

## EFFECT OF CALCIUM SOURCES ON YIELD, QULITY AND DEVELOPMENT OF DRY AND SOFT ROT DISEASES ON SOME POTATO VARIETIES

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### ABSTRACT

Horticultural and pathological experiments were carried out during the summer seasons of 2004 and 2005 at the Experimental Farm of Mallawy Agriculture Research Station, El-Minia, Egypt and the Plant Pathology Dept., Fac. of Agric., El-Minia University, El-Minia, Egypt.

Eleven calcium salts (Dicalcium pyrophosphate, Calcium carbonate, Calcium chloride, Calcium gluconate, Calcium phosphate, Calcium sulphate, Calcium acetate, Calcium tartarate, Calcium hydrogen orthophosphate, Calcium oxide, and Calcium lactate) besides control (tap water) [12 treatments], were applied individually at concentration 2000 ppm by spraying the growing plants at the time of tuberization after 45, 60 and 75days from planting on potato (*Solanum tuberosum* L.), cv. "Nicola". Calcium chloride and Ca hydrogen orthophosphate gave significant increase in the total tubers yield (ton/fed.) as well as No. of tubers/plant in both seasons with insignificant differences between them. Yield percentage increase reached to 16.55 and 13.44 with Ca chloride, 17.81 and 12.33 with Ca hydrogen orthophosphate in both seasons, respectively. Also, No. tubers /plant were affected by the above treatments. In the two seasons, Ca hydrogen orthophosphate recorded a significant increase in number of tubers (10.63 and 8.95 tubers/plant) compared to 11.44 tubers/plant with Ca oxide only, in the first season and 9.14 tubers/plant with Ca chloride only, in the second season. Significant increase in the dry matter % was found with Ca tartarate (21.57%) followed by Ca oxide (19.97%) in the first season, but the difference between them were detected in the second season, was insignificant compared with other Ca sources and the control treatments.

Likewise,  $CaCl_2$  and Ca hydrogen orthophosphate increased the percentage; i. e., of potato seed tubers 41.60 % and 39.67 % in the first season and 38.00 % and 38.28 % in the second. Differences did not reach to the level of significant.

Foliar treatments with  $CaCl_2$  /or Ca oxide gave the highest Ca (%) (averaged 1.40 %) in potato tubers and can be used to off set the shortage of Ca % in potato tubers. Also the total phenolics content (TPC) differed among the potato tubers treated with Ca sources and those treated with Ca oxide (164.0 µg/ml). Also it has been found that their was a relationship between TPC and Ca (%),also, the anion companion may play role.

Among six potato cultivars, (Alpha, Diamant, Hermez, Lady Rosseta, Nicola and Sant) cv. Nicola was the highest susceptible one to soft rot disease followed by cv. Diamant with insignificant difference between them. Ca-oxide was more effective to protect potato tubers against dry rot disease (72.09 %).

**Keywords:** *Solanum tuberosum*, *Erwinia carotovora* subsp. *carotovora*, *Fusarium solani* f.sp. *eumartii*, phenolics.

### INTRODUCTION

Calcium has attracted much interest in plant physiology and molecular biology because of its function as a second messenger in the signal conduction between environmental factors and plant responses in terms of growth and development (Reddy, 2001), required component of the middle

lamella and is essential for intracellular membrane transport (Poovaiah *et al.*, 1988; Alberts *et al.*, 1994). The middle lamella exists as gel and  $\text{Ca}^{2+}$  is very efficient in promoting gelling in a pectic solution (Topfer and Taylor, 1981; Marschner, 1993), Ca is involved in controlling respiration (Faust and Shear, 1972), and can reduce ethylene production (Sams and Conway, 1984). Moreover,  $\text{Ca}^{2+}$  plays a pivotal role in membrane stabilization and in regulation of enzyme synthesis e.g. protein-kinase or phosphatases (Schmitz-Eiberger *et al.*, 2002). Regulation calcium level is important for the survival of the cell. The cytosolic  $\text{Ca}^{2+}$  concentration is delicately balanced by the presence of a large number of calcium stores like vacuoles which can even release calcium when required the presence of an efficient calcium homeostasis system. Moreover, the involvement of calcium in many physiological responses have conclusively proven calcium as the most important signaling molecule, the source of calcium and type of cell responding to a particular signal confers the specificity at the priming level (Parady *et al.*, 2000).

Takano *et al.* (1997) showed that the source of calcium is extracellular or apoplastic, which by influx through plasma membrane channels cause elevation of  $[\text{Ca}^{2+}]_{\text{cyt}}$ . In some other cases  $[\text{Ca}^{2+}]_{\text{cyt}}$  elevated levels were due to release from intracellular stores. Increasing the calcium content of other fruits and vegetables with calcium salts has increased storage life, mainly as a result of the role of calcium in changing physiological and reducing pathological disorders (Conway *et al.*, 1992). Accumulating evidence suggest that  $\text{Ca}^{2+}$  served as messenger in many normal growth and developmental process and in plant responses to biotic and a biotic stresses (Reddy, 2001).

Application of water soluble forms of Ca during the tuber development period was effective in raising Ca level of the nonperiderm tissue and vastly improves tuber quality (Kleinhenz *et al.*, 1999). Several studies implicate the involvement of  $\text{Ca}^{2+}$  signal in plant defense responses such as phytoalexin biosynthesis, induction of defense-related genes and hypersensitive cell death (Bowler and Fluhr, 2000).  $\text{Ca}^{2+}$  is implicated in mediating system, a peptide involved wound-induced activation of defense genes in tomato (Bergey and Ryan, 1999). Further, Flego *et al.* (1997) showed a correlation between increased  $\text{Ca}^{2+}$  concentration in plants and increased resistance to bacterial pathogen *Erwinia carotovora*.

On the other hand, involvement of calcium has also been shown in plant-pathogen interaction by modulating the expression of virulence genes of pathogen and cell to cell communication (Flego *et al.*, 1997).

Resistance of potato tubers to *E. carotovora* subs *atroseptica* was correlated with their higher calcium content of potato tubers (McGuire and Kelman (1986), higher calcium and dry matter contents (Tzeng, 1987), contents of calcium cell wall (Pagel and Heitefuss (1987), cell contents of polygalactouronase (Pagel and Heitefuss (1989). Also, Lambert and Manger (1991) reported that potato tubers with high calcium content were less susceptible to soft rot caused by *E. carotovora* subs *carotovora*.

Because potato tubers are deficient in Ca, improving tuber healthy by increasing Ca level was expected (Palta, 1996).

Thus, the objectives of this study were : (1) compare the effectiveness of several Ca sources for increasing tuber Ca content, tuber yield, quality and potato seed (%) tubers for fall planting, (2) examine the relationship between tuber Ca content and Ca sources as for the incidence of soft and dry rot diseases.

### MATERIALS AND METHODS

Field and laboratory experiments were conducted throughout this investigation

#### Field experiments:

Two main field experiments were carried out in the two successive summer seasons of 2004 and 2005 at the Experimental Farm of Mallawy Agricultural Research Station, El-Minia, Egypt on potato cv. "Nicola". Some physical and chemical properties of the soil at depth of 0-30 cm are shown in Table ( 1) :

**Table (1): Some physical and chemical properties of the soil**

Texture grade	Sand	Silt	Clay	pH	E.C	CEC	CaCO <sub>3</sub>	O.M.	Available nutrient (ppm)		
									N	P	K
Clay loam	7.63 %	61.87 %	30.50 %	8.02 %	1.11 %	36.45 %	2.08 %	1.09 %	45.13	1.25	1.15

CEC = Cation exchange capacity.

E.C = Electric conductivity.

Imported potato seed tubers were planted on 20 and 25 January in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively, with an average seed piece weight of about 50 g . Each plot area 11.25 m<sup>2</sup> consist of 3 ridges, 75 cm width and 25 cm within row and 5 m length. Treatments were arranged in a randomized complete block design with three replicates.

#### The experimental treatments:

Eleven calcium sources treatments compared with tap water spraying were applied at concentration 2000 ppm individually by spraying the growing plants at the time of the tuberization; *i. e.*, after 45, 60 and 75days from planting. Other agricultural practices for potato production were followed as recommended by Ministry of Agriculture. The treatments were as followed in Table 2:

**Table (2): Common forms of calcium sources supplements are in the form of salts (along with % of weight as calcium)**

Calcium sources	Calcium (%)	Actual Ca con. (ppm) tested
Dicalcium pyrophosphate (Ca <sub>2</sub> P <sub>2</sub> O <sub>7</sub> )	15.76	300
Calcium carbonate Ca (CO <sub>3</sub> ) <sub>2</sub>	40.04	800
Calcium chloride (CaCl <sub>2</sub> )	36.40	720
Calcium gluconate (C <sub>14</sub> H <sub>26</sub> Ca)	9.31	180
Calcium phosphate [ Ca (H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ]	17.12	340
Calcium sulphate (CaSO <sub>4</sub> + H <sub>2</sub> O)	26.01	520
Calcium acetate [ Ca (C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> ]	25.34	500
Calcium tartarate (C <sub>4</sub> H <sub>4</sub> O <sub>8</sub> Ca)	21.29	420
Calcium hydrogen orthophosphate Ca HPO <sub>4</sub>	29.44	580
Calcium oxide (CaO)	71.47	1400
Calcium lactate [ Ca (C <sub>3</sub> H <sub>5</sub> O <sub>3</sub> ) <sub>2</sub> ]	18.37	360
Control (tap water)		

At harvest time (110 days from planting) yield and its component, tuber quality, total phenolic compounds, of potato tubers calcium content and the pathological experiments were recorded.

**Yield and its components:**

At harvest time, tuber yield (ton/fed.), average number of tubers/plant, % culturably potato seed tuber ranged from 1.5-3.0 ounces equivalent 42.5-85.0 g were recorded according to (Mosley *et al.*, 1995).

**Tuber quality:**

Dry matter (%), specific gravity, total phenolic compounds (TPC) and calcium analysis were assessed where Dry matter (%) was evaluated according to A.O.A.C (1990) method, and specific gravity was measured in sample of twenty five tubers were randomly taken from each plot to determine specific gravity using wire basket. (Sinha *et al.*, 1992).

tuber weight in air

$$\text{specific gravity (SG)} = \frac{\text{tuber weight in air}}{\text{tuber weight in air} - \text{tuber weight in water}}$$

**Total phenolic compounds (TPC):**

One gram fresh weight of potato tubers from each treatment was vigorously mixed with 1:10 (g.mL<sup>-1</sup>) 80 % aqueous ethanol solution. The mixture was boiled for 5 min. under a hood, centrifuged at 5000 g for 10 min., and the supernatant was collected. The residue was mixed with 5 ml of 80 % aqueous ethanol, boiled for 5 min. to reextract the phenolics and centrifuged under the same conditions. The reextracts were combined, made up to 10 ml, and used for the measurement of total phenolics. The alcohol extracts were diluted to obtain an absorbance reading within the standards from 1µg to 100 µg salicylic acid/ ml. the absorbance was measured at 280 nm. by Islam *et al.* (2003).

**Calcium analysis:**

Dried potato samples from each treatment were used for Ca analysis. All data were subjected to standard analysis of variance.

**Pathological experiments:**

Isolation and identification of soft rot bacterium *Erwinia carotovora* subsp *carotovora* were conducted essentially as reported by Galal (1988). While dry rot pathogen, one isolate of *Fusarium solani* f. sp. *eumartii* (El-Bana *et al.*, 2002) was used throughout this study.

Reaction of some potato cultivars to artificial inoculation with soft rot bacterium *Erwinia carotovora* var *carotovora* and dry rot fungus, *F. solani* f. sp. *eumartii*:

Assessment of potato cultivars to infection by fungal (*F. solani* f.sp. *eumartii*) or bacteria (*Erwinia carotovora* var *carotovora*) which were pathogenic to potato were used in this study. Six potato cultivars (Alpha, Diamant, Cara, Lady rossetta, Nicola and Sante) were tested according to Galal, (1988) in case of soft rot and to El-Bana *et al.* (2002) in case of dry rot.

Direct effects of Ca sources growth of *F. solani* f.sp. *eumartii*:

Erlenmeyer flasks 250 ml containing nutrient agar medium was either amended or not (control) with one of 11 calcium sources (Table 2) to obtain 2000 ppm Ca salt. Flasks were autoclaved, after flasks had been

cooled, they were dispensed into 9.0 cm sterilized Petri dishes and inoculated with 5.0 mm diameter plugs of 10-day-old cultures of *Fusarium* grown on PDA medium inoculated Petri dishes from each treatment were incubated for 10 days at 20°C and then the mycelial growth and spores number were recorded.

**Role of Ca-sources on the development of potato dry and soft rot diseases:**

Potato tubers cv. "Nicola" from treated plants in the summer season were collected at the end of crop. Surface sterilized, make a hill by corky porer 5.0mm in diameter and 5.0mm into the tuber flesh, and then plug 5.0 mm in diameter of 10-day-old cultures in the case of *F. solani* f.sp *eumartii*. In case of bacteria, 0.5 ml of bacterial suspension ( $10^6$  colony forming unit CFU/ml) were put into the hill and then covered by the same tissue and wrapped with Parafilm for 24h, then the Parafilm were removed and the treated tubers were incubated at 20 °C for 20 days. Later on the disease severity index of potato inoculated with either *Fusarium* or bacteria was assayed using an arbitrary 0-5 scale where 0= no symptoms, 1= 1-5 %, 2= 5-10 %, 3= 10-20 %, 4= 20-40 % and 5= > 40 % rotted tuber tissues (Fig. 1)

**Stastical analysis:**

Data were compared using analysis of variance (ANOVA) procedures and statistical analysis was performed using Duncan's multiple range test (1955).

## RESULTS AND DISCUSSION

**Total yield and its components :**

Both Ca chloride and Ca hydrogen orthophosphate gave the significant increase in the total tubers yield (ton/fed.) as well as the number of tubers/plant, in both seasons, but not significant differences between them (Table 3). Yield percentage increment reached to 16.55 % and 13.44 % with Ca chloride, 17.81 % and 12.33 % with Ca hydrogen orthophosphate in both seasons, respectively. No. of tubers /plant was affected by the above treatments. In the two seasons, hydrogen orthophosphate recorded a significant increase (10.63 and 8.95 tubers/plant) compared with 16.55 tubers/plant with Ca oxide only in the first season and 9.14 tubers/plant with Ca chloride only in the second season. These improvements due to chloride anion has active an directly in the plant by improving the water balance and thereby, tolerance to diseases, or indirectly in the soil via inhibition of nitrification or enhancement of manganese mobilization (Graham and Webb, 1991). Also, the hydrogen ion concentration in Ca hydrogen orthophosphate could be a significant factor in the interaction, especially if toxic elements were present in excess and their activity was largely pH dependent (Habe and Soedarjo, 1995).

**Tuber quality :**

Foliar treatments at the time of the tuberization by Ca tartarate and Ca oxide led to an increase in the dry matter (%) in both seasons (Table 4). Significant increase in the dry matter (%) was found with Ca tartarate

(21.57%) followed by Ca oxide (19.97%) in the first season. Insignificant differences between Ca tartarate (21.57 %) and Ca oxide (21.11 %) were detected in the second season compared with the other Ca sources and the control treatments.

Also, Ca tartarate recorded the highest values of the specific gravity (1.087 and 1.085) in the first and the second seasons, respectively followed by Ca oxide but not significant differences between them and/or other Ca salts and control treatment. The increment in the dry matter (%) and specific gravity by using Ca tartarate and Ca oxide might not be due to the effect of Ca % in Ca taratrate but depended on the anion tartarate accompanying with Ca.

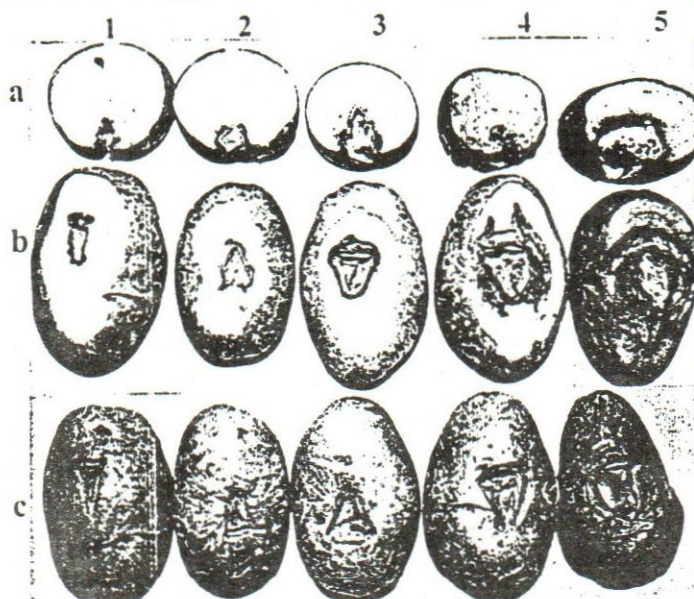


Fig. 1: Various depth (a), width (b) and overview (c) of rotted potato tuber tissues inoculated with *Fusarium solani* f.sp. *eumartii*. Notice from left to right degrees of dry rot 1= >1-5%, 2= >5-10%, 3= >10-20%, 4= >20-40%, 5= >40% rotted tissues.

#### Culturable potato seed tuber (%):

Foliar application of  $\text{CaCl}_2$  or Ca hydrogen orthophosphate increased percentage of potato seed tubers (41.60 and 39.67 in the first season and 38.00 and 38.28 in the second season, respectively but insignificant differences between them (Table 5). Also, Ca sulphate (38.17 %), Ca oxide (38.12%), Ca lactate (37.73 %) and Ca gluconate (37.27%) recorded significant increase only in the second season with insignificant differences between them compared with the control treatment (30.40 %). These data revealed the importance of for using Ca hydrogen orthophosphate and also,  $\text{CaCl}_2$  for improving the culturable potato tubers. These findings may be due to reduce chilling and water stress injury which could, in improving plant growth and productivity this result is in agreement with that of (Singer *et al.*, 1996) who used  $\text{CaCl}_2$  as foliar application on bean .

**Table (3): Total yield (ton/fed.) and it component tubers as affected by Ca sources foliar application during two summer seasons 2004 and 2005.**

Characters	Total yield (ton/fed.)		No. of tubers /plant	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Dicalcium pyrophosphate	11.09 <sup>e</sup>	12.96 <sup>e</sup>	8.02 <sup>de</sup>	7.15 <sup>de</sup>
Calcium carbonate	11.35 <sup>e</sup>	12.97 <sup>de</sup>	7.80 <sup>e</sup>	7.07 <sup>de</sup>
Calcium chloride	12.89 <sup>ab</sup>	14.35 <sup>a</sup>	9.39 <sup>b</sup>	9.14 <sup>a</sup>
Calcium gluconate	12.02 <sup>d</sup>	12.55 <sup>b</sup>	9.36 <sup>b</sup>	7.04 <sup>de</sup>
Calcium phosphate	12.09 <sup>cd</sup>	12.99 <sup>de</sup>	8.37 <sup>cd</sup>	7.40 <sup>d</sup>
Calcium sulphate	12.52 <sup>bc</sup>	13.34 <sup>c</sup>	9.36 <sup>b</sup>	7.38 <sup>de</sup>
Calcium acetate	11.16 <sup>e</sup>	12.75 <sup>f</sup>	9.20 <sup>bc</sup>	7.00 <sup>e</sup>
Calcium tartarate	11.48 <sup>e</sup>	13.16 <sup>cd</sup>	7.67 <sup>e</sup>	7.00 <sup>e</sup>
Calcium hydrogen orthophosphate	13.03 <sup>a</sup>	14.21 <sup>ab</sup>	10.63 <sup>a</sup>	8.95 <sup>ab</sup>
Calcium oxide	12.45 <sup>bcd</sup>	14.06 <sup>b</sup>	11.44 <sup>a</sup>	8.61 <sup>b</sup>
Calcium lactate	12.70 <sup>bd</sup>	14.12 <sup>b</sup>	8.75 <sup>bc</sup>	7.95 <sup>c</sup>
Control (tap water)	11.06 <sup>e</sup>	12.65 <sup>fg</sup>	8.16 <sup>de</sup>	7.12 <sup>de</sup>

Means within years and experiments separated by Duncan's multiple range test 0.5% level

**Table (4): Dry matter (%) and specific gravity of potato tubers as affected by Ca sources foliar application during two summer seasons 2004 and 2005.**

Characters	Dry matter (%)		Specific gravity	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Dicalcium pyrophosphate	18.27 <sup>d</sup>	18.74 <sup>fg</sup>	1.071 <sup>ab</sup>	1.073 <sup>ab</sup>
Calcium carbonate	19.47 <sup>bc</sup>	19.65 <sup>cd</sup>	1.076 <sup>ab</sup>	1.077 <sup>ab</sup>
Calcium chloride	19.39 <sup>c</sup>	19.93 <sup>cd</sup>	1.076 <sup>ab</sup>	1.079 <sup>ab</sup>
Calcium gluconate	18.46 <sup>d</sup>	19.31 <sup>def</sup>	1.072 <sup>ab</sup>	1.075 <sup>ab</sup>
Calcium phosphate	18.61 <sup>d</sup>	18.78 <sup>fg</sup>	1.073 <sup>ab</sup>	1.073 <sup>ab</sup>
Calcium sulphate	19.14 <sup>c</sup>	20.38 <sup>bc</sup>	1.075 <sup>ab</sup>	1.081 <sup>ab</sup>
Calcium acetate	18.29 <sup>d</sup>	19.43 <sup>def</sup>	1.071 <sup>ab</sup>	1.076 <sup>ab</sup>
Calcium tartarate	21.57 <sup>a</sup>	21.25 <sup>a</sup>	1.087 <sup>a</sup>	1.085 <sup>a</sup>
Calcium hydrogen orthophosphate	19.25 <sup>c</sup>	19.19 <sup>def</sup>	1.076 <sup>ab</sup>	1.075 <sup>ab</sup>
Calcium oxide	19.97 <sup>b</sup>	21.11 <sup>ab</sup>	1.079 <sup>ab</sup>	1.084 <sup>ab</sup>
Calcium lactate	18.43 <sup>d</sup>	19.16 <sup>def</sup>	1.072 <sup>ab</sup>	1.075 <sup>ab</sup>
Control (tap water)	18.32 <sup>d</sup>	18.40 <sup>g</sup>	1.071 <sup>ab</sup>	1.072 <sup>ab</sup>

Means within years and experiments separated by Duncan's multiple range test 0.5% level

**Table (5): Culturable potato seed tuber (%) of potato tubers as affected by Ca sources foliar application during two summer seasons of 2004 and 2005.**

Characters	potato seed tubers %	
	1 <sup>st</sup> season	2 <sup>nd</sup> season
Dicalcium pyrophosphate	33.29 <sup>ef</sup>	31.60 <sup>ef</sup>
Calcium carbonate	30.24 <sup>d</sup>	35.16 <sup>d</sup>
Calcium chloride	41.60 <sup>a</sup>	38.00 <sup>ab</sup>
Calcium gluconate	31.87 <sup>fg</sup>	37.27 <sup>abc</sup>
Calcium phosphate	35.00 <sup>cd</sup>	32.43 <sup>e</sup>
Calcium sulphate	36.93 <sup>cd</sup>	38.17 <sup>a</sup>
Calcium acetate	32.07 <sup>fg</sup>	36.25 <sup>cd</sup>
Calcium tartarate	37.59 <sup>bc</sup>	36.89 <sup>bc</sup>
Calcium hydrogen orthophosphate	39.67 <sup>ab</sup>	38.28 <sup>a</sup>
Calcium oxide	34.43 <sup>def</sup>	38.12 <sup>ab</sup>
Calcium lactate	35.54 <sup>cd</sup>	37.73 <sup>ab</sup>
Control (tap water)	31.83 <sup>fg</sup>	30.40 <sup>f</sup>

Means within years and experiments separated by Duncan's multiple range test 0.5% level

seed tuber % for planting the fall season by using suitable size of potato seed tubers.

**Calcium (%):**

In the first season, dicalcium pyrophosphate had the highest values (1.10 % Ca) followed by CaCl<sub>2</sub> (0.80 % Ca) and Ca oxide (0.70 % Ca) as showed in table 6. The remains Ca salts (Ca carbonate, Ca gluconate, Ca sulphate, Ca acetate, Ca tartarate, Ca hydrogen orthophosphate, and Ca lactate gave the lowest values compared with the control treatment but not significant differences between these treatments. However, in the second season, both CaCl<sub>2</sub> and Ca oxide gave significant increase in Ca % (1.40 %) in the dried potato tubers with insignificant differences between them, followed by dicalcium pyrophosphate and Ca acetate (1.20 %). The remains Ca sources gave an increase in Ca % except for Ca gluconate, and Ca hydrogen orthophosphate which gave the lowest values (0.60 % and 0.50 %) compared with the control treatment (0.60 %). The results of this study showed that foliar treatments with CaCl<sub>2</sub> or Ca oxide gave the highest Ca% in potato tubers and can be used to offset the shortage of Ca % in potato tubers and these increments may be due to the highest percentage of Ca in CaCl<sub>2</sub> (36.40 %) and Ca oxide (71.47 %).

**Total phenolic compounds (TPC):**

The effect of foliar treatments of Ca salts on the total phenolic content of potato tubers cv. "Nicola" is shown in ( Table 6 ). All Ca sources gave increase in TPC compared with the control treatment. The phenolics content differed among the Ca sources and this treated with Ca oxide. Since tubers treated with Ca oxide. the greatest phenolic content (164.0 µg/ml), followed by Ca carbonate (159.0 µg/ml), Ca sulphate (152.0 µg/ml), Ca tartarate (149.0 µg/ml), dicalcium pyrophosphate (148.0 µg/ml), CaCl<sub>2</sub> (137.0 µg/ml), Ca lactate (132.0 µg/ml), Ca hydrogen orthophosphate (130.0

**Table (6): Total phenolic compounds (µg/gm) and calcium content (%) in potato tubers as affected by Ca sources foliar application during two summer seasons 2004 and 2005.**

Treatments	Charcaters	TPC (µg/gm)			Ca <sup>++</sup> contents (%)		
		1 <sup>st</sup> growing eason	2 <sup>nd</sup> growing season	Mean of seasons	1 <sup>st</sup> growing season	2 <sup>nd</sup> growing season	Mean of seasons
Dicalcium pyrophosphate		150.0	146.0	148.0 <sup>d</sup>	1.10	1.30	1.20 <sup>b</sup>
Calcium carbonate		161.0	158.0	159.5 <sup>b</sup>	0.60	1.00	0.80 <sup>e</sup>
Calcium chloride		140.5	134.9	137.7 <sup>e</sup>	0.80	2.00	1.40 <sup>a</sup>
Calcium gluconate		121.0	119.0	120.0 <sup>h</sup>	0.50	0.70	0.60 <sup>f</sup>
Calcium phosphate		119.0	119.0	119.0 <sup>h</sup>	0.70	1.20	0.95 <sup>d</sup>
Calcium sulphate		152.0	153.0	152.5 <sup>c</sup>	0.50	1.10	0.80 <sup>e</sup>
Calcium acetate		125.4	127.1	126.3 <sup>g</sup>	0.90	1.50	1.20 <sup>b</sup>
Calcium tartarate		150.2	147.8	149.0 <sup>c</sup>	0.80	1.32	1.06 <sup>c</sup>
Calcium hydrogen orthophosphate		120.3	139.7	130.0 <sup>f</sup>	0.50	0.50	0.50 <sup>f</sup>
Calcium oxide		170.2	157.8	164.0 <sup>a</sup>	1.00	1.80	1.40 <sup>a</sup>
Calcium lactate		133.5	130.5	132.0 <sup>f</sup>	0.70	0.90	0.80 <sup>e</sup>
Control (tap water)		120.1	113.9	117.0 <sup>h</sup>	0.58	0.62	0.60 <sup>f</sup>

Means within years and experiments separated by Duncan's multiple range test 0.5% level



µg/ml), Ca acetate (126.0 µg/ml), Ca gluconate(120.0 µg/ml), Ca phosphate (119.0 µg/ml) in descending order compared with control treatment (117.0 µg/ml). The results indicate that Ca played a role in the stimulation of phenolic production. Also, it has been found that there was a relationship between TPC and Ca %, and also the anion companion may play a role. Secondary phenolic metabolites played an important role in plant defense mechanisms, and increasing evidence indicates that many are important in human health (Asami *et al.*, 2003).

Reaction of some potato cultivars to artificial inoculation with soft rot disease caused *Erwinia carotovora* var *carotovora* and dry rot caused by *F. solani* f.sp *eumartii*.

Potato cultivars cvs. Alpha, Diamant, Hermez, Lady Rossetta, Nicola and Sante' tested for susceptibility to soft and dry rot diseases caused by *Erwinia carotovora* var *carotovora*. Table 7 . Show different reactions with these cultivars and reported that Alpha, Hermez, Lady Rossetta and Sante' cultivars had the least susceptible reaction, while cv. Nicola was the highest susceptible one followed by cv. Diamant with insignificant between them. These results are agreement with those reported by Tohamy *et al.* (1992), Seif EL-Yazal *et al.* (1996) and Abo-Elyousr (1998) found that potato cultivars that contained higher contents of sugars and more active for pectinase (polygalactourinaze and pectine methylestrase) were more susceptible.and cv. "Nicola" contained higher sugars (fructose and glucose) compared to the other tested cultivars. Also, Otozu and Gary (1981) found that a significant and higher correlation was found between the rate of *Erwinia* decay and sucrose content of the tubers.

Table (7): Reaction of some potato cultivars to artificial inoculation with soft rot disease *Erwinia carotovora* var *carotovora* and dry rot disease *F. solani* f.sp *eumartii*

Potato cvs.	Severity (%)	
	Dry rot	Soft rot
Alpha	36.00 <sup>bc</sup>	62.0 <sup>b</sup>
Diamant	42.00 <sup>b</sup>	73.00 <sup>ab</sup>
Hermez	42.00 <sup>b</sup>	63.20 <sup>b</sup>
Lady Rossetta	39.00 <sup>ab</sup>	56.02 <sup>b</sup>
Nicola	48.00 <sup>a</sup>	79.00 <sup>a</sup>
Sante'	37.00 <sup>bc</sup>	69.60 <sup>b</sup>

DI 100 = 15 days after inoculation for soft rot and 7 days after inoculation for dry rot.  
Means within years and experiments separated by Duncan's multiple range test 0.5% level

#### Role of Ca-sources on the development of potato dry and soft rot diseases:

Data indicate that the efficiency of calcium sources differed according to their chemical composition and pathogen (Table 8). Significant differences were found between calcium sources for dry rot severity (Table 8 and Fig. 1 Ca-oxide was more effective to the protection against dry rot disease (72.09 %) followed by Ca-chloride (69.83 %), Ca-tartarate (69.79 %) and Ca-sulphate (67.07 %). While, Ca-acetate, Ca-hydrogen orthophosphate, Ca-

phosphate and Ca-gluconate gave the least significant. These results are in agreement with those reported by Hussien *et al.* (2002) on bean pod disease caused by *Sclerotinia sclerotiorum*. Similar results for antifungal activity of calcium salts were reported on brown rot disease caused by *Monilinia fructicola* (Biggs *et al.*, 1997)

To be mentioned that the protection against dry rot infection is not due to Ca concentration per severity but the forms of Ca-salts play major role as explained in Table 8. Where insignificant effects for CaCl<sub>2</sub> (720 ppm Ca), CaSO<sub>4</sub> (520 ppm Ca), and CaO (1400 ppm Ca) were obtained since they exhibited the most protection although they have different Ca %.

As for soft rot severity, Ca-acetate increased potato tuber susceptibility to infection with *E. C.* subsp. *carotovora* (Table 8). Insignificant effect was obtained by using ca-carbonate or dicalcium pyrophosphate. Least soft rot severity was pronounced by using ca-phosphate (31.86 % as compared with water treatment, 68.40 % soft rot severity. However, ca-chloride, ca-gluconate, ca-tartrate were also effective to suppress soft rot severity.

On the other hand, all tested ca-salts have no significant effect toward pathogens growth (Table 8). Data demonstrated that Ca-sources induced protection in potato tissues through physiological changes to cell wall composition and cell membrane but not through their direct effect on the pathogens themselves. Recent findings have reported by Mori and Schroeder (2004), provide many stimuli cause Reactive oxygen Species (ROS). Production in plant cells and that ROS activation of Ca<sub>2</sub><sup>+</sup> channels may be a central step in many ROS-mediated processes, such as stress and hormone signaling, polar growth, development, and possibly during mechanotransduction. Youssef. (2000) indicated that CaCl<sub>2</sub> was effective to increase potato production and protection against scab disease caused by *Streptomyces scabies*.

Table (8): Severity (%) of dry rot caused by *F. solani* f.sp *eumartii* and soft rot caused by *Erwinia carotovora* var *carotovora*, sporulation of *F. solani* f.sp *eumartii* and number of rot bacterium colonies as influenced by different salts of calcium

Treatments	Severity of dry rot	Sporulation of dry rot fungus (x 10 <sup>3</sup> cm <sup>2</sup> )	Fungal growth	Severity of soft rot	No. colony forming units/ plate of soft rot bacteria
Dicalcium pyrophosphate	26.67 <sup>ef</sup>	17.50 <sup>d</sup>	38 <sup>a</sup>	60.00 <sup>bc</sup>	150 <sup>a</sup>
Calcium carbonate	30.00 <sup>e</sup>	23.33 <sup>c</sup>	38 <sup>a</sup>	66.14 <sup>b</sup>	150 <sup>a</sup>
Calcium chloride	21.62 <sup>fg</sup>	21.67 <sup>c</sup>	35 <sup>ab</sup>	35.84 <sup>e</sup>	140 <sup>ab</sup>
Calcium gluconate	45.00 <sup>fg</sup>	12.50 <sup>e</sup>	38 <sup>a</sup>	36.46 <sup>e</sup>	150 <sup>a</sup>
Calcium phosphate	50.00 <sup>b</sup>	10.83 <sup>e</sup>	38 <sup>a</sup>	43.08 <sup>d</sup>	145 <sup>ab</sup>
Calcium sulphate	23.6 <sup>c</sup>	12.50 <sup>e</sup>	37 <sup>a</sup>	31.68 <sup>f</sup>	150 <sup>a</sup>
Calcium acetate	55.00 <sup>b</sup>	7.50 <sup>f</sup>	40 <sup>a</sup>	74.04 <sup>a</sup>	160 <sup>a</sup>
Calcium tartrate	21.65 <sup>fg</sup>	22.50 <sup>c</sup>	35 <sup>ab</sup>	36.16 <sup>e</sup>	140 <sup>ab</sup>
Calcium hydrogen orthophosphate	50.67 <sup>b</sup>	23.67 <sup>c</sup>	38 <sup>a</sup>	53.78 <sup>c</sup>	150 <sup>a</sup>
Calcium oxide	20.00 <sup>g</sup>	35.83 <sup>b</sup>	36 <sup>ab</sup>	38.38 <sup>e</sup>	145 <sup>ab</sup>
Calcium lactate	23.77 <sup>fg</sup>	41.58 <sup>a</sup>	38 <sup>a</sup>	49.80 <sup>cd</sup>	150 <sup>a</sup>
Control (tap water)	71.67 <sup>a</sup>	15.59 <sup>d</sup>	40 <sup>a</sup>	68.40 <sup>b</sup>	160 <sup>a</sup>

Means experiments separated by Duncan's multiple range test 0.5% level

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## تأثير مصادر الكالسيوم على المحصول والجودة وتطور مرضى العفن الجاف والطرى فى بعض أصناف البطاطس

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تم إجراء دراسات بستانية ومرضية أثناء الموسمى الصيفىين ٢٠٠٤، ٢٠٠٥ بمزرعة محطة البحوث الزراعية بملوى وقسم امراض النبات - كلية الزراعة - جامعة المنيا - مصر. التجارب البساتنية: تم استخدام ١١ مصدر من املاح الكالسيوم (بيروفوسفات ثنائى الكالسيوم، كربونات الكالسيوم، كلوريد الكالسيوم، جلوكونات الكالسيوم، فوسفات الكالسيوم، سلفات الكالسيوم، خلات الكالسيوم، طرطرات الكالسيوم، هيدروجين أورثوفوسفات الكالسيوم، أكسيد الكالسيوم ولاكتات الكالسيوم) بجانب معاملة الكنترول (الماء) حيث تم استخدامهم كل بصورة منفردة بتركيز ٢٠٠٠ جزء فى المليون رشا على نباتات البطاطس النامية صنف "تيقولا" ذلك أثناء فترة تكوين الدرناى بعد عمر ٤٥، ٦٠، ٧٥ يوما من الزراعة.

وقد أوضحت النتائج: تفوق المحصول الكلى (طن/ فدان) وكذلك عدد الدرناى الكلية / نبات باستخدام كلوريد الكالسيوم بنسبة زيادة وصلت إلى (١١٨٦، ١١٨٤، ١١٨٤%) وهيدروجين أورثوفوسفات الكالسيوم (١٢٠٨١، ١٠٩١%) فى كلا الموسمين الأول والثانى على التوالى بدون اختلافات معنوية بينهم بالنسبة للمحصول الكلى. أيضا عند الدرناى الكلية / نبات قد تأثرت بتلك المعاملات وقد أعطى الهيدروجين أورثوفوسفات الكالسيوم أعلى نسبة فى كلا الموسمين (١٠٦٣، ٨٩٥ درنة / نبات) بالمقارنة بالكالسيوم أوكسيد (١١٤٤، ١١٤٤ درنة / نبات) فقط فى الموسم الأول، كلوريد الكالسيوم (٩٠٤، ٩٠٤) فقط فى الموسم الثانى.

أعطى طرطرات الكالسيوم أعلى نسبة زيادة فى المادة الجافة للدرناى ، وكذلك الوزن النوعى فى كلا الموسمين يليها أوكسيد الكالسيوم فى الموسم الأول مع عدم وجود اختلافات معنوية بينهم فى الموسم الثانى ، كما أدى استخدام كلوريد الكالسيوم والهيدروجين أورثوفوسفات إلى زيادة % للدرناى المستخدمة كتناوى للزراعة فى العروة الخريفى (٤١٦٠، ٣٩٦٧%) فى الموسم الأول، (٣٨٠٠، ٣٨٠٢%) فى الموسم الثانى مع عدم وجود اختلافات معنوية بينهم بالمقارنة بمعاملة الكنترول (٣٠٤٠%). أيضا سلفات الكالسيوم وأكسيد الكالسيوم ولاكتات الكالسيوم وجلوكونات الكالسيوم أدت إلى زيادة معنوية فقط فى الموسم الثانى.

أظهر التحليل الكيماوى:

١- أن معاملات الرش بكلوريد الكالسيوم وأوكسيد الكالسيوم قد أدت إلى رفع محتوى الكالسيوم فى نسيج الدرناى فى كلا الموسمين (بمتوسط ١،٤ %) ، وهذه المعاملات يمكن استخدامها لتعويض النقص الطبيعى فى محتوى درناى البطاطس من الكالسيوم.

٢- اختلف تركيز المواد الفينولية الكلية داخل نسيج الدرنة باختلاف مصادر الكالسيوم المستخدمة ، وقد أظهر أوكسيد الكالسيوم أعلى نسبة زيادة فى محتوى الدرناى من المواد الفينولية الكلية (١٦٤٠، ١٦٤٠ ميكروجرام/ملى)، يليه كربونات الكالسيوم (١٥٩٠، ١٥٩٠ ميكروجرام/ملى)، سلفات الكالسيوم (١٥٢٠، ١١٧٠ ميكروجرام/ملى)، طرطرات الكالسيوم (١٤٩٠، ١٤٩٠ ميكروجرام/ملى) بالمقارنة بالكنترول (١١٧٠، ١١٧٠ ميكروجرام/ملى) ، وأن هذه المواد الفينولية الكلية وجد أن لها دورا فعالا فى الية المقاومة الشفاعة للنبات وزيادتها هامة لصحة الانسان.

أظهرت نتائج الدراسات المرضية: من بين الـ ٦ أصناف المختبرة (أنفا، دايمونت، هيرمز، ليدى روزيتا، نيقولا، سانت-) سجل الصنف نيقولا أعلى نسبة حساسية للإصابة بالعفن الطرى يليه الصنف دايمونت مع عدم وجود اختلافات معنوية بينهم بالمقارنة بالأصناف الأخرى المختبرة ، كما أعطى الرش بأوكسيد الكالسيوم أعلى نسبة حماية للإصابة بالعفن الجاف (٧٢،٠٩%) يليه كلوريد الكالسيوم (٦٩،٨٣%) ، طرطرات الكالسيوم (٦٩،٧٩%) ثم سلفات الكالسيوم (٦٧،٠٧%) بينما خلات الكالسيوم، وهيدروجين أورثوفوسفات الكالسيوم، فوسفات الكالسيوم وجلوكونات الكالسيوم أعطوا أقل نسبة حماية.