82.19 and 65.64 % by fresh root extract in Chinese cabbage and mustard respectively. Dried root extract decreased the growth of the Chinese cabbage and mustard respectively to 53.32 and 33.92 % of control. Drymass of the Chinese cabbage was respectively 81.15 and 74.87 % in the fresh and dried roots extract. Mustard exhibited 76.89 and 62.12 % drymass in fresh and dried roots

treatments. Extract from dried roots was more inhibitory than fresh roots.

2. *Root exudate bioassay: I.* Five, 15-day old, healthy seedlings of the Chinese cabbage were rooted up; and their roots thoroughly washed with tap water followed by distilled water and placed on filter papers in a petri dish for one week. These filter papers were used as growth medium for the germination and growth of aforementioned test species following Haq and Hussain [6]. There were 5 replicates, each with 20 seeds. Germination, radicle growth and freshmass of the seedlings were determined after 48 hr incubation at 25°. Seedlings were dried at 65° for 24 hrs. for the determination of drymass.

3. *Root exudate bioassay II.* Root exudates of the Chinese cabbage were collected in glass vials following Dirvi and Hussain [5]. Twenty seeds of each test species were separately grown in 5 replicates using the exudates after Dirvi and Hussain [5] at 25°. Germination, radicle growth, fresh and drymass of the seedlings were determined.

Radicle growth, fresh and drymass of both the test species were retarded by the root exudates in both bioassays (Table 2). The inhibition ranged from 51.24 in Chinese cabbage to 79.91 % in mustard. The drymass of mustard was reduced to 83.71 and 75.66 % respectively in each of the bioassays. It was 88.44 and 78.00 % for the Chinese cabbage in both bioassays respectively.

DISCUSSION

Root exudates inhibit the growth of susceptible species under favourable physical conditions. The present

Table 1. Effect of fresh and dried root extracts of Chinese cabbage on germination and growth of test species. Each value is a mean of 5 replicates, each with 20 seeds.

Test species	Control	Fresh root extract		Dried root extract	
		Test	% of control	Test	% of control
a. Germination (%)					
Chinese cabbage	100.00	98.00	98.00	98.00	98.00
Mustard	100.00	100.00	100.00	100.00	100.00
b. Radicle growth (mm)					
Chinese cabbage	20.44	16.80	82.19	10.90	53.32
Mustard	18.28	12.00	65.64	6.20	33.92
c. Dry weight (mg).					
Chinese cabbage	3.82	3.10	81.15	2.86	74.87
Mustard	2.64	2.03	76.89	1.64	62.12

Table 2. Effect of root exudates of Chinese cabbage on the germination and growth of test species. Each value is a mean of 5 replicates, each with 20 seeds.

Test species	Root exudate bioassay. I			Root exudate bioassay. II		
	Control	Test	% of control	Control	Test	% of control
a. <i>Germination (%)</i>						
Chinese cabbage	98.00	98.00	100.00	100.00	98.00	98.00
Mustard	97.00	94.00	96.90	100.00	100.00	100.00
b. <i>Radicle growth (mm)</i>						
Chinese cabbage	17.23	8.83	51.24	20.44	15.82	77.40
Mustard	23.98	16.05	66.93	18.28	14.06	76.91
c. <i>Fresh weight (mg)</i>						
Chinese cabbage	28.71	15.88	55.31	26.23	13.99	53.33
Mustard	22.35	13.36	59.78	20.92	11.90	56.88
d. <i>Dry weight (mg)</i>						
Chinese cabbage	2.25	1.99	88.44	3.91	3.05	78.00
Mustard	2.21	1.85	83.77	2.67	2.02	75.66

study indicated that toxins present in root extracts reduced the growth of test species. The results agree with those of other workers [12,7,5,16,14,19,20] who reported upon the inhibitory effects of root extracts and exudates of many plants. The growth medium became unfavourable with the release of toxic root exudates in the presence of sufficient nutrients. Similar results were reported for tobacco [6], *Dichanthium* [5] and for *Sorghum* [15] which support our view. The findings also agree with these other workers [1,2,4,13,14,18,19].

The present findings reveal self-declining growth of seedlings in the lowermost 4th row was owing to its auto-toxicity as it persisted in the presence of nutrient, water and growth medium. Allelopathic intensity is more severe under laboratory conditions like hydroponics where plants grow in sand, gravel or aqueous medium. In such cases a slight addition of toxic root exudates will affect the productivity of desired species. In nature, however, the allelopathic intensity is modified by a number of factors [8,10,13,3]. Like other species of *Brassica* [1] the Chinese cabbage exhibits allelopathy which might outweigh the benefits of hydroponics. An effort is, therefore, needed to avoid allelopathic species. It is also suggested that nutrient solutions should be directly supplied to each row or components of the unit instead of its sequential circulation in various rows or components and the re-use of nutrients solutions may be avoided.

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throughly and approximately 2-3 cm taken from each
 representative samples were used in triplicate
 for residue analysis. Soil from the field and greenhouse
 were analysed with pH.

The effect of different pH in the presence of germs
 their insecticide was studied under different conditions
 aqueous buffer in pH 5, 6, 7, 8, and 9 having an
 same amount of 0.1M water bicarbonate [6] and stored in
 reduced bottles. Analytical grade penicillin diluted with
 acetone was added to each bottle to avoid binding of
 penicillin. After thorough mixing, the bottles were stored
 at room temperature (27°C) for 24 hours in triplicate from each
 pH buffer (emulsion) were collected at 0, 4, 8, 12, 16, 20,
 24, 30 and 60 days post treatment for penicillin residue
 analysis.

Extraction from tomatoes. A 50 g tomato sample was
 well washed and blended with 100 ml hexane in high
 speed for 2-3 min. The hexane extract was filtered through
 glass wool on a Buchner funnel and this procedure of
 extraction with hexane was repeated twice. The hexane
 filtrate were combined and concentrated with a rotary
 vacuum evaporator (40-50°C).

Column. A chromatography column (30x2 cm) was
 prepared by filling the glass column with anhydrous sodium
 sulphate (2 cm) followed by 22 cm deactivated florisil
 (10% H₂O to activated florisil) and an additional layer (2
 cm) of anhydrous sodium sulphate. The column was pre-
 washed with 50 ml hexane. The concentration (2 ml sam-
 ple extract was transferred to the column and allowed to
 penetrate the upper portion of florisil. The sample was
 then eluted with 300 ml hexane + methyl ether (10:1). The
 eluent was collected and evaporated to dryness on rotary
 vacuum evaporator (40-50°C) for GC analysis.

The following use of techniques on agricultural crops
 has necessitated a constant effort to study to use them
 (ideal test conditions for comparison). Penicillin is a water
 soluble antibiotic that is highly stable to germs under
 a wide range of conditions and is highly stable to acids.
 persistence and degradation in penicillin under different
 environmental conditions have been studied by different
 researchers [1,2]. The degradation of penicillin in cotton
 plants is related to high temperature, moisture and micro-
 biological activity [3].

The main objective of the present investigation was
 to study and compare the persistence and degradation of
 penicillin on tomatoes grown under greenhouse and field
 conditions and the behavior of penicillin in the soil and
 its stability in buffer solutions at different pH under con-
 trolled conditions. The results of this investigation should
 help producers identify safe periods for harvesting peni-
 cillin treated tomatoes.

MATERIAL AND METHODS

Field and greenhouse experiments were conducted at
 the Regional Agriculture and Water Research Centre,
 Riyadh, Saudi Arabia. Tomato plants at the stage of physio-
 logical maturity were sprayed with 0.2% Karil penicillin
 10 P EC till canopy using a manual blast sprayer. Some
 plants were left unsprayed as control. Five samples each of
 tomato and soil (under the plants) were collected from
 randomly selected locations in the experimental plot at
 0, 1, 2, 5, 7, 9 and 13 days post treatment. The samples of
 tomato and soil were then separately mixed together