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# Potassium or Sodium Bicarbonate in Combination with Nerol for Controlling Early Blight Disease of Potato Plants under Laboratory, Greenhouse and Field Conditions

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Potassium or sodium bicarbonate alone or in combination with Nerol were tested to study their effect on early blight disease caused by *Alternaria solani* of potato plants. In laboratory experiments, results indicated that potassium or sodium bicarbonate and Nerol showed great inhibitory effect in linear growth of *Alternaria solani*. Complete inhibition was obtained with potassium or sodium bicarbonate at 2 % and Nerol at 0.50 %.

In greenhouse experiments, results indicated that the most effective treatments were potassium or sodium bicarbonate at 1.0 and 2.0 % and Nerol at 0.50 % which reduced the early blight incidence by more than 70.6 %. In the other trail, combined treatments between potassium or sodium bicarbonate at 1.0 or 2.0 % and Nerol at 0.50 % reduced the early blight incidence by more than 81.6 %. Chitinase activity was increased in potato plants treated with both salts, Nerol or their combinations. The most effective treatment was potassium bicarbonate at 2.0 % combined with Nerol at 0.5 % which increased the activity by 130.8 % of the check. Potassium or sodium bicarbonate at 1.0 or 1.0 and 2.0%, respectively, in combination with Nerol at 0.5% which increased the enzyme activity by more than 92.3 % as compared with untreated plants.

In field experiments, results indicated that the most effective treatment was potassium bicarbonate at 2.0 % plus Nerol at 0.5 % which reduced the disease incidence by more than 86.8 % during the two successive seasons.

Considerable decrease in disease incidence was obtained with potassium or sodium bicarbonate at 1.0 or 2.0, respectively, plus Nerol at 0.5 % and Ridomil which reduced the early blight incidence by more than 71.1 %. As for tuber yield, high increases were obtained with potassium bicarbonate at 2.0 or 1.0 % plus Nerol at 0.5 % which increased tuber yield by 82.6 or 72.0 %, respectively, during two growing seasons.

It could be suggested that using a combination of potassium bicarbonate and Nerol may be used for controlling early blight disease of potato plants under field conditions.

**Keywords**: Early blight, Nerol, potato, potassium bicarbonate and sodium bicarbonate.

Potato crop (*Solanum tuberosum* L.) is one of the most important vegetable crops in Egypt. Early blight caused by *Alternaria solani* is the most important disease attacking potato plants (Waals *et al.*, 2004; Pasche *et al.*, 2004 and 2005 and El-Gamal *et al.*, 2007). Controlling this disease depends mainly on fungicidal treatments (Pasche *et al.*, 2005).

There has been considerable interest in the use of sodium bicarbonate , ($NaHCO_3$) and potassium bicarbonate ($KHCO_3$) for controlling various fungal diseases in plants (Karabulut *et al.*, 2003 and Smilanick *et al.*, 2006). Bicarbonate are widely used in the food industry (Lindsay, 1985) and were found to suppress several fungal diseases of cucumber plants (Ziv and Zitter, 1992). Spraying plants with $NaHCO_3$ solution provided good control of several plant diseases (Horst *et al.* 1992; Arimoto *et al.*, 1997; Palmer *et al*, 1997; Janisiewicz and Peterson, 2005). Also, spraying with $KHCO_3$ solution provided the most effective protection against plant diseases (Fallilk *et al.*,1996 and Smilanick and Margosan, 1999 and Smilanick *et al.*,2006). Sodium or potassium bicarbonate combined with oil were effective in controlling plant diseases (Horst *et al.*, 1992 and Ziv and Zitter, 1992). Nerol is a commercial product of the citrus essential oil fractions it was reported to have antifungal activity against *Giotrichum candidum*, *Penicillium digitatum* and *P. italicum* as causal agents of fruit citrus diseases (El-Mohamedy *et al.*, 2002).

The main objective of the present research are studying the effect of sodium or potassium bicarbonate alone or in combination with Nerol against early blight (mm-diameter) of 10-day-old culture of *Alternaria solani*. Five plates were used as replicates for each particular treatment. Inoculated plates were incubated at 25±2°C. disease of potato plants under field conditions .

## Materials and Methods

*Source of pathogenic fungi and potato tubers:*

Pathogenic isolate of *Alternaria solani* the causal agent of early blight diseases was kindly provided by Plant Pathol. Dept., National Res. Centre, Giza, Egypt. Potato tubers cv. Nigola were obtained from the Dept. of Vegetable Crop Res., Agric. Res. Centre, Giza, Egypt.

*Laboratory experiments:*

*Testing of different concentrations of potassium or sodium bicarbonate or Nerol on linear growth of Alternaria solani:*

Different concentrations of potassium or sodium bicarbonate and Nerol were tested to study their inhibitory effect on linear growth of *Alternaria solani in vitro*. Five concentrations of potassium or sodium bicarbonate, *i.e.* 0.0 ,0.25 ,0.50 , 1.0 and 2.0 % ( w / v ) and Nerol at 0.10 , 0.25 , and 0.50 % (v/ v) were added individually to conical flasks containing sterilized PDA medium to obtain the proposed concentrations, then mixed gently and dispensed in sterilized Petri plates (10-cm-diameter). Plates were individually inoculated at the centre with equal disks (6-mm). The average linear growth of fungus was estimated after 10 days.

*Greenhouse experiments:*

*Testing of different concentrations of potassium or sodium bicarbonate and Nerol on early blight severity of potato plants:*

Different concentrations of potassium or sodium bicarbonate and Nerol were tested against early blight incidence of potato plants.

- Inoculum preparation of *A. solani*: Spore suspensions of *A. solani* were prepared by inoculating sterilized PDA medium with disk (6 mm diameter) taken from 10-day-old cultures of *A. solani*. Plates were incubated at 25°C and spores suspension ($10^6$spores / ml) of *A. solani* were prepared.

- Potato plants: Potato tubers cv. Nigola grown in plastic pots (30-cm-diameter) containing a sandy loam soil under greenhouse conditions (23-25$^{O}$C) were used when plants had 4-5 compound leaves. Three plants / pot and ten pots for each treatment were used. Irrigation and fertilization were carried out as needed.

- Treatments: Potassium or sodium bicarbonate at five concentrations, *i.e.* 0.0, 0.25, 0.50, 1.0 and 2.0% (w/v) and Nerol at three concentrations, *i.e.* 0.1, 0.25 and 0.50% beside a non treated control treatments were applied as foliar spray to study their effects against early blight of potato plants which had 4-5 compound leaves. Plant inoculation was carried out after 5 days of chemical treatments by spraying potato plants with spore suspensions ($10^6$ spores/ml) of *A. solani*. Plants sprayed with tap water served as a check. Treated inoculated potato plants were incubated at 23-25$^{O}$C.

*Testing of combined treatment of potassium or sodium bicarbonate and Nerol on early bight incidence of potato plants:*

Potassium or sodium bicarbonate at 1.0 or 2.0% alone or in combination with Nerol at 0.5% were tested to study their effect on early blight severity of potato plants.

Potato plants had 4-5 compound leaves were sprayed with Potassium or sodium bicarbonate at 1.0 or 2.0 % alone or in combination with Nerol at 0.50 % .Plant inoculation was carried out as mentioned before.

*Disease assessment:*

Diseases was recorded after 20 days of inoculation following the Early blight scale from 0 to 4 according to Cohen *et al.*, (1991) based on the leaf area infected was used , as follows: -

0= No leaf lesions, 1= 25% or less, 2= 26 to 50%, 3= 51 to 75% and 4= 76 to 100% infected leaf area.

*Effect of potassium or sodium bicarbonate alone or in combination with Nerol on chitinase activity of potato plants:*

Potassium or sodium bicarbonate at 1.0 or 2.0% alone or in combination with Nerol at.0.5 % were tested to study their effect on chitinase activity of potato plants.

*Extraction of chitinase enzyme:*

Chitinase activity was determined after 10 days of inoculation. Extraction of enzyme from potato leaves was done according to method of Tuzun *et al.* (1989).

*Chitinase assay:*

Chitinase activity was determined by colourimetric method of Boller and Mauch (1988). Colloidal chitin was used as a substrate and dinitrosalicylic acid as reagent to measure reducing sugars.

Chitinase activity was expressed as mM N-acetylglucosamine equivalent released / gram fresh weight tissue / 60 minutes.

*Field experiments:*

*Testing of potassium or sodium bicarbonate alone or in combination with Nerol on early blight severity of potato plants under field conditions:*

Experiments were carried out, at the Experimental Farm of National Res. Centre at El-Noubaryia, Behiera Governorate, Egypt.

The promising treatments in pot experiments were applied under field conditions to study the possibility of their effect under large scale for safe control against early blight diseases during two seasons. Potato yield was also determined in two the seasons. Field experiments were conducted under natural infection in plots (4x8 m) each comprised of 8 rows (32 holes / row) in a randomized complete block design with three replicates (plots) for each treatment.

*Treatments:*

Potassium or sodium bicarbonate at 1.0 or 2.0 % alone or in combination with Nerol at 0.5 % in addition to the Fungicides (Ridomil-plus at 2 g / l) were applied as follow:

| Treatment | |
|---|---|
| Single | Combined |
| 1- $KHCO_3$ 1 % | 1- $KHCO_3$ 1 % + Nerol 0.5% |
| 2- $KHCO_3$ 2 % | 2- $KHCO_3$ 2 % + Nerol 0.5% |
| 3- $NaHCO_3$ 1 % | 3 - $NaHCO_3$ 1 % + Nerol 0.5% |
| 4- $NaHCO_3$ 2 % | 4- $NaHCO_3$ 2 % + Nerol 0.5% |
| 5- Nerol 0.5 % | |
| 6- Fungicide (Ridomil plus 2 g / l) | |
| 7- Untreated plants (control) | |

*Application:*

All treatments were applied as foliar application on potato plants which had 4-5 compound leaves and every 15 days up to 90 days of planting.

*Disease assessment:*

Early blight scale was used as mentioned before and disease was recorded up to 90 days of planting.

*Determination of tuber yield:*

Tuber yield of potato (kg /$m^2$) for each treatment was determined.

*Statistical analysis:*

Tukey test for multiple comparisons among means was utilized (Neler *et al.*, 1985).

## Results

*Laboratory experiments:*

*Effect of potassium or sodium bicarbonate and Nerol on Linear growth of Alternaria solani:*

Potassium or sodium bicarbonate at four concentrations, *i.e.* 0.25, 0.50, 1.0 and 2.0 % (w/v) and Nerol at three concentrations, *i.e.* 0.1, 0.25, and 0.50 % (v/v) beside non treated plates (control) were tested to study their inhibitory effect on linear growth of *Alternaria solani in vitro*. Results in Table (1) indicate that both salts or Nerol significantly reduced the linear growth of *Alternaria solani*. Complete inhibition was obtained with potassium or sodium bicarbonate at 2 % and Nerol at 0.50 %. High reduction was achieved with potassium bicarbonate at 1.0 % which reduced the linear growth by 91.1% as compared with untreated. Potassium or sodium bicarbonate at 0.50 and 1.0% or Nerol at 0.25% exhibited a moderate effect. Other treatments were less effective.

*Greenhouse experiments:*

*Effect of potassium or sodium bicarbonate and Nerol on early blight incidence of potato plants under artificial infection:*

The different concentrations of potassium or sodium bicarbonate or Nerol significantly reduced the early blight incidence (Table 2). The most effective treatments were potassium or sodium bicarbonate at 1.0 and 2.0% or Nerol at 0.50% which reduced the early blight incidence by more than 70.6%. Moderate effect was obtained using potassium or sodium bicarbonate at 0.5% as well as Nerol at 0.25% which reduced the disease incidence by more than 41.1%. Other treatments were less effective.

**Table 1. Linear growth (mm) of *Alternaria solani* as affected with different concentrations of potassium or sodium bicarbonate and Nerol**

| Treatment | Concentration (%) | Linear growth (mm) | Reduction (%) |
|---|---|---|---|
| $KHCO_3$ | 0.25 | 51.2 c * | 43.1 |
| | 0.50 | 22.5 f | 75.0 |
| | 1.0 | 8.0 g | 91.1 |
| | 2.0 | 0.0 g | 100 |
| $NaHCO_3$ | 0.25 | 62.1b | 31.0 |
| | 0.50 | 42.0 d | 53.3 |
| | 1.0 | 25.0 ef | 72.2 |
| | 2.0 | 0.0 g | 100 |
| Nerol | 0.1 | 55.2 c | 38.7 |
| | 0.25 | 30.0 e | 66.7 |
| | 0.50 | 0.0 g | 100 |
| Control | | 90.0 | ----- |

* Figures with the same letter are not significantly different (P= 0.05).

**Table 2. Early blight incidence on potato plants as affected with different concentrations of potassium or sodium bicarbonate and Nerol under greenhouse conditions**

| Treatment | Concentration (%) | Early blight incidence* | Reduction (%) |
|---|---|---|---|
| $KHCO_3$ | 0.25 | 2.0 b** | 41.2 |
| | 0.50 | 1.7 c | 50.0 |
| | 1.0 | 0.8 d | 76.5 |
| | 2.0 | 0.8 d | 76.5 |
| $NaHCO_3$ | 0.25 | 2.2 bc | 35.3 |
| | 0.50 | 1.8 c | 47.1 |
| | 1.0 | 1.0 d | 70.6 |
| | 2.0 | 0.8 d | 76.5 |
| Nerol | 0.1 | 2.5 b | 26.5 |
| | 0.25 | 2.0 bc | 41.2 |
| | 0.50 | 1.0 d | 70.6 |
| Control | | 3.4 a | — |

* Early blight scale from 0 to 4 according to Cohen *et al.* (1991).
** Figures with the same letter are not significantly different (P= 0.05).

*Effect of combined application of potassium or sodium bicarbonate and Nerol on early blight incidence of potato plants under greenhouse conditions:*

Potassium or sodium bicarbonate at 1.0 or 2.0 % alone or in combination with Nerol at 0.50% were tested under greenhouse experiment to study their effect on early blight severity of potato plants. Data in Table (3) indicate that all treatments receiving both salts or Nerol have significantly reduced disease incidence. High reduction was obtained with potassium or sodium bicarbonate at 1.0 and 2.0% combined with Nerol at 0.50% which reduced the early blight incidence by more than 81.6% as compared with untreated plants. Moderate effect was obtained with potassium or sodium bicarbonate at 2.0% as single treatment which reduced the early blight incidence by 73.3%. Potassium or sodium bicarbonate at 1.0 as well as Nerol at 0.50% as single treatments reduced the disease more than 65.8% as compared with untreated plants.

*Effect of potassium or sodium bicarbonate alone or in combination with Nerol on chitinase activity of potato plants under field conditions:*

Potassium or sodium bicarbonate at 1.0 or 2.0 % alone or in combination with Nerol at 0.50 % were applied to study their effect on chitinase activity of potato plant. Data in Table (4) indicate that all treatments receiving salts or Nerol significantly increased chitinase activity. The most effective treatment was potassium bicarbonate at 2.0% combined with Nerol at 0.5 % which increased the activity by 130.8 %. Potassium or sodium bicarbonate at 1.0 or 1.0 & 2.0 % respectively in combination with Nerol increased the enzyme activity by more than 92.3 %. Potassium or sodium bicarbonate applied singly at 1.0 or 2.0 % showed moderate effects.

**Table 3. Effect of combined treatments between potassium or sodium bicarbonate and Nerol on early blight incidence of potato plants under greenhouse conditions**

| Application (%) | Early blight incidence * | Reduction (%) |
|---|---|---|
| Single treatment | | |
| $KHCO_3$ 1.0 | 1.2 b ** | 68.4 |
| $KHCO_3$ 2.0 | 1.0 bc | 73.7 |
| $NaHCO_3$ 1.0 | 1.3 b | 65.8 |
| $NaHCO_3$ 2.0 | 1.0 bc | 73.7 |
| Nerol 0.5 | 1.2 b | 68.4 |
| Combined treatment | | |
| $KHCO_3$ 1.0 + Nerol | 0.6 d | 84.2 |
| $KHCO_3$ 2.0 + Nerol | 0.4 d | 89.5 |
| $NaHCO_3$ 1.0 + Nerol | 0.7 d | 81.6 |
| $NaHCO_3$ 2.0 + Nerol | 0.5 d | 86.8 |
| Control | 3.8 a | — |

* Early blight scale from 0 to 4 according to Cohen *et al.* (1991).

** Figures with the same letter are not significantly different (P= 0.05).

**Table 4. Chitinase activity on potato plants inoculated with *Alternaria solani* as affected by potassium or sodium bicarbonate alone or in combination with Nerol**

| Application (%) | Chitinase activity * | Increase (%) |
|---|---|---|
| Single treatment | | |
| $KHCO_3$ 1.0 | 2.2 d ** | 69.3 |
| $KHCO_3$ 2.0 | 2.3 cd | 76.9 |
| $NaHCO_3$ 1.0 | 1.8 e | 38.5 |
| $NaHCO_3$ 2.0 | 2.1 de | 53.8 |
| Nerol 0.5 | 2.1 de | 61.5 |
| Combined treatment | | |
| $KHCO_3$ 1.0 + Nerol | 2.6 bc | 100 |
| $KHCO_3$ 2.0 + Nerol | 3.0 a | 130.8 |
| $NaHCO_3$ 1.0 + Nerol | 2.5 bc | 92.3 |
| $NaHCO_3$ 2.0 + Nerol | 2.6 bc | 100 |
| Control | 1.3 f | — |

* Chitinase activity expressed as mM N-acetyl glucosamine equivalent released/ gram fresh weight/ 60 min.

** Figures with the same letter are not significantly different (P= 0.05).

*Field experiments:*

*Effect of potassium or sodium bicarbonate alone or in combination with Nerol on early blight incidence of potato plants under natural infection:*

The promising treatments in the greenhouse experiments were applied under field conditions during two successive seasons. Potassium or sodium bicarbonate at 1.0 or 2.0% singly or in combination with Nerol at 0.50 %. Fungicides (Ridomil–plus at 2 g / l) was applied to study the effect on early blight incidence of potato plants. Results in Table (5) indicate that all treatments receiving salts, Nerol or fungicide significantly reduced the disease incidence.

**Table 5. Early blight incidence* on potato plants as affected with Potassium or sodium bicarbonate alone or in combination with Nerol under field conditions**

| Application (%) | First season (2005) | | Second season (2006) | |
|---|---|---|---|---|
| | Disease incidence | Reduction (%) | Disease incidence | Reduction (%) |
| Single treatment | | | | |
| $KHCO_3$ 1.0 | bc 2.0 ** | 42.9 | bc 2.1 | 44.7 |
| $KHCO_3$ 2.0 | d 1.6 | 54.3 | de 1.4 | 63.2 |
| $NaHCO_3$ 1.0 | b 2.3 | 34.3 | b 2.2 | 42.1 |
| $NaHCO_3$ 2.0 | bc 2.0 | 42.9 | bc 2.0 | 47.4 |
| Nerol 0.5 | d 1.5 | 57.1 | d 1.6 | 57.9 |
| Combined treatment | | | | |
| $KHCO_3$ 1.0 + Nerol | f 0.8 | 77.1 | f 1.0 | 73.7 |
| $KHCO_3$ 2.0 + Nerol | g 0.3 | 91.4 | g 0.5 | 86.8 |
| $NaHCO_3$ 1.0 + Nerol | de 1.3 | 62.9 | d 1.6 | 57.9 |
| $NaHCO_3$ 2.0 + Nerol | ef 1.0 | 71.4 | ef 1.2 | 68.4 |
| Ridomil – plus 0.2 | ef 1.0 | 71.4 | ef 1.1 | 71.1 |
| Control | a 3.5 | — | a 3.8 | — |

* Early blight scale from 0 to 4 according to Cohen *et al.* (1991).

** Figures with the same letter are not significantly different (P= 0.05).

The most effective treatment was potassium bicarbonate at 2.0 % combined with Nerol at 0.5 % which reduced the disease incidence by average of 86.8% during the two growing seasons. High reduction was obtained with potassium or sodium bicarbonate at 1.0 or 2.0% combined with Nerol at 0.5 % and Ridomil which reduced the disease incidence by more than 71.1 %. Applying potassium bicarbonate singly at 2.0 % or Nerol singly at 0.50 % has reduced the disease incidence by more than 54.3 % during the two growing seasons. Other treatments showed moderate effects.

*Effect of potassium or sodium bicarbonate singly or in combination with Nerol on tuber yield of potato plants under field conditions:*

Potassium or sodium bicarbonate at 1.0 or 2.0 % singly or in combination with Nerol at 0.50%. In addition to Fungicides (Ridomil–plus at 2 g/l). Treatments were applied to study their effect on tuber yield of potato plants. Results in table (6) indicate that all treatments receiving both salts, Nerol and fungicide significantly increased the tuber yield.

A considerable increase was obtained with potassium bicarbonate at 2.0 or 1.0 % plus Nerol at 0.5% which giving 82.6 or 72.0% more yield respectively. Moderate increase was obtained with potassium bicarbonate applied singly at 2.0, or sodium bicarbonate applied at 2.0% combined with Nerol at 0.5% as well as Ridomil treatment. Other treatments showed moderate effects.

**Table 6. Tuber yield of potato plants as affected with different concentrations of potassium or sodium bicarbonate alone or in combination with Nerol under field conditions**

| Application (%) | First season (2005) | | Second season (2006) | |
|---|---|---|---|---|
| | Yield ($kg/m^2$) | Increase (%) | Yield ($kg/m^2$) | Increase (%) |
| Single treatment | | | | |
| $KHCO_3$ 1.0 | de 3.5 * | 52.2 | cd 3.8 | 52.0 |
| $KHCO_3$ 2.0 | cd 3.7 | 60.9 | bc 4.0 | 60.0 |
| $NaHCO_3$ 1.0 | f 3.0 | 30.4 | d 3.6 | 44.0 |
| $NaHCO_3$ 2.0 | de 3.4 | 47.8 | cd 3.7 | 48.0 |
| Nerol 0.5 | de 3.4 | 47.8 | d 3.5 | 40.0 |
| Combined treatment | | | | |
| $KHCO_3$ 1.0 + Nerol | ab 4.0 | 73.9 | ab 4.3 | 72.0 |
| $KHCO_3$ 2.0 + Nerol | a 4.2 | 82.6 | a 4.6 | 84.0 |
| $NaHCO_3$ 1.0 + Nerol | cde 3.6 | 56.5 | cd 3.8 | 52.0 |
| $NaHCO_3$ 2.0 + Nerol | bc 3.8 | 65.2 | bc 4.0 | 60.0 |
| Ridomil – plus 0.2 | cde 3.6 | 56.5 | bc 4.0 | 60.0 |
| Control | g 2.3 | ---- | e2.5 | |

* Figures with the same letter are not significantly different (P= 0.05).

## Discussion

Early blight caused by *Alternaria solani* is one of the most important disease attacking potato plants (Abd-El-Kareem *et al.*, 2002; Waals *et al.*, 2004; Pasche *et al.*, 2005 and El-Gamal *et al.*, 2007). Bicarbonate are widely used in the food industry (Lindsay, 1985) have antifungal activity (Ziv and Zitter, 1992). In the present study, results indicate that potassium or sodium bicarbonate and Nerol showed high inhibitory effect in linear growth of *Alternaria solani.*

Complete inhibition was obtained with potassium or sodium bicarbonate at 2 % and Nerol at 0.50 % *in vitro*. In this respect, Ziv and Zitter (1992) reported that potassium and sodium bicarbonate showed inhibitory effects against several pathogenic fungi. In addition, bicarbonate salts has been shown to have a considerable inhibitory effect on several fungi and causes the collapse of hyphal walls and shrinkage of conidia (Punja and Grogan ,1982 and Ziv and Zitter, 1992 ). Potassium and sodium bicarbonate were found to control several plant diseases (Smilanick and Margosan, 1999; Janisiewicz and Peterson, 2005 and Smilanick *et al.*, 2006). In the present study , under greenhouse conditions results indicate that combined treatments of potassium or sodium bicarbonate with Nerol reduced the early blight incidence by more than 81.6%. In field experiments, potassium bicarbonate at 2.0 % combined with Nerol at 0.5 % reduced the early blight incidence by more than 86.8 % and increased tuber yield by 82.6 and 84 % during two successive seasons respectively. In this study bicarbonate and Nerol oil were effective for controlling early blight disease. Their effectiveness is quite good when applied as single treatments but improved when used in combination. This result may be due to: the antifungal activity of bicarbonate and Nerol, synergistic effect between bicarbonate and Nerol and increasing the activity of chitinase enzyme of potato against fungal pathogen. In this respect Punja and Grogan, (1982) reported that the high effectiveness control with combinations of bicarbonate plus oil was attributed to fungicidal characteristics of bicarbonate ions. The fungicidal and spreader sticker characteristics of oil that keep the bicarbonate ions on foliar surfaces may be responsible (Homma *et al.*, 1981 and Ziv and Zitter, 1992).

Hypothesis have been proposed for the inhibitory mechanisms of bicarbonate and oil as follows:- Hydrogen ion concentration of bicarbonate salts has been shown to have a profound inhibitory effect on sclerotia and conidia germination of *S. rolfsii* and *S. fuliginea*, respectively (Punja and Grogan , 1982 and Homma *et al.*, 1981). Furthermore, film-forming polymers may form a physical barrier on leaf surfaces against germ tube penetrations (Elad *et al.*, 1989 and Ziv and Zitter 1992). The bicarbonate causes the collapse of hyphal walls and shrinkage of conidia, (Punja and Grogan, 1982 and Ziv and Zitter, 1992). On the other hand the role of potassium bicarbonate in increasing crop resistance to diseases caused by bacteria and fungi was widely reviewed by Perrenoud (1990). In general, potassium application improves plant health and vigour, making infection less likely or enabling a quick recover (Perrenoud, 1993).Potassium probably exerts its greatest effects on disease through specific metabolic functions that alter compatibility relationships of the host-parasite environment and increases the production of disease inhibitory compounds, such as phenols, phytoalexins and auxins around infection sites of resistant plants. (Kiraly, 1976). In the present study, results indicate that all treatments increased the chitinase activity.

In this respect, B-1,3-glucanases and chitinases are able to hydrolyze B-1,3-glucan and chitin, respectively, the major components of fungal cell walls (Kauffmann *et al.*, 1987; Legrand *et al.*, 1987 and Abd-El-Kareem *et al.*, 2004). Sodium or potassium bicarbonate combined with oil were effective in controlling several plant fungal diseases (Horst *et al.*, 1992 and Ziv and Zitter, 1992).

It could be suggested that combined treatments between potassium bicarbonate plus Nerol might be used for controlling early blight disease of potato plants under field conditions.

## References

Abd-El-Kareem, F.; Abd-Alla, M. A. and El-Mohamedy, R.S.R. 2002. Induced resistance in potato plants for controlling Early blight disease under field conditions . *Egypt. J. App. Sci.*, **17**: (2) 51–66.

Abd-El-Kareem, F.; El-Mougy, Nehal S.; El-Gamal, Nadia, G. and Fotouh, Y. O. 2004. Induction of Resistance in squash plants against powdery mildew and Alternaria leaf spot diseases using chemical inducers as protective or therapeutic treatments. *Egypt. J. Phytopathol.*, **32**: (No, 1-2) 65- 76.

Arimoto, Y., Homma, Y. and Misato, T. 1977. The effect of sodium hydrogen carbonate on the occurrence of citrus storage diseases. *J. Pest. Sci.*, **2**:163-167.

Boller, T. and Mauch, F. 1988. Colourimetric assay for chitinase. *Methods in Enzymology*, **161**: 430 -435.

Cohen, Y.; Gisi, U. and Mosinger, E. 1991. Systemic resistance of potato plants against *Phytophthora infestans* induced by unsaturated fatty acids. *Physiol. Mol. Plant Pathol.*, **38**: 255-263.

Elad, Y.; Zive, O.; Ayash, N. and Katan, J. 1989. The effect of film forming polymers on powdery mildew of cucumber. *Phytoparasitica*, **17**: 179- 288.

El-Gamal, Nadia G.; Abd-El-Kareem, F.; Fotouh, Y. O. and El- Mougy, Nehal S. 2007. Induction of systemic resistance in potato plants against late and early blight diseases using chemical inducers under greenhouse and field conditions. *Res. J. Agric. & Biol. Sci.*, **3**(2): 73-81.

El-Mohamedy, R.S.R.; Abd-El-Kareem, F. and Abd-Alla, M.A. 2002. Effect of some constituents of citrus essential oils against postharvest pathogenic fungi of citrus fruits. *Arab. Univ. Agric. Sci.*, **10**: 335-350 .

Fallilk, E.; Grinberg, S. and Ziv, O. 1996. Potassium bicarbonate reduces postharvest decay development on bell pepper fruits. *J. Hort. Sci.*, **71**: 121 -127.

Homma, Y.; Arimoto, Y. and Misato, T. 1981. Studies on the control of plant diseases by sodium bicarbonate formulation. 2. Effect of sodium bicarbonate on each growth stage of cucumber powdery mildew fungus (*Sphaerotheca fuliginea*) in its life cycle. *J. Pestic. Sci.*, **6**: 201-209.

Horst, R.K.; Kawamoto, S.O. and Porter, L.L. 1992. Effect of sodium bicarbonate and oils on control of powdery mildew and black spot of roses. *Plant Dis.*, **76**: 247-251.

Janisiewicz , W.J. and Peterson, D.L. 2005. Experimental Bin drenching system for testing biocontrol agents to control postharvest decay of apples. *Plant Dis.*, **89**: 487-490.

Karabulut, O.A.; Bursa, G. and Mansour, M. 2003. Near-harvest applications of *Metschnikowia fructicola*, ethanol and sodium bicarbonate to control postharvest diseases of grape in central California. *Plant Dis.*, **87**: 1384-1389.

Kauffmann, S.; Legrand, M.; Jeoffroy, P. and Fritig, B. 1987. Biological function of pathogenesis-related proteins. Four PR-proteins of tobacco have B-1,3-glucanase activity . *EMBO J.*, **6**: 3209-3212.

Kiraly, Z. 1976. Plant disease resistance as influenced by biochemical effects of nutrients in fertilizers. In: Proceedings of the IPI 12th Colloquium on: Fertilizer Use and Plant Health.

Legrand, M.; Kauffmann, S.; Jeoffroy, P. and Fritig, B. 1987. Biological function of pathogenesis-related proteins, Four tobacco pathogenesis-related proteins are chitinases. *Proc. Natl. Acad. Sci.*, **84**: 6750-6754.

Lindsay, R.C. 1985. Food additives. In: Fennema. Chapter 10. Food Chemistry. Marcel Dekker, Inc., New York, USA.

Neler, J.; Wassermann, W. and Kutner, M.H. 1985. *Applied linear statistical models. Regression, analysis of variance and experimental design* : 2nd Ed. Richard, D. Irwin Inc. Homewood, Illinois, USA.

Palmer, C.L.; Horst, R.K. and Langhans, R.W. 1997. Use of bicarbonate to inhibit *in vitro* colony growth of *Botrytis cinerea*. *Plant Dis.*, **81**: 1432-1438.

Pasche, J.S.; Wharam, C.M. and Gudmestad, N.C. 2004. Shift in Sensitivity of *Alternaria solani* in response to Q(o)I fungicides. *Plant Dis.*, **88**:181-187.

Pasche, J.S.; Piche, L.M. and Gudmestad, N.C. 2005. Effect of the F129L Mutation in *Alternaria solani* on fungicides affecting mitochondrial respiration. *Plant Dis.*, **89**: 269-278.

Perrenoud, S. 1990. Potassium and Plant Health. IPI Research Topics No. 3. 2nd Ed. International Potash Institute, Bern, Switzerland.

Perrenoud, S. 1993. Fertilizing for High Yield Potato. IPI Bulletin 8. 2nd Ed. International Potash Institute, Basel, Switzerland.

Punja, Z. and Grogan, R.G. 1982. Effects of inorganic salts carbonate-bicarbonate anions, ammonia and the modifying influence of pH on sclerotia germination of *Sclerotium rolfsii*. *Phytopathology*, **72**: 635–639.

Smilanick, J.L. and Margosan, D.A. 1999. Control of citrus green mould by carbonate and bicarbonate salts and the influence of commercial postharvest practices on their efficacy. *Plant Dis.*, **83**: 139-145.

Smilanick, J.L.; Mansour, M.F. and Sorenson, D. 2006. Pre- and postharvest treatments to control green mould of citrus fruit during ethylene degreasing. *Plant Dis.*, **90**: 89-96.

Tuzun, S.; Rao, M.N.; Vogeli, U.; Schardl, C.L. and Kuc, J. 1989. Induced systemic resistance to blue mould: Early induction and accumulation of ß-1,3-glucanase, chitinase and other pathogenesis proteins (b-proteins) in immunized tobacco. *Phytopathology,* **79**: 979-983.

Waals, J.E; Korsten, L. and Slippers, B. 2004.Genetic Diversity Among *Alternaria solani* Isolates from Potatoes in South Africa. *Plant Dis.*, **88**:959-964.

Ziv, O. and Zitter, T.A. 1992. Effects of Bicarbonates and Film-Forming Polymers on Cucurbit Foliar Diseases. *Plant Dis.*, **76**: 513-517.

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## استخدام بيكربونات البوتاسيوم والصوديوم مع النيرول في مقاومة مرض اللفحة المبكرة في نباتات البطاطس تحت ظروف الصوبة و الحقل

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تم اختبار عدد من التركيزات الخاصة لكل من بيكربونات البوتاسيوم والصوديوم و النيرول بصورة فردية أومجتمعة ودراسة تأثيرها علي مقاومة مرض اللفحة المبكرة في نباتات البطاطس تحت ظروف الحقل وأوضحت النتائج ما يلي:

تجارب المعمل: أدت جميع المعاملات الي انخفاض نمو الفطر الترناريا سولاني وأدت المعاملات بيكربونات البوتاسيوم والصوديوم بتركيز 2.0% والنيرول بتركيز 0.5 % الي التثبيط الكامل لنمو الفطر الممرض .

تجارب الصوبة : أدت المعاملات بيكربونات البوتاسيوم والصوديوم بتركيز 1.0 أو 0 .2 % و النيرول بتركيز 0.5 % الي انخفاض نسبة حدوث مرض اللفحة المبكرة بواقع 70.6 % علي الأقل .وفي تجربة أخري أدي تكامل المعاملات بين بيكربونات البوتاسيوم أوالصوديوم بتركيز 1.0 أو 0 .2 % مع النيرول بتركيز 0.5 % الي انخفاض نسبة حدوث المرض بواقع 81.6 % بالمقارنة بالنباتات الغير معاملة. أدت جميع المعاملات الي زيادة نشاط انزيم الشيتينيز وكانت افضل النتائج المتحصل عليها بواسطة تكامل المعاملات بين بيكربونات البوتاسيوم بتركيز 0 .2 % مع النيرول بتركيز 0.5 % حيث أدت الي زيادة نشاط الانزيم بمقدار 130.8 % بينما أدت المعاملات بيكربونات البوتاسيوم أوالصوديوم بتركيز 1.0 أو 1.0 & 0 .2 % علي الترتيب مع النيرول بتركيز 0.5 % الي زيادة نشاط الانزيم بمقدار 92.3 % علي الاقل.

تجارب الحقل: أظهرت تفوق معاملة بيكربونات البوتاسيوم بتركيز 0 .2 % مع النيرول بتركيز 0.5 % حيث أدت الي انخفاض نسبة حدوث مرض اللفحة المبكرة بواقع 86.8 % علي الاقل خلال موسمي نمو متتابعين بينما أدي تكامل المعاملات بين بيكربونات البوتاسيوم أوالصوديوم بتركيز 1.0 أو0 .2 % علي الترتيب مع النيرول بتركيز 0.5 % و المبيد الفطري ( ريدوميل بلس) الي انخفاض نسبة حدوث المرض بواقع 71.1 % علي الأقل بالمقارنة بالنباتات الغير معاملة .

بالنسبة لمحصول الدرنات أدي تكامل المعاملات بين بيكربونات البوتاسيوم بتركيز 1.0 أو 0 .2 % مع النيرول بتركيز 0.5 % الي زيادة المحصول بواقع 82.6 و 72.0 % علي الترتيب بالمقارنة بالنباتات الغير معاملة .وتشير النتائج الي امكانية استخدام تكامل المعاملات بين بيكربونات البوتاسيوم مع النيرول في مكافحة مرض اللفحة المبكرة علي نباتات البطاطس تحت ظروف الحقل .