EFFECT OF METHANOL ON SOME PLANTS

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ABSTRACT

Plants which use the Calvin-Benson pathway to fix Co_2 to ribulose-1,5-biphosphate eventually producing two molecules of 3-phospholyceric acid (C_3 plants) photorespire significantly under direct sunlight. Plants treated with methanol solutions show suppressed photorespiration and greater incorporation of C into organic compounds. Methanol enhanced the growth of oil seed rape, soybeans, small bean, cabbage, sugarbeet and ornamental plants. Concentrations of 20-30% methanol caused significant yield increases and diminished water requirement of the treated plants.

Key words: methanol, photosynthesis, cultivated plants, yield.

INTRODUCTION

Plants incorporate carbon from dioxide using two pathways: those which fix it through phosphoenolopyruvic acid into oxalo-acetic acid are C_4 plants, the other incorporate the carbon through ribulose - 1,5-biphosphate into phosphoglyceric acid - C_3 plants. The latter which include most cultivated plants are characterised by a high photorespiration, particularly if the plants are exposed to sun and water stress. An elevated CO_2 concentration can counteract these effects, as was shown by Dahlman (1993) who noticed 30-50% increases in various plants exposed to elevated CO_2 concentrations.

As early as in 1951 Benson found that C^{14} from methanol was incorporated by algi as fast as from CO_2. Studies by Nonomura and Benson (1992), Karczmarczyk et al. (1996), Devlin et al. (1994), have shown consistently significant yield increases of several plants. The authors suggest that plants respond to methanol in two or more stages, first using photorespiratory and other available metabolic pathways for detoxification, and thereafter activating a mechanism that improves carbon fixation. These findings are supported by Hemming et al. (1995) who report that exposure of bell pepper leaf tissue to methanol resulted in an increased carbon converstion efficiency.

MATERIALS AND METHODS

In greenhouse experiments, plants were grown in styrofoam pots containing a 50/50 mixture of sand and potting soil. Methanol applications, containing 0.2% glycine and a trace of Tween-80 were made by small atomizer. The rates of methanol applied were 10. 20, 30, 40, 50%, treatments were repeated 5 times in 7 days intervals. Geranium (*Pelargonium hortorum*) plants were harvested in the vegetative stage and flowering stage. The conditions for growing wheat and oil-seed rape seedlings were the same.

Winter rape was grown in pots of 0.04 m^2 surface, 4 plants per 1 pot. Methanol treatments of 20, 30 and 40% concentration were applied 5 times. Sugarbeet and small bean were cultivated in the field on 0.5 m^2 plots. The last three plants were divided into two blocks - one grown under natural conditions, the other recevied supplemental overhead irrigation. All experiments were done in 4 replicates and the data collected were sujected to analysis of variance.

RESULTS AND DISCUSSIONS

The greenhous study with ornamental plants showed that geranium plants treated with methanol developed better roots, the dry weight of roots increased as effect of 20% methanol by 50% (Table 1).

Table 1. Effect of methanol on the growth of geranium. Plants were harvested 14 days after the last application of methanol

Methanol %	Shoots			Roots		
	Length	Fr Wt	Dry Wt	Length	Fr Wt	Dry Wt
	% of control					
0	100	100	100	100	100	100
10	115	147	149	97	147	141
20	121	148	154	109	158	150
30	121	161	157	104	159	149
40	111	153	153	104	152	146
50	109	128	124	97	121	118
LSD 5%	6.9	14.3	17.0	14.1	23.1	19.2
1%	9.3	19.6	23.2	19.2	31.6	26.0

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The shoot growth was even more enhanced: 30% methanol solution caused a 57% increase of dry weight. The better developed plants produced also more blossoms.

As shown in table 2, wheat seedlings also reacted positively to methanol treatment. Even 10% solution caused a 130% increase of shoot dry matter.

Table 2. Effect of methanol (containing 0.2% glycine) on the growth of wheat

Methanol %	Shoots			Roots		
	Length	Weigth Fresh	Weigth Dry	Length	Weigth Fresh	Weigth Dry
	% of control					
0	100	100	100	100	100	100
Gly*	103	103	100	98	94	103
5	147	244	234	99	104	100
10	149	239	231	94	92	95
15	152	240	239	93	92	96
20	147	232	224	94	90	93
50	117	143	148	85	70	81
70	109	131	132	83	69	75
LSD 5%	3.9	18.4	17.9	5.4	8.6	11.1

* Gly = 0.2% glycine in water

If 15% methanol had been applied, the shoot dry matter increased by 139%. Methanol did not positively affect the root growth, on the contrary, both the fresh and dry weight of the roots was diminished with 30% decreased by 50% solution of methanol.

The response of plants to methanol treatment was expressed as stimulation of some physiological processes. As shown in table 3, an almost double biomass synthesis took place if the plants had been treated with 20% methanol solution, a 50% increase of nitrate reductase activity was also found as effect of this treatment.

Table 3. Effect of methanol on biomass synthesis and nitrate reductase activity in winter rape leaves

Methanol %	Fresh weigth mg/m^2/h	Fresh weigth %	Dry weigth mg/m^2/h	Dry weigth %	Nitrate reductase uMN O^2/g/h	Nitrate reductase %
0	1.62	100	0.13	100	31.6	100
10	2.49	154	0.19	150	36.7	116
20	3.11	192	0.24	190	47.9	152
40	1.66	102	0.13	106	42.0	133
LSD 5%	0.629		0.049		4.75	

Oil-seed rape grown till maturity proved to be higly sensitive to methanol (Table 4). The number of branches, rose by 30% and that of siliques per plant by 15%. Consequently the yield of rape seeds markedly increased - up to 40% - as effect of 40% methanol and irrigation. Rape submitted to water stress responded to 20% methanol by an 23% yield increase, to 30% by 27%.

Table 4. Effect of methanol on oil-seed rape

Treatment Irrigation	Treatment MeOH %	No of branches	No of siliq/ plant	Yield g/ pot	Yield %
40% field capacity	0	4.5	102	22.5	100
	20	6.3	141	27.7	123
	30	6.5	142	28.5	127
	40	6.5	141	27.5	122
Mean		5.9	132	26.5	
70% field capacity	0	5.7	128	29.2	130
	20	7.2	159	37.5	166
	30	7.0	159	38.4	171
	40	7.4	160	40.8	181
Mean		6.8	152	36.4	
LSD 5% for MeOH		0.8	29	7.2	

Table 5 depicts the effect of methanol on small bean. Although methanol caused an increase of the number of pods per one plant, the resulting yield increases were not significant - up to 16%.

Table 5. Effect of methanol on small bean

Treatment Irrigation	Treatment MeOH	No of pods	No of seeds	Seed yield g/plot	Seed yield %
Non irrigated	0	6.5	16.1	190	100
	20	9.5	17.6	221	116
	30	8.8	18.3	214	113
	40	7.8	17.2	213	112
Mean		8.1	17.3	209	-
Irrigated	0	10.2	25.7	316	166
	20	10.8	25.7	349	183
	30	11.0	27.0	357	188
	40	11.8	25.6	338	178
Mean		10.9	28.5	341	-
LSD 5%		1.6	n.s	n.s	-

Similarly low was the effect of methanol treatment on sugarbeet (Table 6). The yield of roots increased by 10% under the influence of 20 or 30% methanol solution, but the increase could not be proven statistically.

According to Nonomura and Benson (1992), treatment of plants with methanol can enhance their net photosynthesis, thus improving the yield. The stimulation of carbon incorporation by some plants, led according to these authors, to up to 100% increases of cabbage, tomatoes, ornamentals yield. The results obtained in our experiment support the above findings, particularly the part pertaining to cruciferae plants. Lesser yield increases are probably due to the fact that the best effects of methanol were obtained under dry desert conditions, not in temperate climate. Plants which incorporate carbon via Calvin - cycle, that is most of our cultivated plants, when exposed to high temperature, light intensity and water stress, show lengthy periods of photorespiration which limits the photosynthesis and thus can stop growth for several hours per dry.

Table 6. Effect of methanol on sugarbeet yield (six plants per 1 plot)

Treatment		Roots		Leaves	
Irrigation	MeOH	kg	%	kg	%
Non irrigated	0	3.50	100	4.15	100
	20	4.15	119	4.30	104
	30	4.15	119	4.31	104
	40	3.99	114	4.27	103
Means		3.94	-	4.25	-
Irrigated	0	5.40	154	5.48	132
	20	5.72	163	5.90	142
	30	5.58	159	6.07	146
	40	5.50	157	6.02	145
Means		5.55	-	5.86	-

Photorespiration is a biochemical term describing plant uptake of oxygen in light, outcompeting carbon dioxide uptake. This results in the breakdown of sugars that were made previously during photosynthesis. Methanol can be utilized to inhibit photorespiration, thus increasing the photosynthetic productivity.

Because photosynthesis and photorespiration are of the highest orders of scientific complexity, the application of methanol to crops poses a certain need for further studies and continual practical consideration.

CONCLUSIONS

Application of methanol solutions to geranium plants caused a stimulation of growth and flowering of the plants.

Wheat seedlings responded to methanol by more than twofold increases of dry matter production.

The synthesis of biomass by oil-seed rape leaves was markedly enhanced as effect of methanol treatment, so was also the leaf-tissue activity of nitrate reductase.

Yield of winter rape seeds was by 23% higher if the plants had been treated with 20% solutions of methyl alcohol.

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