Oxygen fertilizers in technology of plant seeds. Influence of CaO_2 additive on the quality of pelleted seeds

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Introduction

Seed pelleting is performed using a method of agglomerative granulation (Domoradzki 1978, Korpal 1982). Field seedlings of pelleted seeds of vegetable plants depend on soil moisture. A few-day delays in seeding of pelleted seeds of beet and parsley during wet spring are noticed.

The works on a laboratory germination test on accordion-pleated oil filter paper have demonstrated the necessity to maintain an adequate ratio between water mass and the mass of filter paper substrate applied in seed testing (Domoradzki 1999).

A problem of inundated inside of pellet is solved by a careful selection of materials to construct the pellet or the application of laminar coats, whose structure does not block oxygen access to seeds. Another method used to prevent the inundation effects is the delivery of oxygen to seeds by the degradation of peroxides (Langan 1986). In Japan and the USA, the rice seeds pelleted with peroxides releasing oxygen in contact with water were sown. The method of rice indirect sowing in the ground below water is to become an alternative for striking and thinning. Zinc and calcium peroxides are the most promising oxygen carriers for seeds. The prime goal of peroxide is to deliver oxygen, however, toxin neutralisation and anti-bacterial effects are also observed.

The greatest hopes rest in the use of calcium peroxide CaO_2 in the agriculture sector. Hydrolysis of calcium peroxide to hydroxide and hydrogen peroxide solution takes place according to the following equation:

$$CaO_2 + 2\,H_2O \rightarrow H_2O_2 + Ca(OH)_2$$
$$2\,H_2O_2 \leftrightarrow 2\,H_2O + O$$

Calcium peroxide usefulness as an additive to pellet will depend on its phytotoxicity to germinating seeds. Hydrogen peroxide solution, formed during the reaction, is decomposed to highly reactive oxygen and water. The reaction rate of hydrogen peroxide solution decomposition depends on: temperature, concentration, such catalytic agents as iron – Fe and manganese – Mn ions and the concentration of catalase – the enzyme produced by germinating seeds.

An additional function of peroxides is to decontaminate seeds, which may result in increased energy and seed germination ability.

Calcium peroxide is used in the agriculture sector as a source of oxygen at a dose of 50 kg/ha during potato planting and to deliver oxygen to root systems of replaced plant, which cause quick growth of capillary roots. Calcium peroxide can be also applied for leaves and grass composting in an amount of up to 2% per compost mass, which replaces the mechanical compost shovelling. In ecology and biosystems, CaO_2 liquidates unpleasant odours by converting fermentation into aerobic one.

Objective of work

The objective of this work was to determine phytotoxicity of calcium peroxide to germinating seeds, to test kinetics of calcium peroxide decomposition with water, and to determine the location of peroxide in the pellet as well as to determine the impact of this additive on germination of pelleted seeds. Besides, an amount of peroxide remaining in a pellet after pelleting process was to be determined.

Materials and methodology

This research was focused on seeds of vegetable plants. Seeds of carrot, parsley, red beet, onion and radish were selected for research purposes.

Calcium peroxide containing 74.72% of CaO_2 was used in the research tests.

Phytotoxicity tests of peroxides

The tests on vegetable seed germination ability after drenching in calcium peroxide solutions at different concentrations – 0.2, 0.5 and 1.0 % were conducted and comparison with control seeds was made. In control tests, the seeds were soaked in distilled water. The seeds were germinated on the filter paper in 3 Petri dishes, each with 50 seeds. The results are presented in Figure 1. Calcium peroxide additive up to 1% has practically no effect on the seed germination.

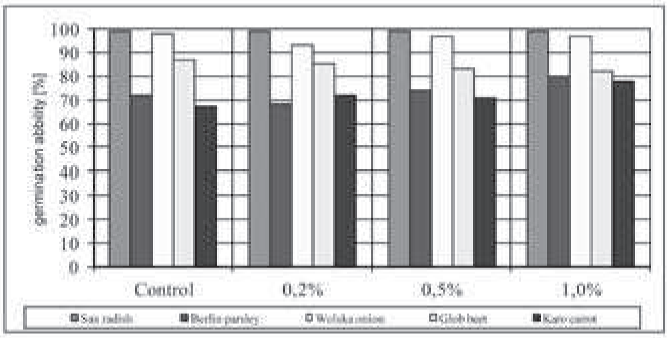

Fig.1. Phytotoxicity. CaO_2 impact on germinating seeds

Test on kinetics of peroxide decomposition

Test on kinetics of CaO_2 decomposition

The tests on peroxide decomposition were conducted in aqueous solutions by titration of the whole sample. 0.1 g of peroxide and 20 ml of distilled water (ca. 0.5 % aqueous suspension) were added to the Erlenmayer glass flask.

Beakers were placed in a thermostat at 5, 10, 15, 20°C for hydrolysis. The measurement of peroxide content in the sample was performed at the beginning (control test) and at daily intervals to day 12.

The quantitative determination of peroxide in the suspension was based on adding 25 ml of acid mixture (containing 125 ml of 85 % o-orthophosphoric acid, 125 ml of 98 % sulphuric acid, and 750 ml of distilled water) to the suspension and titrating with 0.1 mol/l $KMnO_4$ solution to obtain a permanent pink colour.

The results were calculated from the following dependence:

$$\%CaO_2 = \frac{V * n * 72{,}08 * 100}{2 * 1000 * m}$$

The normality of $KMnO_4$ solution was determined by the oxalate method. The obtained results are presented in Table 1 and Figure 2.

Table 1

Kinetics of calcium peroxide decomposition

No.	analysis:		T=5°C	T=10°C	T=15°C	T=20°C
	0.5%.CaO_2	Day	CaO_2 %	CaO_2 %	CaO_2 %	CaO_2 %
0	CaO_2 suspension	0	0.3778	0.3778	0.3778	0.3778
1	CaO_2 suspension	1	0.3397	0.3446	0.3335	0.3360
2	CaO_2 suspension	2	0.3163	0.3335	0.2954	0.2978
3	CaO_2 suspension	3	0.2929	0.3188	0.2634	0.2560
4	CaO_2 suspension	4	0.2843	0.3000	0.2437	0.2154
5	CaO_2 suspension	5	0.2745	0.2966	0.2000	0.1575
6	CaO_2 suspension	6	0.2400	0.2671	0.1846	0.1300
7	CaO_2 suspension	7	0.2302	0.2572	0.1268	0.0837
8	CaO_2 suspension	9	0.2018	0.2302	0.0748	0.0554
9	CaO_2 suspension	10	0.1900	0.2142	0.0615	0.0300
10	CaO_2 suspension	11	0.1700	0.2000	0.0298	0.0168
11	CaO_2 suspension	12	0.1658	0.1882	0.0242	0.0037

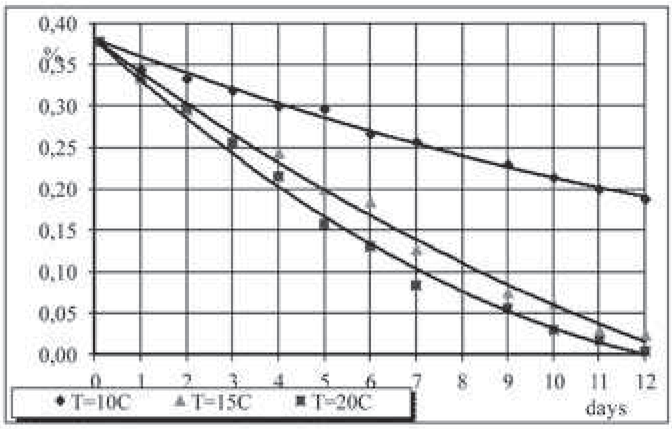

Fig. 2. Decomposition kinetics of CaO_2 aqueous solution

Tests on germination of pelleted seeds with CaO2 additive in pellets.

The effect of oxygen released inside the pellet on the seed germination was determined under the conditions of variable water content in the pellet. Seed pelleting was performed without peroxide additive, with 20 g/kg of peroxide added directly on seeds, with 2% peroxide added to the pellet material and with both additives present in both places at the same time. The pelleted seeds were germinated in boxes with accordion-pleated oil filter paper at various levels of substrate saturation with water. The attention was paid to seed germination at high levels of filter paper cartridge saturation with water, for which seed inundation was observed. Pelleted seeds without calcium peroxide additive were used as control seeds.

Tabela 2

Germination of pelleted seeds with CaO_2 additive

SAXA radish | **Berlin parsley**

Water capacity	Con-trol	Seeds 2 %	Pellet 2 %	Pellet + Seeds 2 % +2 %	Con-trol	Seeds 2 %	Pellet 2 %	Pellet + Seeds 2 % +2 %
	GA*/ 6 days	GA	GA	GA	GA/ 21 days	GA	GA	GA
0.5	93	90	92	94	76	76	84	82
0.6	95	92	89	92	76	81	81	82
0.7	96	92	91	93	80	86	81	85
0.8	96	95	93	96	75	79	85	80
0.9	**93**	**93**	**89**	95	63	70	62	82
1.0	86	94	91	96	48	46	52	66

Wolska onion | **Perfekcja carrot**

Water capacity	Con-trol	Seeds 2 %	Pellet 2 %	Pellet + Seeds 2 % +2 %	Con-trol	Seeds 2 %	Pellet 2 %	Pellet + Seeds 2 % +2 %
	GA/ 12 days	GA	GA	GA	GA/ 14 days	GA	GA	GA
0.5	96	97	93	93	76	77	84	74
0.6	94	99	95	97	78	79	82	76
0.7	97	96	97	93	76	78	75	75
0.8	94	94	91	91	57	74	73	71
0.9	**72**	**79**	**74**	**94**	**51**	**72**	**60**	**70**
1.0	**13**	**28**	56	86	32	42	52	69

Opolski beet | **Orzeł parsley**

Water capacity	Con-trol	Seeds 2 %	Pellet 2 %	Pellet + Seeds 2 % +2 %	Con-trol	Seeds 2 %	Pellet 2 %	Pellet + Seeds 2 % +2 %
	GA/ 14 days	GA	GA	GA	GA/ 21 days	GA	GA	GA
0.5	89	85	87	93	89	87	83	88
0.6	92	96	88	96	84	85	88	89
0.7	87	88	87	92	77	78	84	91
0.8	89	90	83	90	77	78	82	90
0.9	89	82	87	92	67	52	79	90
1.0	59	68	81	87	45	42	81	88

*GA – germination ability

More efficient seed germination at high levels of pellet saturation with water was observed for all cases. However, the most powerful effects were demonstrated by pelleted seeds of parsley, carrot and onion. As a result, the effectiveness of "oxygen fertilizer" as an additive was shown in preventing the germination of inundated seeds from being blocked.

Tests on decomposition rate of calcium peroxide in pellets

The tests on disappearance of calcium peroxide in pelleted seeds were performed using manganometric determination. Pelleted seeds with peroxide in various places inside the pellet were tested.

0 control test seeds without CaO_2 additive
1 CaO_2 present directly on seeds 20 g/kg of seeds
2 CaO_2 in peat 2%
3 CaO_2 on spar 2% only for parsley
4 CaO_2 on seeds 20 g/kg of seeds + 2% into pellet material

Tabela 3

Chemical analysis of pelleted seeds

Place of	Species /		CaO_2	CaO_2	Left	Left	Left
CaO_2 placement	Variety	%	%	% average	%	after correction	%
0	Berlin parsley	0	0.00	0.1040	-0.1032	0.0000	0.000
1	Berlin parsley	20g	0.10	0.1949	-0.0981	0.0909	0.939
2	Berlin parsley	2	1.50	0.8782	0.6218	0.7742	0.516
3	Berlin parsley	2	**1.50**	1.2958	0.2042	1.1918	**0.795**
4	Berlin parsley	2+20g	**1.60**	1.2403	0.2597	1.1363	**0.758**
0	Opolski beet	0	0.00	0.0649	-0.0642	0.0000	0.005
1	Opolski beet	20g	0.21	0.0972	0.1171	0.0323	0.151
2	Opolski beet	2	1.50	0.9539	0.5461	0.8890	0.593
4	Opolski beet	2+20g	**1.50**	1.1735	0.3265	1.1086	**0.739**
0	Perfekcja carrot	0	0.00	0.0793	-0.0786	0.0000	0.000
1	Perfekcja carrot	20g	1.50	0.0913	1.4087	0.0120	0.008
2	Perfekcja carrot	2	1.50	0.8801	0.6199	0.8008	0.534
4	Perfekcja carrot	2+20g	**1.50**	1.2493	0.2507	1.1700	**0.780**
0	Saxa radish	0	0.00	0.1408	-0.1401	0.0000	0.000
1	Saxa radish	20g	0.60	0.5986	0.0014	0.4578	0.763
2	Saxa radish	2	**1.50**	1.4369	0.0631	1.2961	**0.864**
4	Saxa radish	2+20g	**1.70**	1.5975	0.1050	1.4567	**0.856**
0	Wolska onion	0	0.00	0.0903	-0.0895	0.0000	0.000
1	Wolska onion	20g	1.50	0.1621	1.3379	0.0718	0.048
2	Wolska onion	2	1.50	0.1461	1.3539	0.0558	0.037
4	Wolska onion	2+20g	**1.50**	1.3137	0.1863	1.2234	**0.816**

After completing the pelleting process, the tested seeds with an additive of 20 g/kg of seeds + 2% CaO_2 in the pellet material contain more than 50 % of CaO_2.

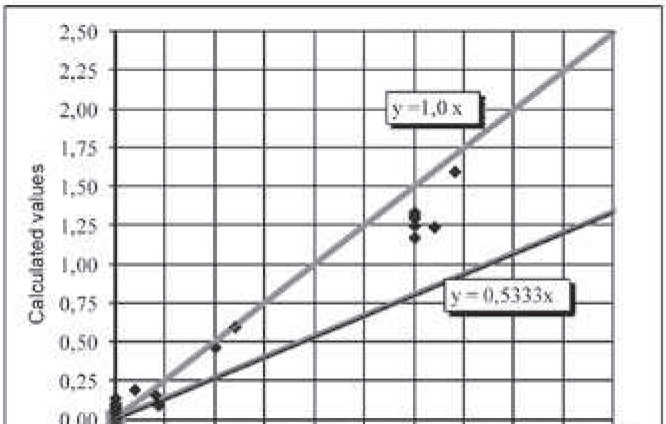

Fig. 3.Decomposition of calcium peroxide in pellets

The maximum calculated concentration of CaO_2 in the pellet did not exceed 1.7%. After pelleting and drying, CaO_2 was partly decomposed inside the pellets, the lowest decomposition degree was observed for parsley and radish seeds. Generally, CaO_2 concentration is likely to drop to the level of 53 % of the initial amount of calcium peroxide.

Summary

The work has presented tests on phytotoxicity and calcium peroxide decomposition in water. Calcium peroxide added to the pellet material protects the pelleted seed against the reduced germination ability at high water content in the substrate (wet spring).

1.Phytotoxicity of peroxides

Seeds of beet, parsley, radish, onion and carrot were selected for phytotoxicity tests. On the basis of the conducted tests, it was found that germination of parsley and carrot seeds have improved. For other vegetable seeds, i.e. red beet, onion and radish, calcium peroxide neither is toxic nor decontaminates them.

2.Effect of calcium peroxide on the germination of pelleted seeds.

The application of 20 g/kg of seeds and 2% CaO_2/per pellet mass is the most favourable solution for all tested seeds. However, calcium peroxide is the most effective to parsley.

3.Decomposition of calcium peroxide in a pellet

The maximum degree of CaO_2 disappearance in particular layers of the pelleted seeds after granulation and drying is ca. 50%. Calcium peroxide present directly on seeds (first layer) mainly decontaminates the seeds, while present at the remaining layers of the pellet deliver oxygen to inundated seeds.

Literature

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