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Research Article

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Synthesis and antifungal activity of aryl aldoxime ethers and esters

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ABSTRACT

Several ether and ester derivatives of aryl aldoximes have been synthesized from the aryl aldehydes. Structures of all new products were established by spectral methods. Many of the obtained compounds showed higher activity against fungal pathogens Botrytis cinerea, Fusarium culmorum, Phytophthora cactorum, and Rhizoctonia solani than the reference substance chlorothalonil, reaching 100% inhibition rate at 200 mg/L concentration.

Keywords: Fungicides, lipophilicity, oxime esters, oxime ethers, partition coefficient, synthesis

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INTRODUCTION

Biological activity of oxime derivatives is known for several decades. They are attractive synthetic goal because of their low toxicity to non-target organisms and unique mode of action [1]. The reported oxime derivatives can be classified into a few groups of compounds. Most are derivatives or analogues of known strobilurins, derivatives of 3-methoxypropenoic acid [2-4] or azoles – pyrazoles and thiazoles [5], benzimidazole [6], triazole [7], thiadiazole [8-9]. To the other classes of known oxime ethers belong macrocyclic ketones or analogue derivatives [10-11], carbamate derivatives [12], triterpene oleanolic acid oxime ester derivatives [13], and benzyl ethers, derivatives of acetophenone oxime and arylaldoxime [14].

Several oxime ethers listed in the Pesticide Manual, such as alloxydim, pyrifenox, and fluxofenim, displayed herbicidal and fungicidal activity [15].

Fungal pathogens *Botrytis cinerea*, *Fusarium culmorum*, *Phytophthora cactorum*, and *Rhizoctonia solani* are a threat to many valuable crops. There is a continuous need for new selective plant protection agents due to appearance of growing pathogens resistance. Therefore we decided to examine the biological potency of the new simple aromatic aldehyde derivatives.

We have been interested in the synthesis and properties of aryl aldehyde Schiff bases for some time. Several salicylaldehyde hydrazones showed a moderate fungicidal and bactericidal activity [16]. In continuation of our work on aryl aldehydes Schiff bases we undertook the synthesis of new oxime derivatives as potentially biologically active compounds. Herein we present results of our research on preparation and biological screening of several aryl aldoxime alkyl ethers as well as acetate and crotonate esters, which were the subject of our recent patent application [17].

EXPERIMENTAL SECTION

Reagent grade chemicals were used without further purification unless otherwise noted. *O*-MOM protective group was introduced following the published procedure [18]. Spectra were obtained as follows: IR spectra on a JASCO FTIR-420 spectrometer, ^{1}H NMR spectra on a Varian 200 UNITY plus 200, spectrometer in deuterated chloroform.

Chemical shifts are given in ppm (δ) relative to TMS as an internal standard, coupling constants are reported in Hz. EI mass spectra were run on a AMD M-40, HR EI mass spectra on a AMD 604. The octanol/water partition coefficients (clog*P*) were calculated using the computer program Hyperchem 7.5.

2.1. A typical procedure for synthesis of oxime ethers 3aa–3ee

A solution of oxime **2a** (0.4 g, 2.2 mmol), DMSO (3 ml), propyl bromide (0.5 g, 4.1 mmol), and potassium hydroxide (0.8 g) in water (6 ml) was stirred at room temperature for half an hour. Then brine was added (15 ml) and the mixture was extracted with ethyl acetate. The organic layer was washed with brine. After drying over anhydrous $MgSO_4$, the solvent was evaporated under vacuum. The product **3ab** was obtained as a yellow oil 0.38 g (77%). IR (neat) 1608, 1511, 1236, 1152, 1014, 952, 834 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.04 (s, 1H, HC=N), 7.51 (dd, *J* = 8.8 Hz, 2H, H-2,6), 7.02 (t, *J* = 8.8 Hz, 2H, H-3,5), 5.19 (s, 2H, O-CH_2-O), 4.10 (t, *J* = 6.8 Hz, 3H, O-CH_2-CH_3), 3.48 (s, 3H, -OCH_3), 0.97 (t, *J* = 7.5 Hz, 3H, CH_3). EI MS m/z (% intensity) 223 (58), 192 (8), 164 (5), 151 (15). HR EI MS calcd. for $C_{12}H_{17}NO_3$: 223.1208, found: 223.1203.

2.1.1. ***(E)*-4-Methoxymethoxybenzaldoxime O-ethyl ether (3aa)**

A yellow oil (67%); IR (neat) 3000, 1649, 1511, 1438, 1237, 1153, 1016, 953, 709 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) *δ* 8.03 (s, 1H, HC=N), 7.52 (d, *J* = 8.8 Hz, 2H, H-2,6), 7.03 (d, *J* = 8.8 Hz, 2H, H-3,5), 5.19 (s, 2H, OCH_2O), 4.21 (q, *J* = 7.0 Hz, 2H, O-$\underline{CH_2}$-CH_3), 3.47 (s, 3H, O-CH_2-O-$\underline{CH_3}$), 1.3 (t, *J* = 7.0 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 209 (75), 179 (30), 151 (20), 134 (7). HR EI MS calcd. for $C_{11}H_{15}NO_3$: 209.1052, found: 209.1055.

2.1.2. *(E)*-4-methoxymethoxybenzaldoxime *O*-2-propyl ether (3ac)

A yellow oil (85%); IR (neat) 2974, 1607, 1511, 1236, 1153, 972, 834 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) *δ* 8.01 (s, 1H, HC=N), 7.52 (d, *J* = 8.8 Hz, 2H, H-2,6), 7.02 (d, *J* = 8.8 Hz, 2H, H-3,5), 5.19 (s, 2H, OCH_2O), 4.42 (septuplet, 1H, $(CH_3)_2$-$\underline{CH}$), 3.48 (s, 3H, O-CH_2-O-$\underline{CH_3}$), 1.3 (d, *J* = 6.4 Hz, 6H, CH_3). EI MS *m/z* (%) 223 (74), 192 (44), 181 (41), 516 (64). HR EI MS calcd. for $C_{12}H_{17}NO_3$: 223.1208, found: 223.1216.

2.1.3. *(E)*-4-Methoxymethoxybenzaldoxime *O*-butyl ether (3ad)

A yellow oil (52%); IR (neat) 2958, 1607, 1511, 1309, 1236, 1153, 997, 834 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) *δ* 8.03 (s, 1H, HC=N), 7.51 (d, *J* = 8.9 Hz, 2H, H-2,6), 7.02 (d, *J* = 8.9 Hz, 2H, H-3,5), 5.19 (s, 2H, OCH_2O), 4.15 (t, *J* = 6.6; 13.2 Hz, 2H, O-$\underline{CH_2}$-CH_2), 3.48 (s, 3H, O-CH_2-O-$\underline{CH_3}$), 0.95 (t, *J* = 7.2Hz, CH_3). EI MS *m/z* (% of intensity) 237 (54), 236 (17), 206 (47). HR EI MS calcd. for $C_{13}H_{19}NO_3$: 237.1365, found: 237.1365.

2.1.4. *(E)*-4-Methoxymethoxybenzaldoxime *O*-pentyl ether (3ae)

A yellow oil (46%); IR (neat) 2932, 1607, 1511, 998, 834 cm^{-1} ; ^1H NMR ($CDCl_3$, 200 MHz) *δ* 8.03 (s, 1H, HC=N), 7.51 (d, *J* = 9.0 Hz, 2H, H-2,6), 7.03 (d, *J* = 9.0 Hz, 2H, H-3,5), 5.19 (s, 2H, O-CH_2-O), 4.14 (t, *J* = 6.6 Hz, 2H, O-$\underline{CH_2}$-CH_2), 3.48 (s, 3H, OCH_3), 0.92 (m, 3H, CH_3). EI MS *m/z* (%of intensity) 251 (60), 250 (23), 220 (60), 192 (46). HR EI MS calcd. for $C_{14}H_{21}NO_3$: 251.1521, found: 251.1527.

2.1.5. *(E)*-2-Methoxymethoxybenzaldoxime *O*-ethyl ether (3ba)

A yellow oil (96%); IR (neat) 3441, 2878, 1605, 1485, 1239, 1154, 1052, 998, 757 cm^{-1} ; ^1H NMR ($CDCl_3$, 200 MHz) *δ* 8.49 (s, 1H, HC=N), 7.81 (ddd, *J* = 8.0; 1.7; 0.5 Hz, 1H, H-6), 7.31 (m, 1H, H-4), 7.11 (dd, *J* = 8.4; 1.3 Hz, 1H, H-3), 7.00 (m, 1H, H-5), 5.20 (s, 2H, O-CH_2-O), 4.23 (q, *J* =7.0 Hz, 2H, O-CH_2CH_3), 3.47 (s, 3H, OCH_3), 1.33 (t, *J* = 7.0 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 209 (30), 178 (55), 164 (55), 132 (50). HR EI MS calcd. for $C_{11}H_{15}NO_3$: 209.1052, found: 209.1057.

2.1.6. ***(E)*-2-Methoxymethoxybenzaldoxime *O*-propyl ether (3bb)**

A yellow oil (85%); IR (neat) 2964, 1605, 1485, 1340, 1239, 1154, 988, 756, 628 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) *δ* 8.49 (s, 1H, HC=N), 7.81 (dd, *J* = 1.6; 7.8 Hz, 1H, H-6), 7.30 (m, 1H, H-4), 7.09 (dd, *J* =8.6; 1.2 Hz, 1H, H-3), 6.99 (tm, *J* = 7.0 Hz, 1H, H-5), 5.21 (s, 2H, O-CH_2-O, 4.13 (t, *J* = 6.7 Hz, 2H, O-$\underline{CH_2}$-CH_2-CH_3), 3.48 (s, 3H, OCH_3), 1.74 (sextuplet, *J* = 7.2 Hz, 2H, $CH_2\underline{CH_2}CH_3$), 0.98 (t, *J* = 7.5 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 223 (30), 164 (70), 132 (52), 119 (35). HR EI MS calcd. for $C_{12}H_{17}NO_3$: 223.1208, found: 223.1207.

2.1.7. *(E)*-2-Methoxymethoxybenzaldoxime *O*-2-propyl ether (3bc)

A yellow oil (66%); IR (neat) 2974, 1603, 1486, 1239, 1154, 1080, 972, 756 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) *δ* 8.47 (s, 1H, HC=N), 7.81 (dd, *J* = 1.9; 7.8 Hz, 1H, H-6), 7.30 (m, 1H, H-4), 7.12 (dd, *J* = 0.8; 7.6 Hz, 1H, H-3), 7.00 (t, *J* = 7.7 Hz, 1H, H-5), 5.19 (s, 2H, O-CH_2-O), 4.46 (septuplet, *J* = 6.2 Hz, 1H, $\underline{CH}$-$(CH_3)_2$), 3.47 (s, 3H, O-$\underline{CH_3}$), 1.31 (d, *J* = 6.2 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 223 (35), 164 (70), 132 (48), 119 (60). HR EI MS calcd. for $C_{12}H_{17}NO_3$: 223.1208, found: 223.1204.

2.1.8. *(E)*-2-Methoxymethoxybenzaldoxime *O*-butyl ether (3bd)
A yellow oil (73%); IR (neat) 2959, 1606, 1486, 1239, 1154, 997, 755 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.49 (s, 1H, HC=N), 7.88 (dd, J = 2.0; 7.8 Hz, 1H, H-6), 7.31 (m, 1H, H-4), 7.11 (dd, J = 8.4; 1.0 Hz, H-3), 7.00 (m, 1H, H-5), 5.20 (s, 2H, O-CH_2-O), 4.17 (t, J = 6.6 Hz, 2H, O$\underline{CH_2}$-$(CH_2)_2$), 3.48 (s, 3H, O$\underline{CH_3}$), 1.68 (m, 2H, $\underline{CH_2}$-CH_2-O), 1.44 (m, 2H), 0.96 (t, J = 7.0 Hz, 3H, $\underline{CH_3}$-CH_2). EI MS *m/z* (% of intensity) 237 (14), 164 (55), 132 (40), 45 (100). HR EI MS calcd. for $C_{13}H_{19}NO_3$: 237.1365, found: 237.1368.

2.1.9. *(E)*-2-Methoxymethoxybenzaldoxime *O*-pentyl ether (3be)
A yellow oil (46%); IR (neat) 2932, 1605, 1485, 1457, 1378, 1239, 1204, 1105, 1080, 997, 755, 628 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.49 (s, 1H, HC=N), 7.81 (dd, J = 1.8; 7.6 Hz, 1H, H-6), 7.31 (m, 1H, H-4), 7.10 (m, 1H, H-3), 7.0 (m, 1H, H-5), 5.20 (s, 2H, O-CH_2-O), 4.16 (t, J = 6.8 Hz, 2H, $\underline{CH_2}$-$(CH_2)_2$), 3.48 (s, 3H, O-$\underline{CH_3}$), 1.72 (m, 2H, $\underline{CH_2}CH_2O$), 1.39 (m, 4H), 0.92 (t, J = 7.0 Hz, 3H, $\underline{CH_3}CH_2$). EI MS *m/z* (% of intensity) 251 (13), 164 (56), 119 (41), 45 (100). HR EI MS calcd. for $C_{14}H_{21}NO_3$: 251.1521, found: 251.1532.

2.1.10. *(E)*-2-Methoxymethoxy-5-chlorobenzaldoxime *O*-ethyl ether (3ca)
A yellow oil (85%); IR (neat) 2977, 1481, 1401, 1241, 1158, 1126, 1080, 1052, 992, 813 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.39 (s, 1H, HC=N), 7.79 (d, J = 2.6 Hz, 1H, H-6), 7.27 (dd, J = 8.8; 2.6 Hz, H-4), 7.05 (d, J = 8.8 Hz, 1H, H-3), 5.18 (s, 2H, O-CH_2-O), 4.23 (q, J =7.1 Hz, 2H, -O-$\underline{CH_2}CH_3$), 3.47 (s, 3H, -OCH_3), 1.33 (t, J =7.1 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 243 (10), 214 (80), 198 (12), 142 (100). HR EI MS calcd. for $C_{11}H_{14}ClNO_3$: 243.0662, found: 243.0669.

2.1.11. *(E)*-2-Methoxymethoxy-5-chlorobenzaldoxime *O*-propyl ether (3cb)
A yellow oil (85%); IR (neat) 2964, 1481, 1401, 1241, 1158, 1126, 1080, 990, 813 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.40 (s, 1H, HC=N), 7.79 (d, J = 2.8 Hz, 1H, H-6), 7.25 (dd, J =8.8; 2.6 Hz, 1H, H-4), 7.05 (d, J =8.8 Hz, 1H, H-3), 5.18 (s, 2H, O-$\underline{CH_2}$-O), 4.13 (t, J = 6.8 Hz, 2H, O-$\underline{CH_2}$-CH_2), 3.47 (s, 3H, OCH_3), 1.74 (sextuplet, J = 7.6 Hz, 2H, $CH_2\underline{CH_2}CH_3$), 0.98 (t, J = 7.8; 7.4 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 257 (20), 198 (30), 166 (20), 153 (40). HR EI MS calcd. for $C_{12}H_{16}ClNO_3$: 257.0819, found: 257.0823.

2.1.12. *(E)*-2-Methoxymethoxy-5-chlorobenzaldoxime *O*-2-propyl ether (3cc)
A yellow oil (65%); IR (neat) 2975, 1482, 1401, 1370, 1322, 1241, 1158, 1125, 1080, 977, 813, 625 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.38 (s, 1H, HC=N), 7.79 (d, J = 2.6 Hz, 1H, H-6), 7.45 (dd, J = 8.8; 2.6 Hz, 1H, H-4), 7.05 (d, J = 8.8 Hz, 1H, H-3), 5.17 (s, 2H, O-$\underline{CH_2}$-O), 4.46 (septuplet, J = 6.2 Hz, 1H, $(CH_3)_2$-$\underline{CH}$), 3.46 (s, 3H, OCH_3), 1.29 (t, J = 6.2 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 257 (14), 198 (22), 153 (31), 45 (100). HR EI MS calcd. for $C_{12}H_{16}ClNO_3$: 257.0819, found: 257.0820.

2.1.13. *(E)*-2-Methoxymethoxy-5-chlorobenzaldoxime *O*-butyl ether (3cd)
A yellow oil (61%); IR (KBr) 2959, 1481, 1241, 1158, 992 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.39 (s, 1H, HC=N), 7.79 (d, J = 2.8 Hz, 1H, H-6), 7.22 (dd, J = 9.0; 2.6 Hz, H-4), 7.05 (d, J = 9.0 Hz, 1H, H-3), 5.18 (s, 2H, O-CH_2-O), 4.18 (t, J = 7.0 Hz, 2H, O-$\underline{CH_2}$-CH_2), 3.47 (s, 3H, OCH_3), 0.96 (t, J =7.4 Hz, 3H, CH_3). 1.71 (m, 2H, $\underline{CH_2}CH_2O$), 1.43 (m, 2H), 0.96 (t, J = 7.4 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 271 (19), 200 (22), 198 (31), 153 (47). HR EI MS calcd. for $C_{13}H_{18}ClNO_3$: 271.0984, found: 271.0983.

2.1.14. (*E*)-2-Methoxymethoxy-5-chlorobenzaldoxime *O*-pentyl ether (3ce)
A yellow oil (48%); IR (neat) 2933, 1481, 1241, 1158, 1126, 1080, 991, 813 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.39 (s, 1H, HC=N), 7.79 (d, J = 2.6 Hz, 1H, H-6), 7.24 (dd, J = 9.0; 2.6 Hz, 1H, H-4), 7.06 (d, J = 9.0 Hz, 1H, H-3), 5.18 (s, 2H, O-$\underline{CH_2}$-O), 4.17 (t, J =6.6 Hz, 2H, O-$\underline{CH_2}$-CH_2), 3.47 (s, 3H, OCH_3), 1.72 (m, 2H, $OCH_2\underline{CH_2}$), 1.36 (m, 4H, $\underline{CH_2}CH_2CH_3$), 0.92 (s, 3H, CH_3). EI MS *m/z* (% of intensity) 285 (26), 200 (18), 198 (48), 153 (58). HR EI MS calcd. for $C_{14}H_{20}ClNO_3$: 285.1132, found: 285.1131.

2.1.15. *(E)*-4-(2-propyl)benzaldoxime *O*-ethyl ether (3da)
A yellow oil (67%); IR (neat) 2962, 1055, 933, 830 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.06 (s, 1H, HC=N), 7.50 (d, J = 8.4 Hz, 2H, H-2,6), 7.22 (d, J = 8.4 Hz, 2H, H-3,5), 4.21 (q, J = 7.2 Hz, 2H, CH_2O), 2.92 (m, 1H, -CH-), 1.32 (t, J = 7.2 Hz, 3H, $CH_2\underline{CH_3}$), 1.25 (d, J = 6.8 Hz, 6H, $(\underline{CH_3})_2$-CH). EI MS *m/z* (% of intensity) 191 (93), 176 (100), 148 (55), 130 (33). HR EI MS calcd. for $C_{12}H_{17}NO$: 191.1310, found 191.1305.

2.1.16. *(E)*-4-(2-propyl)benzaldoxime *O*-propyl ether (3db)
A yellow oil (68%); IR (neat) 2962, 1461, 1056, 991, 936, 829 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.06 (s, 1H, HC=N), 7.50 (d, J = 8.2 Hz, 2H, H-2,6), 7.22 (d, J = 8.2 Hz, 2H, H-3,5), 4.11 (t, J = 6.8 Hz, 2H, CH_2O), 2.91 (m, 1H, $(CH_3)_2$-$\underline{CH}$), 1.73 (m, 2H, $\underline{CH_2}$-CH_3), 1.25 (d, J = 6.8 Hz, 6H, $(\underline{CH_3})_2$-CH), 0.97 (t, J = 7.2 Hz, 3H, $\underline{CH_3}$-CH_2).

EI MS *m/z* (% of intensity) 205 (83), 190 (45), 148 (100), 132 (81). HR EI MS calcd. for $C_{13}H_{19}NO$: 205.1470, found: 205.1470.

2.1.17. *(E)*-4-(2-propyl)benzaldoxime *O*-2-propyl ether (3dc)
A yellow oil (69%); IR (neat) 2965, 1321, 1123, 976, 829 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.04 (s, 1H, HC=N), 7.5 (d, *J* = 8.4 Hz, 2H, H-2,6), 7.22 (d, *J* = 8.4 Hz, 2H, H-3,5), 4.44 (m, 1H, $(CH_3)_2$-CH-O), 2.91 (m, 1H, $(CH_3)_2$-CH), 1.30 (d, *J* = 8.2 Hz, 6H, $(CH_3)_2$-CH-O), 1.25 (d, *J* = 7.0 Hz, 6H, $(CH_3)_2$-CH-O). EI MS *m/z* (% of intensity) 205 (1), 148 (100), 146 (48), 130 (30). HR EI MS calcd. for $C_{13}H_{19}NO$: 205.1471, found: 205.1471.

2.1.18. *(E)*-4-(2-propyl)benzaldoxime *O*-butyl ether (3dd)
A yellow oil (67%); IR (neat) 2960, 1462, 1054, 951, 829 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.06 (s, 1H, HC=N), 7.50 (d, *J* = 8.1 Hz, 2H, H-2,6), 7.22 (d, *J* = 8.1 Hz, 2H, H-3,5), 4.16 (t, *J* = 6.6 Hz, 2H, CH_2O), 2.91 (m, 1H, $(CH_3)_2$-CH), 1.70 (m, 2H, OCH_2CH_2), 1.45 (m, 2H, $CH_2CH_2CH_2$), 1.25 (d, *J* = 6.8 Hz, 6H, $(CH_3)_2$-CH), 0.91 (t, *J* = 7.0 Hz, 3H, CH_3-CH_2). EI MS *m/z* (% of intensity) 219 (21), 77 (26), 57 (28), 41 (55). HR EI MS calcd. for $C_{14}H_{21}NO$: 219.1628, found: 219.1633.

2.1.19. *(E)*-4-(2-propyl)benzaldoxime *O*-pentyl ether (3de)
A yellow oil (70%); IR (neat) 2959, 1460, 1056 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.06 (s, 1H, HC=N), 7.50 (d, *J* = 8.2 Hz, 2H, H-2,6), 7.22 (d, *J* =8.2 Hz, 2H, H-3,5), 4.15 (t, *J* =6.6 Hz, 2H, CH_2O), 2.91 (m, 1H, $(CH_3)_2$-CH), 1.71 (m, 2H, OCH_2CH_2), 1.36 (m, 4H), 1.25 (d, *J* = 7.0 Hz, 6H, $(CH_3)_2$-CH), 0.91 (t, *J* = 6.8 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 233 (42), 202 (36), 188 (60), 174 (65), 160 (70). HR EI MS calcd. for $C_{15}H_{23}NO$: 233.1780, found: 233.1775.

2.1.20. *(E)*-2,4-Dichlorobenzaldoxime *O*-ethyl ether (3ea)
A yellow oil (68%); IR (neat) 2977, 1587, 1477, 1384, 1126, 1047, 969, 850, 821 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.42 (s, 1H, HC=N), 7.40 (d, *J* = 8.6 Hz, 1H, H-6), 7.38 (d, *J* = 2.0 Hz, 1H, H-3), 7.24 (dd, *J* = 8.6; 2.2 Hz, 1H, H-5), 4.25 (q, *J* = 7.1 Hz; 2H, O-CH_2), 1.33 (t, *J* = 7.1 Hz; 3H, O-CH_3). EI MS *m/z* (% of intensity) 217 (94), 191 (25), 174 (40), 172 (55). HR EI MS calcd. for $C_9H_9Cl_2NO$: 217.0048, found: 217.0051.

2.1.21. *(E)*-2,4-Dichlorobenzaldoxime *O*-propyl ether (3eb)
A yellow oil (63%); IR (neat) 2965, 1588, 1472, 1383, 1059, 993, 944, 864, 821 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.43 (s, 1H, HC=N), 7.84 (d, *J* = 8.6 Hz, 1H, H-6), 7.39 (d, *J* = 2.0 Hz, 1H, H-3), 7.23 (dd, *J* = 8.6; 2.0 Hz, 1H, H-5), 4.15 (t, *J* = 6.6 Hz; 2H, O-CH_2), 1.74 (m, 2H, -CH_2-), 0.89 (t, *J* = 7.4 Hz; 3H, CH_3). EI MS *m/z* (% of intensity) 231 (34), 119 (23), 189 (35), 172 (66). HR EI MS calcd. for $C_{10}H_{11}Cl_2NO$: 231.0204, found: 231.0207.

2.1.22. *(E)*-2,4-Dichlorobenzaldoxime *O*-2-propyl ether (3ec)
A yellow oil (67%); IR (neat) 2976, 1588, 1473, 1381, 1122, 1053, 982, 830 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.40 (s, 1H, HC=N), 7.85 (d, *J* = 8.6 Hz, 1H, H-6), 7.39 (d, *J* = 2.2 Hz, 1H, H-3), 7.23 (dd, *J* = 8.6; 2.2 Hz, 1H, H-5), 4.67 (septuplet; *J* = 6.2 Hz, 1H, O-CH-), 1.29 (d, *J* = 6.2 Hz; 6H, -CH_3). EI MS *m/z* (% of intensity) 231 (11), 189 (23), 149 (12), 111 (18). HR EI MS calcd. for $C_{10}H_{11}Cl_2NO$: 231.0213, found: 231.0210.

2.1.23. *(E)*-2,4-Dichlorobenzaldoxime *O*-butyl ether (3ed)
A yellow oil (79%); IR (neat) 2959, 2873, 1587, 1472, 1380, 1208, 1101, 1062, 968, 929, 965, 821 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.42 (s, 1H, HC=N), 7.84 (d, *J* = 8.4 Hz, 1H, H-6), 7.39 (d, *J* = 2.0 Hz, 1H, H-3), 7.23 (dd, *J* = 8.6; 2.0 Hz, 1H, H-5), 4.19 (t, *J* =6.6 Hz; 2H, O-CH_2), 1.71 (m, 2H, CH_2CH_2O), 1.44 (m, 2H), 0.96 (t, *J* = 7.4 Hz, 3H, -CH_3). EI MS *m/z* (% of intensity) 245 (14), 214 (26), 200 (26), 180 (56). HR EI MS calcd. for $C_{11}H_{13}Cl_2NO$: 245.0369, found: 245.0369.

2.1.24. *(E)*-2,4-dichlorobenzaldoxime *O*-pentyl ether (3ee)
A yellow oil (69%); IR (neat) 2932, 1588, 1471, 1380, 1057, 864, 821 cm^{-1}; ^1H NMR ($CDCl_3$, 200 MHz) δ 8.42 (s, 1H, HC=N), 7.84 (d, *J* = 8.6 Hz, 1H, H-6), 7.39 (d, *J* = 2.2 Hz, 1H, H-3), 7.23 (dd, *J* = 8.6; 2.0 Hz, 1H, H-5), 4.18 (t, *J* = 6.8 Hz; 2H, O-CH_2), 1.72 (m, 2H, -CH_2-), 1.36 (m, 4H), 0.92 (m, 3H, -CH_3). EI MS *m/z* (% of intensity) 259 (38), 230 (48), 228 (53), 216 (62). HR EI MS calcd. for $C_{12}H_{15}Cl_2NO$: 259.0533, found: 259.0533.

2.2. Deprotection of oxime ethers
A solution of ether **3ba** (0.092 g, 0.44 mmole) was added to the solution of conc. HCl (1 drop) in methanol (4 mL) and the mixture was heated to reflux for 26 h. The solvent was removed *in vacuo*, water was added and the mixture was extracted with dichloromethane (3x5 mL). The solution was dried ($MgSO_4$) and the solvent was evaporated *in vacuo* to yield a phenol oxime ether as an oil, 0.056 g (86%). IR (neat) 2979, 1609, 1490, 1266, 1052, 957, 755 cm^{-1};

^{1}H NMR ($CDCl_3$, 200 MHz) δ 9.96 (s, 1H, OH), 8.17 (s, 1H, HC=N), 7.23 (m, 2H, H-4,6), 6.94 (m, 2H, H-3,5), 4.23 (q, *J* = 7.0 Hz, 2H, O-CH_2-CH_3), 1.35 (t, *J* = 7.0 Hz, 3H, CH_3).

2.3. A typical procedure for synthesis of oxime ethers *3af– 3ef*

A mixture of oxime **2c** (0.43 g, 2 mmol), DMSO (3 ml), ethyl bromoacetate (0.5 mL, 4.95 mmol) and potassium carbonate (3 g) in water (2 ml) was stirred at room temperature for 18 h. Then 20 ml of brine was added and the solution was extracted with ethyl acetate. After drying over anhydrous $MgSO_4$, the solvent was evaporated under vacuum. The product **3cf** was obtained as a yellow oil 0.45 g (75%); IR (neat) 2934, 1759, 1482, 1402, 1202, 1158, 1079, 987, 815 cm^{-1}. ^{1}H NMR ($CDCl_3$, 200 MHz) *δ* 8.54 (s, 1H, HC=N), 7.76 (d, *J* = 2.6 Hz, 1H, H-6), 7.26 (dd, *J* = 9.0; 2.6 Hz, 1H, H-3), 7.06 (d, *J* = 9.0 Hz, 1H, H-4), 5.18 (s, 2H, O-CH_2-O), 4.71 (s, 2H, O-CH_2-C=O), 4.26 (q, *J* = 7.0 Hz, 2H, O-$\underline{CH_2}CH_3$), 3.47 (s, 3H, OCH_3), 1.31 (t, *J* = 7.0 Hz, 3H, CH_3-C). EI MS *m/z* (% of intensity) 301 (12), 200 (12), 166 (11), 153 (39). HR EI MS calcd. for $C_{13}H_{16}ClNO_5$: 301.0717, found: 301.0722.

2.3.1. *(E)*-Ethyl 4-methoxymethoxybenzaldoxime *O*-acetate (3af)

A yellow oil (69%); IR (neat) 2932, 1754, 1606, 1510, 1152, 999, 836 cm^{-1}. ^{1}H NMR ($CDCl_3$, 200 MHz) *δ* 8.16 (s, 1H, HC=N), 7.52 (d, *J* = 8.8 Hz, 2H, H-2,6), 7.02 (d, *J* = 8.8 Hz, 2H, H-3,5), 5.20 (s, 2H, O-CH_2-O), 4.69 (s, 2H, O-CH_2-C=O), 4.25 (q, *J* = 7.2 Hz, 2H, -O$\underline{CH_2}CH_3$), 3.48 (s, 3H, -O-CH_3), 1.29 (t, *J* = 7.2 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 267 (75), 137 (20), 164 (21), 134 (20). HR EI MS calcd. for $C_{13}H_{17}NO_5$: 267.1107, found: 267.1108.

2.3.2.*(E)*-Ethyl 2-methoxymethoxybenzaldoxime *O*-acetate (3bf)

A yellow oil (69%); IR (neat) 2983, 1737, 1373, 1241, 1155, 1046, 759 cm^{-1}. ^{1}H NMR ($CDCl_3$, 200 MHz) *δ* 8.63 (s, 1H, HC=N), 7.77 (dd, *J* = 1.4; 7.8 Hz, 1H, H-6), 7.32 (ddd, *J* = 2.0; 7.6; 8.4 Hz, 1H, H-4), 7.12 (dd, *J* = 1.0; 8.2 Hz, 1H, H-3), 6.98 (td, *J* = 0.4; 7.4; 7.2 Hz, 1H, H-5), 5.21 (s, 2H, O-CH_2-O), 4.71 (s, 2H, O-CH_2C=O). EI MS *m/z* (% of intensity) 164 (12), 133 (15), 119 (10), 102 (7).

2.3.3. *(E)*-Ethyl 4-(2-propyl)benzaldoxime *O*-acetate (3df)

A yellow oil (67%); IR (neat) 2963, 1739, 1283, 1103, 958, 831 cm^{-1}. ^{1}H NMR ($CDCl_3$, 200 MHz) *δ* 8.12 (s, 1H, HC=N), 7.50 (d, *J* = 8.0 Hz, 2H, H-2,6), 7.24 (d, *J* = 8.0 Hz, 2H, H-3,5), 4.70 (s, 2H, O-CH_2-OC=O), 4.26 (m, 2H, -O-C_2H_5), 2.92 (m, 1H, $(CH_3)_2$-$\underline{CH}$), 1.26 (t, *J* = 7.0 Hz, 2H, -CH_3), 1.25 (d, *J* = 6.8 Hz, 6H, $(\underline{CH_3})_2$-CH). EI MS *m/z* (% of intensity) 249 (5), 163 (86), 148 (100), 130 (53). HR MS calcd. for $C_{14}H_{19}NO_3$: 249.1365, found: 249.1360.

2.3.4. *(E)*-Ethyl 2,4-dichloro) benzaldoxime *O*-acetate (3ef)

A yellow oil (75%); IR (neat) 2982, 1761, 1587, 1473, 1381, 1205, 1100, 1052, 1025, 917, 872 cm^{-1}. ^{1}H NMR ($CDCl_3$, 200 MHz) *δ* 8.57 (s, 1H, HC=N), 7.80 (d, *J* = 8.6 Hz, 1H, H-6), 7.40 (d, *J* = 1.8 Hz, 1H, H-3), 7.23 (dd, *J* = 8.6; 2.0 Hz, 1H, H-5), 4.73 (s, 2H, O-CH_2-C=O), 4.25 (q, *J* =7.2 Hz, 2H, O-CH_2), 1.31 (t, *J* = 7.2 Hz, 3H, CH_3). EI MS *m/z* (% of intensity) 275 (30), 176 (22), 172 (100), 147 (33). HR EI MS calcd. for $C_{11}H_{11}Cl_2NO_3$: 275.0116, found: 275.0116.

2.4. A typical procedure for synthesis of oxime esters *3bg, 3eg*

A solution of the oxime **2e** (0.78 g, 4.1 mmol) and triethylamine (0.41 g, 4.1 mmol) in methylene chloride (20 ml) was stirred at 0 °C for 5 minutes. Then a solution of crotonoyl chloride (0.82 ml, 4.1 mmol) was added and the solution was stirred for 20 hours at room temperature. After this time, the reaction mixture was washed successively with 10% cold acetic acid (5 ml), 10% sodium carbonate (5 ml), brine and water. Product **3eg** was obtained as a white solid 0.72 g (68%), mp. 48-49 °C. IR (KBr) 1753, 1654, 1584, 1475, 1387, 1296, 1141, 1091, 986, 826 cm^{-1} ; ^{1}H NMR ($CDCl_3$, 200 MHz) δ 8.78 (s, 1H, HC=N), 7.62 (d, *J* = 8.4 Hz, 1H, H-6'), 7.55 (d, *J* = 1.8 Hz, 1H, H-3'), 7.42 (qd, *J* = 15.8; 7.0 Hz, 1 H, H-3), 7.38 (dd, *J* = 8.4; 1.9 Hz, 1H, H-5'), 5.97 (dd, *J* = 15.8; 1.9 Hz; 1H, -CH=CH-), 1.97 (dd, *J* =7.0; 1.9 Hz, 3H). EI MS m/z (% intensity) 173 (17), 171 (23), 147 (20), 136 (31). HR EI MS calcd. for $C_{11}H_9Cl_2NO_2$: 257.0010, found: 257.0018.

2.4.1. (*E*)-2-methoxymethoxybenzaldoxime crotonate (3bg)

A yellow oil (67 %); IR (KBr) 2959, 1747, 1374, 1239, 1049 cm^{-1} ; ^{1}H NMR ($CDCl_3$, 200 MHz) δ 8.45 (s, 1H, HC=N), 7.54 (m, 1H, H-4), 7.23 (m, 1H, H-3), 7.10 (m, 1H, H-5), 6.92 (m, 1H, H-6), 5.96 (dq, J=16.6; 1.6 Hz, 2H, H-7), 5.31 (s, 1H, H-8), 5.24 (s, 2H, -O-CH $_2$-O-), 3.53 (s, 3H, -OCH_3) 1.97 (dd, J=7.2; 1.7 Hz, 3H, CH_2-CH=). EI MS m/z (%) 217 (10), 101 (20), 86 (100), 58 (22).

2.5. Fungicidal testing

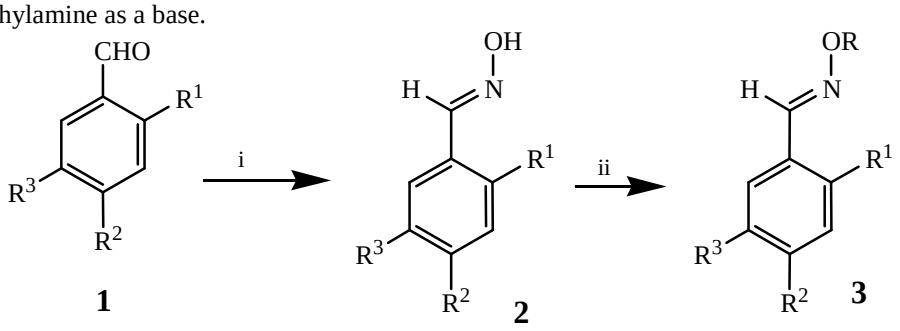
The compounds were screened for fungicidal activity *in vitro* test carried out against *B. cinerea* Pers. Ex Fr, *F. culmorum* Sacc., *P. cactorum* Schroek, and *R. solani* Kuhn, which involved determination of mycelial growth retardation in potato-glucose agar (PGA). Stock solutions of test chemicals in acetone were added to agar medium to give a concentration of 200 μg x ml^{-1} and dispersed into Petri dishes. Four discs containing the test fungus were

placed at intervals on the surface of the solidified agar and the dishes were then inoculated for 4-8 days depending on the growth rate of the control samples, after which fungal growth was compared with that in untreated control samples. The fungicidal activity was expressed as the percentage of fungi linear growth inhibition compared to that of the control.

RESULTS AND DISCUSSION

3.1. Chemistry

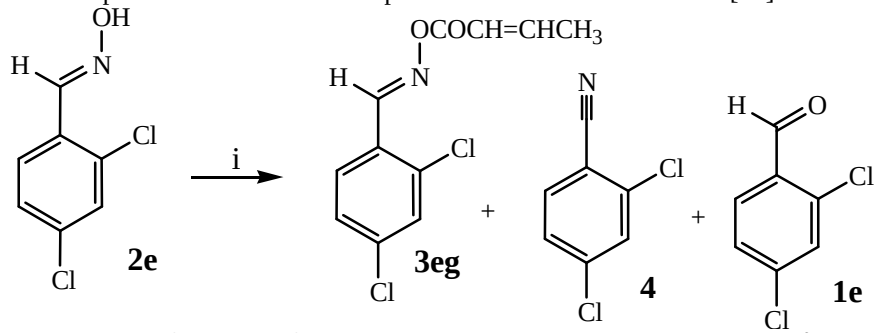
The title compounds were synthesized as presented in Scheme 1. The starting materials were 4-isopropylbenzaldehyde, 2,4-dichlorobenzaldehyde, salicylaldehyde, 4-hydroxybenzaldehyde, and 5-chlorosalicylaldehyde. In the hydroxybenzaldehyde derivatives protection as a methoxymethyl (MOM) ethers was applied. It was introduced using P_2O_5 catalyzed acetal exchange reaction with dimethoxymethane and the Huning's base [18], thus avoiding using of carcinogenic chloromethyl methyl ether as a substrate. This protection function was used because it is very labile and on the other hand some *O*-MOM-protected compounds were screened and showed biological activity [19]. The aldehydes **1a-1e** were then converted to the oximes with hydroxylamine hydrochloride in the presence of aqueous sodium hydroxide. *E* configuration of the oximes was established based on chemical shift values of HC=N proton in ^{1}H NMR spectra above 8.0 ppm [20-22]. Oxime ethers were frequently obtained in the literature in anhydrous conditions in the presence of strong bases such as sodium hydride or sodium methoxide [23]. We have carried out arylaldehyde oxime alkylation with primary or secondary alkyl bromides with application of aqueous-DMSO solutions of potassium hydroxide following the known procedure [24]. On the other hand oxime acetates were prepared in milder conditions of the reaction in aqueous-DMSO solutions of potassium carbonate. Some *O*-MOM derivatives (e.g. **3ba**) were deprotected using modification of the published procedure with a methanolic solution of hydrochloric acid [25]. Neutral conditions of this deprotection can be applied as well, such as ones using zirconium(IV) chloride [26]. Oxime esters were obtained with crotonoyl chloride in DCM in the presence of triethylamine as a base.



1,2				3								
	R^1	R^2	R^3	R^1	R^2	R^3	R=Et	R=Pr	R=*i*-Pr	R=Bu	R=pentyl	$R=CH_2CO_2Et$	$R=COCH=CHCH_3$
1,2a	H	OMOM	H	H	OMOM	H	**3aa**	**3ab**	**3ac**	**3ad**	**3ae**	**3af**	-
1,2b	OMOM	H	H	OMOM	H	H	**3ba**	**3bb**	**3bc**	**3bd**	**3be**	**3bf**	**3bg**
1,2c	OMOM	H	Cl	OMOM	H	Cl	**3ca**	**3cb**	**3cc**	**3cd**	**3ce**	**3cf**	-
1,2d	H	*i*-Pr	H	H	*i*-Pr	H	**3da**	**3db**	**3dc**	**3dd**	**3de**	**3df**	-
1,2e	Cl	Cl	H	Cl	Cl	H	**3ea**	**3eb**	**3ec**	**3ed**	**3ee**	**3ef**	**3eg**

Scheme 1. Synthesis of oximes 2 and oxime ethers and esters 3. Reagents: i NH_2OH x HCl, NaOH, rt, 10 h; ii AlkBr, KOH, DMSO-H_2O, rt, 0.5 h; $BrCO_2Et$, K_2CO_3, DMSO, rt, 18 h; $CH_3CH=CHCOCl$, NEt_3, CH_2Cl_2, 0 °C->rt, 20 h.

Esterification of oximes was accompanied by formation of side products, resulting from oxime dehydration and from deoximation as exemplified in Scheme 2. Such processes were observed before [27].



Scheme 2. Products of oxime esterification. Reagents: i $CH_3CH=CHCOCl$, NEt_3, CH_2Cl_2, 0 °C->rt, 20 h

3.2. Biological activity and structure-activity relationship

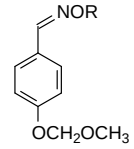
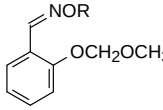
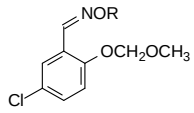
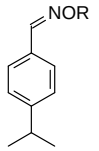
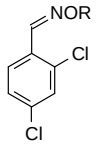
The obtained 32 oxime derivatives were evaluated *in vitro* against four plant pathogenic fungi *B. cinerea (BC), F. culmorum (FC), P. cactorum (PC),* and *R. solani (RS).* The screening results are displayed in the Table together with calculated logarithms of octanol-water partition coefficient c*logP*. They indicate variable antifungal activity at concentration of 200 mg/L. This concentration is routinely used in our laboratories in standard screening experiments. Tests at the lower concentrations are carried out only where there is a special interest in a given compound. Comparison of the activity with chlorothalonil shows that many compounds are more potent than the reference substance. Altogether 13 oxime derivatives were more active against *BC,* 19 compounds were more active against *FC,* 4 compounds against *PC* and 16 compounds were more potent against *RS* than chlorothalonil.

The obtained ethers and esters can be divided into five groups differing in the phenyl ring and oxime part substituents. In all five groups the oxime moiety is functionalized with different alkyl and alkenylcarbonyl groups. Compounds from the first and the second group are derivatives of, respectively, 4-alkoxy- and 2-alkoxybenzaldehyde. Four ethers from the first group show high activity against *R. solani*. Ethers and esters from the second group are particularly active against *B. cinerea* and *R. solani* fungal strains.

The third group include 2-alkoxy-5-chloro derivatives. Three ethers and the ester **3cg** excel in inhibitory activity against *B. cinerea*; this ester is highly active also against the other three tested fungal strains. Compounds from the fourth group, derivatives of 4-isopropylbenzaldehyde are less potent; the exception are ethers substituted with methylethoxycarbonyl function, which are active against all fungal strains. Ethers and esters from the fifth group with 2,4-dichloro aromatic substitution pattern excel in antifungal activity against *B. cinerea* and *R. solani* fungal strains.

In general 11 compounds showed 100% inhition rate against *B. cinerea,* and 14 compounds exhibited 100% inhition rate against *R. solani*. The antifungal activity of the title compounds showed some correlation with lipophilicity of the oxime derivatives as measured by the logarithm

Table. **Antifungal activity of compounds 3aa-3eg as inhibion rate (%) at 200 mg/L and c*log P***

Compounds	R: C_2H_5	R: C_3H_7	R: $(CH_3)_2CH$	R: C_4H_9	R: C_5H_{11}	R: CH_2COOEt	R: $CH_3CH=CHCO$
	2.43±0.55 *BC* 69.5 *FC* 76 *PC* 64.5 *RS* **100**	2.96±0.55 *BC* 47 *FC* 80 *PC* 68.5 *RS* **100**	2.78±0.55 *BC* 82 *FC* 80 *PC* 56% *RS* **100%**	3.50±0.55 *BC* 60 *FC* 48 *PC* 30 *RS* **100**	4.03±0.55 *BC* 66 *FC* 47 *PC* 6 *RS* 56	2.53±0.59 *BC* 0 *FC* 10 *PC* 0 *RS* 14	-
	2.03±0.55 *BC* **100** *FC* **100** *PC* 10 *RS* **100**	2.57±0.55 *BC* **100** *FC* 31,5% *PC* 0% *RS* **100**	2.38±*0.56* *BC* **100%** *FC* 69,5% *PC* 29% *RS* **100%**	3.10±0.55 *BC* 70 *FC* 53 *PC* 16.3 *RS* **100**	3.63±0.55 *BC* 28 *FC* 40 *PC* 2 *RS* 66	2.13±0.59 *BC* 0 *FC* 22 *PC* 0 *RS* 0	2.24±0.61 *BC* **100** *FC* 76 *PC* **100** *RS* **100**
	2.92±0.56 *BC* **100** *FC* 67.5 *PC* 13.5 *RS* **100**	3.45±0.56 *BC* **100** *FC* 61.5 *PC* 0 *RS* 75	3.27±0.57 *BC* **100%** *FC* 58% *PC* 4% *RS* 76%	3.98±0.56 *BC* 75 *FC* 58 *PC* 0 *RS* 50	4.51±0.56 *BC* 4 *FC* 19 *PC* 5 *RS* 62	3.02±0.60 *BC* 40 *FC* 53 *PC* 0 *RS* 56	-
	4.25±0.53 *BC* 32 *FC* 34 *PC* 6.3 *RS* 58	4.78±0.50 *BC* 73 *FC* 33 *PC* 8.8 *RS* 68	4.59±0.51 *BC* 26% *FC* 14% *PC* 2,5% *RS* 70%	5.31±0.50 *BC* 46 *FC* 29 *PC* 6 *RS* 64	5.84±0.50 *BC* 38 *FC 10* *PC* 15 *RS* 26	4.35±0.55 *BC* **100** *FC* **100** *PC* **100** *RS* **100**	-
	4.36±0.53 *BC* **100** *FC* 40 *PC* 58 *RS* **100**	4.90±0.53 *BC* **100** *FC* 50 *PC* 25 *RS* **100**	4.71±0.53 *BC* **100** *FC* 30 *PC* 12.5 *RS* **100**	5.43±0.53 *BC* 66 *FC* 44 *PC* 3.8 *RS* 58	5.96±0.53 *BC* 58 *FC* 35 *PC* 0 *RS* 46	4.46±0.57 *BC* 76 *FC* 20 *PC* 58 *RS* **100**	5.02±0.59 *BC* **100** *FC* 69 *PC* **100** *RS* **100**
Chlorothalonil [a]	cLog *P* 2.53±0.41; BC 80; FC 38; PC 61; RS 88						

[a] reference compound; *BC*: *Botrytis cinerea, FC: Fusarium culmorum, PC: Phytophthora cactorum, RS: Rhizoctonia solani*

of octanol-water partition coefficient *clogP* [28]. No straightforward dependence was found between the calculated lipophilicity and the biological activity which can be partly explained by presence of three different structural types of compounds in this study. However, the optimal ranges of c*logP* could be observed. For the most active against *B. cinerea* ether derivatives with electron-donating substituents on the aromatic ring (isopropyl and MOM ether) c*logP* fell in the range of 2.0 – 2.8. The other favourable range of c*logP* for ethers and esters with electron-withdrawing

substituents (2,4-dichloro) was that of 4.3 – 5.0. In case of compounds most active against *R. solani* the optimal range of lipophilicity corresponded to c*logP* of 2.2 – 3.1. Only for esters with strongly electron-withdrawing substituents more lipophilic compounds were preferred (c*logP* equal 4.3 – 5.0). Finally, for compounds most potent against *F. culmorum* and *P. cactorum* the advantageous ranges of lipophilicity were those with c*logP* values of 2.0 – 3.1 and 4.3-5.0.

CONCLUSION

Several new aryl aldoxime ethers and esters have been prepared. The obtained compounds characterized by spectroscopic data (IR, ^{1}H NMR and MS) showed antifungal activity particularly pronounced against *B. cinerea* and *R. solani* fungal strains. The observed biological potency could be related to the lipophilicity of the compounds measured by octanol-water partition coefficient c*logP* and optimal ranges of c*logP* have been found. Based on the obtained results syntheses of new, more potent derivatives could be envisaged. Research is in progress to enhance the biological activity of the aromatic aldoxime and the other Schiff-base type derivatives.

Acknowledgements
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REFERENCES

[1] R Sun; Y Li; M Lü; L Xiong; Q Wang, *Bioorg. Med. Chem. Lett*., **2010**, 20, 4693–4699.
[2] Y-Q Xie; Y-B Huang; J-S Liu; L-Y Ye; L-M Che; S Tu; C-L Liu, *Pest Manag. Sci.*, DOI 10.1002/ps.3819.
[3] S Tu; Y-Q Xie; S-Z Gui; L-Y Ye; Z-L Huang; Y-B Huang; L-M Che, *Bioorg. Med. Chem. Lett*., **2014**, 24, 2173–2176.
[4] Z-B Hu; H-A Luo; X-G Wang; M-Z Huang; L Huang; H-L Pang; C-H Mao; H Pei; C-Q Huang; J Sun; P-L Liu; A-P , *B. Kor. Chem. Soc*., **2014**, 35, 1073-1076.
[5] H Dai; H Yu; J. Liu; X Qin; T Wang; X Zhang; Z Qin; J Fang, *Chin. J. Org. Chem*., **2013**, 33, 1104-1107.
[6] L Jiang; H Wang; W Mu; Z Ji; P Cao, *Chin. J. Chem*. **2011**, 29, 539-543.
[7] X-F Zhu; D-Q Shi, *J. Heterocyclic Chem*., **2009**, 46, 1218-1221.
[8] W-L Dong; H -W Yao; Z -M Li; W -G Zhao. *J. Chem. Res-s*. **2008**, 145-147.
[9] W Xue; B Song; W He; H Wang; S Yang; L Jin; D Hu; G Liu; P Lu, *J. Heterocyclic Chem*., **2006**, 42, 867-871.
[10] J-Y Huang; Y-M Jia; X-M Liang; W-J Zhu; J-J Zhang; Y-H Dong; H-Z Yuan; S-H Qi; J-P Wu; F-H Chen; D-Q Wang, *J. Agr. Food Chem*., **2007**, *55*, 10857–10863.
[11] Y-S Xiao; X-J Yan; Y-J Xu; J-X Huang; H-Z Yuan; X-M Liang ; J-J Zhang ; D-Q Wang, *Pest Manag. Sci*., **2013**, 69, 814-826.
[12] W-D Liu; S-L Lan; Z-L Lan; X-G Wang, *Chin. J. Org. Chem*., **2006**, 26, 1115-1119.
[13] H Zhao; M Zhou; L Duan; W Wang; J Zhang; D Wang; X Liang, *Molecules*, **2013**, 18, 3615-3629.
[14] T Zhang; R Xie; T Zhang; X Mei; J Yang; J Ning, *J. Pest. Sci*., **2013**, 38, 88-90.
[15] CDS. Tomlin, ed. The pesticide Manual, 13th edition, British Crop ProtectionCouncil, Alton, Great Britain, **2003**.
[16] WM Gołębiewski; M Cholewińska, *Pol. J. Appl. Chem*., **2003**, 47, 137-145.
[17] WM Gołębiewski; M Cyrta; M Krawczyk. Patent Application P.405407, September 20, **2013**.
[18] AG González; R Rosa; J M Trujillo, *Tetrahedron*, **1986**, 42, 3899-3904.
[19] M Ito; H Okui; H Nakagawa; S Mio; A Kinoshita; T Obayashi; T Miura; J Nagai; Yokoi; R Ichinose; K Tanaka; S Kodama; T Iwasaki; T Miyake; M Takashio; J Iwabuchi, *Bioorg. Med. Chem*., **2003**, 11, 761-764.
[20] I Pejković-Tadić; M Hranisavljevic-Jakovljevic; S Nesic; C Pascual; W Simon, *Helv. Chim. Acta*, **1965**, 48, 1157-1160.
[21] R Sun; M Lu; L Chen; Q Li; H Song; F Bi; R Huang; Q Wang, *J. Agric. Food Chem*, **2008**, 56, 11376-11391.
[22] AJ McCarroll; JC Walton, *J. Chem. Soc. Perkin Trans, 2* **2000**, 2399-2409.
[23] S Itsuno; M Nakano; K Miyazaki; H Masuda; K Ito, *J. Chem. Soc. Perkin Trans, 1* **1985**, 2039-2044.
[24] CB. Li; Y Cui; WQ Zhang; JL Li; SM Zhang; MCK Choi; ASC Chan, *Chem. Lett.*, **2002**, 13, 95-100.
[25] JP Yardley; H Fletcher 3rd, *Synthesis*, **1976**, 244.
[26] GVM Sharma; KL Reddy; PS Lakshmi; PR Krishna, *Tetrahedron Lett.*, **2004**, 45, 9229-9232.
[27] WM Gołębiewski; M Gucma, *Synthesis*, **2008**, 1997-1999 and the references cited there.
[28] B Łozowicka; P Kaczyński; J Nawrot, *Centr. Eur. J. Chem.*, **2013**, 11, 2120-2133 and the references cited there.