Preparation and Plant Growth-Regulatory Activity of *N'*-Substituted *N*-Furfuryloxamides

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***N'*-Substituted *N*-furfuryloxamides (4) were prepared *via* condensation of potassium methyl oxalate (8) with furfurylamine (5f) using 1,1'-oxalyldiimidazole (6), followed by hydrolysis of the resulting amide-ester (10), and finally condensation with aliphatic or aromatic amines (5). The prepared compounds (4) were examined for activity as plant growth regulators using two kinds of plant seeds, namely, those of rape, *Brassica campestris* L. (Dicotyledoneae) and leek, *Allium tuberosum* ROTTLER (Monocotyledoneae). *N'*-Benzyl- and *N'*-phenyl-*N*-furfuryloxamides (4b and 4c) and *N,N'*-difurfuryloxamide (4f) inhibited root growth in seedlings of both species.**

Key words furan derivative; plant growth regulator; phytogrowth activity; seedling; 1,1'-oxalyldiimidazole; unsymmetrical oxamide

Oxamide derivatives are known to have plant growth-regulatory activities. For instance, *N,N'*-bis(2-phenylpyrimidin-5-yl)oxamide (**1**)[1] stimulated root growth in oat seedlings, and a 3-substituted dialkylaminooxanilide (**2**)[2] caused severe injury to annual morning glory. In addition, *N,N'*-bis(2-propenyloxy)ethanediamide (**3**)[3] has been synthesized as a plant growth regulator. We therefore extended our earlier synthetic study of furan derivatives[4] to prepare various *N*-furfuryloxamide derivatives (**4**) with an aliphatic, an aromatic or a heterocyclic ring as the *N'*-substituent. The plant growth-regulatory properties of the synthesized compounds (**4**) were examined.

Preparation of *N'*-Substituted *N*-Furfuryloxamides (4) In general, the synthesis of symmetrical oxamides, for example, *N,N'*-difurfuryloxamide (**4f**) was easily accomplished by the reaction of 2 eq of furfurylamine (**5f**) with 1 eq of 1,1'-oxalyldiimidazole (ODI; **6**).[5] The preparation of unsymmetrical oxamides (**4**) was more time-consuming. First, dimethyl oxalate (**7**) was hydrolyzed with equimolar water at 60 °C for 1 h in the presence of potassium acetate to form the potassium salt of oxalic acid monomethyl ester (**8**). To activate the carboxyl group, **8** was converted into *N*-(methoxyoxalyl)imidazole (**9**) using ODI (**6**). The mechanism of activation of **8** to **9** may involve nucleophilic attack of oxalic acid monomethyl ester (**14**) at the carbonyl carbon of ODI (**6**), followed by intramolecular rearrangement of an anhydride-type intermediate (**15**) with liberation of carbon dioxide and carbon monoxide, or nucleophilic attack of counter anion of imidazole on the carbonyl carbon of **15** as shown in Chart 3. Subsequently, the reaction of **9** with furfurylamine (**5f**) proceeded smoothly to afford methyl *N*-furfuryloxamate (**10**) in 82% yield calculated on the basis of **8**. Hydrolysis of **10** in sodium hydroxide solution at room temperature afforded *N*-furfuryloxamic acid (**12**), which is an oily, hygroscopic material. Thus, we used the sodium salt (**11**) of **12** for the next reaction with various kinds of

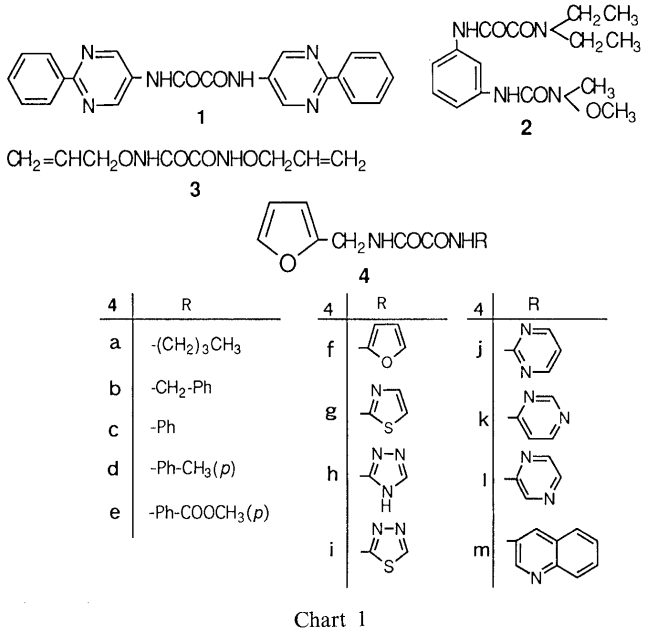
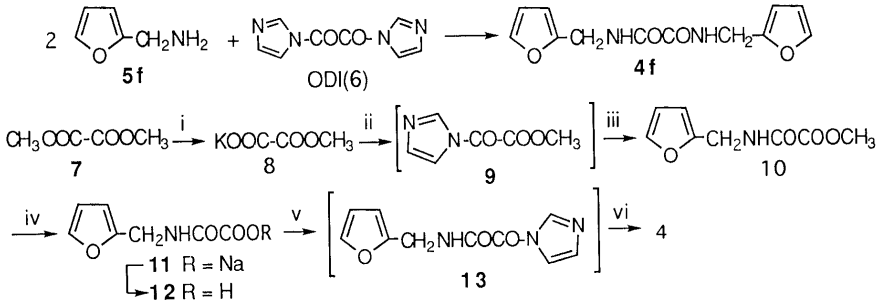


Chart 1



i aq. CH_3COOK, ii CH_3SO_3H, and then ODI(6), iii furfurylamine(5f), iv NaOH, and then CH_3SO_3H, v ODI(6), vi RNH_2(5)

Chart 2. Preparation of Symmetrical and Unsymmetrical Oxamides (**4f** and **4**)

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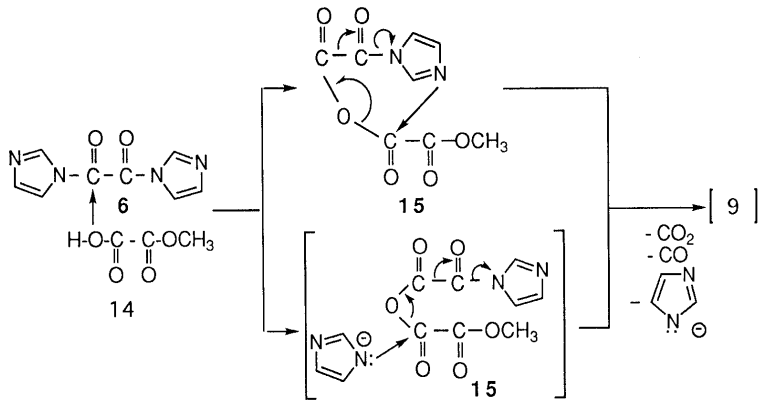

Chart 3

Table 1. Plant Growth-Regulatory Activities of *N'*-Substituted *N*-Furfuryloxamides (**4**)

Compd. **4**	R	Dicotyledoneae Rape; *Brassica campestris* L. Growth (ratio)[a] concentration (M)				Monocotyledoneae Leek; *Allium tuberosum* ROTTLER Growth (ratio)[a] concentration (M)			
		1.0×10^{-3}	5.0×10^{-4}	1.0×10^{-4}	5.0×10^{-5}	1.0×10^{-3}	5.0×10^{-4}	1.0×10^{-4}	5.0×10^{-5}
a	*n*-Butyl	93	79	99	73	100	75	83	102
b	Benzyl	85	83	63	92	58	55	56	52
c	Phenyl	43	33	48	45	64	78	47	67
d	4-Tolyl	85	70	76	101	108	87	127	114
e	$-C_6H_4-$COOMe (**4**)	63	70	68	93	150	120	115	115
f	Furfuryl	24	52	45	83	37	58	69	100
g	2-Thiazolyl	121	124	107	143	127	160	115	117
h	1,2,4-Triazin-3-yl	171	152	118	147	65	64	69	94
i	5-Me-1,3,4-thiadiazol-2-yl	84	90	108	108	103	80	82	95
j	2-Pyrimidinyl	94	92	135	110	142	200	150	215
k	4-Pyrimidinyl	88	122	109	113	82	101	68	78
l	2-Pyrazinyl	84	90	108	108	151	160	177	187
m	3-Quinolinyl	91	101	128	86	100	125	119	88

a) Growth in control experiments after seven days (*A. tuberosum*: ten days) was taken as 100. Quantity of light: 8500 $m^{-2}\cdot cd\cdot Sr$. Temperature 25 °C. Relative humidity of 60%. Experimental size: 20 seeds/group, 2 groups.

amines (**5**).

As illustrated in Chart 2, the above-mentioned hydrolysis-activation-amidation methodology was applied to the conversion of methyl *N*-furfuryloxamate (**10**) to *N'*-substituted *N*-furfuryloxamides (**4**) in yields of 84% to 13%. Among them, the yields of *N'*-(2-pyrimidinyl)- and *N'*-(4-pyrimidinyl)-*N*-furfuryloxamides (**4j** and **4k**) were only 13% and 28%, respectively. This may be due to the high solubility of **4j** and **4k** in water, so that they are not readily extractable from the aqueous solution. All thirteen of the prepared *N*-furfuryloxamide derivatives (**4a**—**m**) were examined for phytogrowth activity.

Phytogrowth Activity Tests Phytogrowth activity was assayed according to the method reported by Inamori *et al.*[6] using seeds of rape, *Brassica campestris* L. (Brassicaceae), as a dicotyledon and leek, *Allium tuberosum* ROTTLER (Lilliaceae), as a monocotyledon. The results are summarized in Table 1. The root growth of rape and leek seedlings was inhibited by the *N'*-benzyl, *N'*-phenyl and *N'*-furfuryl derivatives (**4b**, **4c** and **4f**). The introduction of a methoxycarbonyl or methyl group onto the benzene ring of **4c** did not cause enhanced inhibitory activity compared with the parent compound **4c**.

It is noteworthy that **4h** exhibited different rooting activity depending on the kind of plant seed. Namely, it showed about 50% stimulatory activity on growth of rape seedlings, but 30% inhibitory activity on root growth of leek seedlings. The 2-pyrimidinyl, 4-pyrimidinyl and 2-pyrazinyl derivatives (**4j**, **4k** and **4i**), containing two nitrogen atoms in an *N'*-substituted six-membered aromatic ring, did not exhibit any marked effect.

In summary, the synthetic method described here is convenient for the preparation of *N'*-substituted *N*-furfuryloxamides (**4**) under essentially neutral conditions. Preliminary evaluation of **4** revealed that *N'*-benzyl- and *N'*-phenyl-*N*-furfuryloxamides (**4b** and **4c**), and *N*,*N'*-difurfuryloxamide (**4f**) exhibit root growth-inhibitory activity in seedlings of rape and leek. Future work will concentrate on the synthesis and activity of *N'*-(halogenated phenyl)- or *N'*-(halogenated benzyl)-*N*-furfuryloxamides.

Experimental

Oxalyl chloride, imidazole, DMSO, were purchased from commercial sources and used as received. ODI (**6**) was prepared according to the reported procedure.[5] Melting points were taken on a Yanagimoto melting point apparatus. All melting points are uncorrected. IR spectra were measured on a Hitachi model 270-30 IR spectrophotometer. NMR spectra were measured on a Bruker AM-400 spectrometer (400 MHz) using tetramethylsilane as an internal reference, and chemical shifts were recorded as δ-values.

Potassium Methyl Oxalate (8) The preparation of **8** was carried out according to the method of Efimovsky.[7] A mixture of methanol (118 g, 3.6 mol) and dimethyl oxalate (118 g, 1 mol) was added dropwise to a

stirred mixture of potassium acetate (98 g, 1 mol) and water (98 g, 5.4 mol). The resultant mixture was refluxed at 60 °C for 1 h, and then concentrated *in vacuo* at 40 °C to one-half of its original volume. The residue was triturated with a mixed solution of ethanol (40 ml) and ether (80 ml) to give 114 g (80%) of **8**, mp 194—197 °C (lit.[7] 197 °C). The product (**8**) was dried in a vacuum desiccator over phosphorus pentoxide at room temperature, and used without further purification.

Methyl *N*-Furfuryloxamate (10) Oxalyl chloride (1.3 g, 10 mmol) was added dropwise to an ice-cold, stirred solution of imidazole (2.8 g, 40 mmol) in acetonitrile (80 ml). The mixture was stirred at room temperature for 5 min, then a suspension of potassium methyl oxalate (**8**) (1.4 g, 10 mmol) and methanesulfonic acid (1 g, 10 mmol) in acetonitrile (10 ml) was added rapidly in a single portion. The mixture was stirred at room temperature for 20 min, and then furfurylamine (**5f**) (1 g, 10 mmol) was added dropwise at room temperature. The resultant mixture was stirred for 1 h at room temperature. The solvent was removed *in vacuo*, and the resultant residue was poured into ice-cooled water and extracted with ethyl acetate. Washing of the ethyl acetate extract with 1% citric acid and water, followed by drying and evaporation of the solvent left the crude product (**10**), which was recrystallized from ether/ethyl acetate to afford 1.5 g (82%) of **10**, mp 39—40 °C. IR (KBr) cm^{-1}: 1742, 1695 (CO). ^{1}H-NMR ($CDCl_3$): 3.3 (s, 3H, $-CH_3$), 4.3 (d, $J=6$ Hz, 2H, $-CH_2-$), 6.0—7.3 (m × 3, 1H × 3, furan-4H, -3H, -5H) and 9.3 (t, 1H, –NH–). *Anal.* Calcd for $C_8H_9NO_4$: C, 52.46; H, 4.92; N, 7.65. Found: C, 52.62; H, 4.82; N, 7.73.

***N*-Furfuryloxamic Acid Sodium Salt (11)** A 4% sodium hydroxide solution (100 ml) was added to a methanol solution (100 ml) of methyl *N*-furfuryloxamate (**10**) (18.3 g, 0.1 mol), and the resulting mixture was stirred for 1 h at room temperature. The reaction mixture was concentrated to one-third of its original volume *in vacuo*, and the resultant residue was poured onto ice, then extracted with ethyl acetate. The aqueous layer was evaporated to dryness *in vacuo* to afford 12 g (82% yield) of *N*-furfuryloxamic acid sodium salt (**11**), which was used for the preparation of N′-substituted *N*-furfuryloxamide (**4**) without further purification.

***N*-Furfuryloxamic Acid (12)** A mixture of *N*-furfuryloxamic acid sodium salt (**11**) (21 g, 0.1 mol) and methanesulfonic acid (10 g, 0.1 mol) in acetonitrile (100 ml) was stirred at room temperature for 30 min. Most of the solvent was distilled off *in vacuo*, and the remainder was added to a mixture of ethyl acetate (100 ml) and ice-cooled water (30 ml). The organic layer was collected, and dried over anhydrous sodium sulfate. The organic layer was concentrated by distillation and the residue was distilled to afford 8.1 g (53%) of the crude free acid (**12**), which was sufficiently pure for preparative purposes, bp 170—175 °C (1 mmHg). IR (neat) cm^{-1}: 3310 (NH); 1764, 1683 (CO) . ^{1}H-NMR d_6-DMSO) δ: 4.2 (d, $J=5.6$ Hz, 2H, $-CH_2-$), 6.2—7.4 (m × 3, 1H × 3, furan-4H, -3H, -5H), 8.3 (br s, 1H, $-CH_2\underline{NH}CO-$).

Preparation of *N′*-Substituted *N*-Furfuryloxamides (4) A General Method. A solution of oxalyl chloride (0.64 g, 5 mmol) in acetonitrile (5 ml) was added dropwise to an ice-cold, stirred solution of imidazole (1.35 g, 20 mmol) in acetonitrile (80 ml). The mixture was stirred at room temperature for 5 min, then a suspension of *N*-furfuryloxamic acid sodium salt (**11**) (0.88 g, 5 mmol) and methanesulfonic acid (0.5 g, 5 mmol) in acetonitrile (5 ml) was added rapidly in a single portion. The mixture was stirred at room temperature for 20 min, and then a solution of an amine (**5**) (5 mmol) in acetonitrile (5 ml) was added dropwise at room temperature. The resultant mixture was stirred for 3 h at 40 °C. The solvent was removed *in vacuo*, and the resultant residue was poured onto ice and extracted with ethyl acetate. Washing of the ethyl acetate extract with 1% citric acid and water, followed by drying and evaporation of the solvent left the crude product (**4**).

N′-Butyl-*N*-furfuryloxamide (**4a**) was prepared as above from the reaction of **11** with *n*-butylamine (**5a**) in 56% yield. Recrystallization from ethyl acetate gave **4a**, mp 148—150 °C. IR (KBr) cm^{-1}: 1656 (CO). ^{1}H-NMR (d_6-DMSO) δ: 0.93 (t, 3H, $-CH_3$), 1.3—3.3 (m, 6H, $-(CH_2)_3-$), 6.2—7.4 (m × 3, 1H × 3, furan-4H, -3H, -5H), 7.5 (br s, 1H, –NHCO–), 7.8 (br s, 1H, –NHCO–). *Anal.* Calcd for $C_{11}H_{16}N_2O_3$: C, 58.91; H, 7.11; N, 12.49. Found: C, 58.94; H, 7.22; N, 12.58.

N′-Benzyl-*N*-furfuryloxamide (**4b**) was prepared as above from the reaction of **11** with benzylamine (**5b**) in 83% yield. Recrystallization from toluene gave **4b**, mp 172—174 °C. IR (KBr) cm^{-1}: 1656 (CO). ^{1}H-NMR (d_6-DMSO) δ: 4.4 (s, 2H, $-NH\underline{CH_2}-$), 4.5 (s, 2H, $-NH\underline{CH_2}-$), 6.3—7.4 (m × 3, 1H × 3, furan-4H, -3H, -5H), 7.2—7.4 (m, 5H, C_6H_5-), 7.8 (br s, 1H × 2, –NHCO– × 2). *Anal.* Calcd for $C_{14}H_{14}N_2O_3$: C, 65.11; H, 5.46; N, 10.58. Found: C, 65.15; H, 4.49; N, 10.91.

N′-Phenyl-*N*-furfuryloxamide (**4c**) was prepared as above from the reaction of **11** with aniline (**5c**) in 46% yield. Recrystallization from ethyl acetate gave **4c**, mp 151—153 °C. IR (KBr) cm^{-1}: 1656, 1627 (CO). ^{1}H-NMR (d_6-DMSO) δ: 4.4 (d, $J=6$ Hz, 2H, $-\underline{CH_2}NH$), 6.2—7.5 (m × 3, 1H × 3, furan-4H, -3H, -5H), 7.3—7.8 (m, 5H, C_6H_5-), 9.4 (t, 1H, $-CH_2\underline{NH}-$), 10.6 (br s, 1H, –CONH–) *Anal.* Calcd for $C_{13}H_{12}N_2O_3$: C, 63.92; H, 4.93; N, 11.47. Found: C, 64.08; H, 5.03; N, 11.45.

N′-(4-Tolyl)-*N*-furfuryloxamide (**4d**) was prepared as above from the reaction of **11** with 4-tolylamine (**5d**) in 84% yield. Recrystallization from toluene gave **4d**, mp 168—172 °C. IR (KBr) cm^{-1}: 1665 (CO). ^{1}H-NMR (d_6-DMSO) δ: 2.2 (s, 3H, $-CH_3$), 4.3 (s, 2H, $-\underline{CH_2}NH-$), 6.3—7.4 (m × 3, H × 3, furan-4H, -3H, -5H), 7.1—7.7 (d × 2, each $J=8$ Hz, 2H × 2, Ph-2H, -6H and Ph-3H, -5H), 9.3 (t, 1H, $-\underline{CH_2}NH-$), 10.5 (br s, 1H, –CONH–). *Anal.* Calcd for $C_{14}H_{14}N_2O_3$: C, 65.11; H, 5.46; N, 10.58. Found: C, 65.25; H, 5.55; N, 10.69.

N′-(4-Methoxycarbonylphenyl)-*N*-furfuryloxamide (**4e**) was prepared as above from the reaction of **11** with 4-methoxycarbonylaniline (**5e**) in 62% yield. Recrystallization from ethyl acetate gave **4e**, mp 201—202 °C. IR (KBr) cm^{-1}: 1728, 1674 (CO). ^{1}H-NMR (d_6-DMSO) δ: 3.8 (s, 3H, $-CH_3$), 4.4 (d, $J=6$ Hz, 2H, $-NH\underline{CH_2}-$), 6.3—7.6 (m × 3, 1H × 3, furan-4H, -3H, -5H), 7.2—7.4 (d × 2, each $J=8$ Hz, 2H × 2, Ph-2H, -6H and Ph-3H, -5H), 9.4 (t, 1H, $-CH_2\underline{NH}-$), 11.0 (br s, 1H, –CONH–). *Anal.* Calcd for $C_{15}H_{14}N_2O_5$: C, 59.60; H, 4.64; N, 9.27. Found: C, 59.37; H, 4.67; N, 9.06.

N,N′-Difurfuryloxamide (**4f**) was prepared as above from the reaction of **11** with furfurylamine (**5f**) in 93% yield. Recrystallization from ethyl acetate gave **4f**, mp 168—170 °C. IR (KBr) cm^{-1}: 1650 (CO). ^{1}H-NMR (d_6-DMSO) δ: 4.4 (d, $J=6$ Hz, 2H, $-\underline{CH_2}NH-$), 6.2—7.3 (m × 3, 1H × 3, furan-4H, -3H, -5H), 7.7 (br s, 1H, –NH–). *Anal.* Calcd for $C_{12}H_{12}N_2O_4$: C, 58.06; H, 4.83; N, 11.29. Found: C, 57.90; H, 4.74; N, 11.30.

N′-(2-Thiazolyl)-*N*-furfuryloxamide (**4g**) was prepared as above from the reaction of **11** with 2-aminothiazole (**5g**) in 68% yield. Recrystallization from water gave **4g**, mp 209—212 °C. IR (KBr) cm^{-1}: 1704, 1671 (CO). ^{1}H-NMR (d_6-DMSO) δ: 4.3 (d, $J=6$ Hz, 2H, $-\underline{CH_2}NH-$), 6.2—7.5 (m × 3, H × 3, furan-4H, -3H, -5H), 7.3—7.5 (d × 2, each $J=3.5$ Hz, 1H × 2, thiazole-4H, -5H), 9.5 (t, 1H, $-CH_2\underline{NH}-$), 12.5 (br s, 1H, –CONH–). *Anal.* Calcd for $C_{10}H_9N_3O_3S$: C,47.80; H, 3.61; N, 16.72. Found: C, 47.64; H, 3.66; N, 16.77.

N′-(1,2,4-Triazin-3-yl)-*N*-furfuryloxamide (**4h**) was prepared as above from the reaction of **11** with 3-amino-1,2,4-triazine (**5h**) in 34% yield. Recrystallization from *N,N*-dimethylformamide (DMF) gave **4h**, mp 264—266 °C. IR (KBr) cm^{-1}: 1671 (CO). ^{1}H-NMR (d_6-DMSO) δ: 4.3 (d, 2H, $-\underline{CH_2}NH-$), 6.2—7.5 (m × 3, 1H × 3, furan-4H, -3H, -5H), 7.9 (s, 1H, triazine-5H), 9.4 (br. t, 1H, $-CH_2\underline{NH}-$), 13.8 (br s, 1H, –CONH–). *Anal.* Calcd for $C_9H_8N_5O_3$: C, 45.96; H, 3.86; N, 29.78. Found: C, 46.14; H, 3.91; N, 30.04.

N′-(5-Methyl-1,3,4-thiadiazol-2-yl)-*N*-furfuryloxamide (**4i**) was prepared as above from the reaction of **11** with 2-amino-5-methyl-1,3,4-thiaziazole (**5i**) in 51% yield. Recrystallization from DMF gave **4i**, mp 237—239 °C. IR (KBr) cm^{-1}: 1722, 1680 (CO). ^{1}H-NMR (d_6-DMSO) δ: 2.6 (s, 3H, $-CH_3$), 4.3 (d, $J=6$ Hz, 2H, $-\underline{CH_2}NH-$), 6.2—7.5 (m × 3, 1H × 3, furan-4H, -3H, -5H), 9.6 (t, 1H, $-CH_2\underline{NH}-$), 12.9 (br s, 1H, –CONH–). *Anal.* Calcd for $C_{10}H_{10}N_4O_3S$: C, 45.10; H, 3.79; N, 21.04. Found: C, 45.24; H, 3.79; N, 21.17.

N′-(2-Pyrimidinyl)-*N*-furfuryloxamide (**4j**) was prepared as above from the reaction of **11** with 2-aminopyrimidine (**5j**) in 13% yield. Recrystallization from ethyl acetate gave **4j**, mp 124—126 °C. IR (KBr) cm^{-1}: 1722, 1685 (CO). ^{1}H-NMR (d_6-DMSO) δ: 4.3 (d, $J=6$ Hz, 2H, $-\underline{CH_2}NH-$), 6.2—7.3 (m × 3, 1H × 3, furan-4H, -3H, -5H), 7.5—8.7 (m, 1H × 3, pyrimidine-4H, -5H, -6H), 9.4 (t, 1H, $-CH_2\underline{NH}-$), 11.0 (br s, 1H, –CONH–). *Anal.* Calcd for $C_{11}H_{10}N_2O_3$: C, 53.66; H, 4.09; N, 22.76. Found: C, 53.71; H, 3.99; N, 22.89.

N′-(4-Pyrimidinyl)-*N*-furfuryloxamide (**4k**) was prepared as above from the reaction of **11** with 4-aminopyrimidine (**5k**) in 28% yield. Recrystallization from ethyl acetate gave **4k**, mp 154—156 °C. IR (KBr) cm^{-1}: 1722, 1685 (CO). ^{1}H-NMR (d_6-DMSO) δ: 4.4 (d, $J=6$ Hz, 2H, $-\underline{CH_2}NH-$), 6.3—7.5 (m × 3, 1H × 3, furan-4H, -3H, -5H), 8.0—8.9 (m, 1H × 3, pyrimidine-2H, -5H, -6H), 9.4 (t, 1H, $-CH_2\underline{NH}-$), 10.4 (br s, 1H, –CONH–). *Anal.* Calcd for $C_{11}H_{10}N_4O_3$: C, 53.66; H, 4.09; N, 22.76. Found: C, 53.76; H, 4.13; N, 22.76.

N′-(2-Pyrazinyl)-*N*-furfuryloxamide (**4l**) was prepared as above from the reaction of **11** with 2-aminopyrazine (**5l**) in 30% yield. Recrystallization from ethyl acetate gave **4l**, mp 147—149 °C. IR (KBr)

cm^{-1}: 1722, 1683 (CO). ^{1}H-NMR (d_6-DMSO) δ: 4.4 (d, J=6 Hz, 2H, –$\underline{CH_2}$NH–), 6.3—7.5 (m×3, 1H×3, furan-4H, -3H, -5H), 8.4—9.2 (m×3, 1H×3, pyazine-3H,-5H, -6H), 9.5 (t, 1H, –$CH_2\underline{NH}$–), 10.6 (br s, 1H, –CONH–). *Anal.* Calcd for $C_{11}H_{10}N_4O_3$: C, 53.66; H, 4.09; N, 22.76. Found: C, 53.71; H, 3.98; N, 22.96.

N'-(3-Quinolinyl)-*N*-furfuryloxamide (**4m**) was prepared as above from the reaction of **11** with 2-aminoquinoline (**5m**) in 31% yield. Recrystallization from ethyl acetate gave **4m**, mp 212—216 °C. IR (KBr) cm^{-1}: 1758, 1668 (CO). ^{1}H-NMR (d_6-DMSO) δ: 4.4 (d, J=6 Hz, 2H, –$\underline{CH_2}$NH–), 6.3—7.7 (m×3, 1H×3, furan-4H, -3H, -5H), 7.5—9.2 (m, 1H×6, quinoline-2H, -4H, -5H, -6H, -7H, -8H), 9.5 (t, 1H, –$CH_2\underline{NH}$–), 11.2 (br s, 1H, –CONH–). *Anal.* Calcd for $C_{16}H_{13}N_3O_3$: C, 65.08; H, 4.44; N, 14.23. Found: C, 65.37; H, 4.52; N, 14.28.

Phytogrowth-Inhibitory Activity Test This test was carried out according to the method reported by Inamori *et al.*[6] Dimethyl sulfoxide (DMSO) solution (1.0 ml) containing an oxamide derivative (**4a—m**) or DMSO alone (1.0 ml) as a control was diluted in 100 ml of sterilized agar (0.8%, Nacalai Tesque, Inc.) to give concentrations of 5×10^{-5} M, 1.0×10^{-4} M, 5×10^{-4} M and 1.0×10^{-3} M. The agar containing a test chemical or DMSO as a control was poured into a sterilized culture jar of 500 ml. Then 20 seeds of each of the plant species, sterilized with 70% ethanol and 1% NaClO, were put on the agar and left for seven days (*A. tuberosum*; ten days) at 25 °C under a relative humidity of 60% and a light intensity of 8500 $m^{-2}\cdot cd\cdot Sr$. The phytogrowth-inhibitory activity was expressed as the ratio of the root length in seedings exposed to a test chemical to that of the control (100). The results are summarized in Table 1.

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