Induce Systemic Resistance against Root Rot and Wilt Diseases in Fodder Beet (Beta vulgaris L. var. rapacea Koch.) by Using Potassium Salts

Montaser F Abdel-Monaim*, Marwa AM Atwa and Kadry M Morsy

Plant Pathology Research Institute, Agriculture Research Center, Giza 12619, Egypt

Abstract

Rhzoctonia solani, Fusarium solani, F. oxysporum F. aequiseti and F. semitectum were found to be associated with root rot and wilt symptoms of fodder beet plants collected from different fields in New Valley governorate, Egypt. All the obtained isolates were able to attack fodder beet plants (cv. Starmon) causing damping-off and root rot/wilt diseases. R. solani isolate FB1, F. solani isolate FB7 and F. oxysporum isolate FB11 were the more virulent ones in the pathogenicity tests. The efficacy of 4 different potassium salts for controlling damping-off, root rot and wilt diseases in fodder beet were evaluated in vitro and in vivo.

In vitro studies, all the tested potassium salts were significantly suppressed growth of the pathogenic fungi at different concentrations. KHCO3 showed superior higher inhibitory effect on radial growth of the tested pathogenic fungi especially at higher concentration (20 mM).

Under green house and field conditions, all potassium salts significantly reduced damping-off and root rot/wilt severity and increased survival of plants. The reduction in damping-off and root rot/wilt increased with increasing of potassium salts concentration except potassium sulfate (K2SO4), while concentration 10 mM was more effective for reducing damping-off and root rot/wilt severity than 20 mM. K2SiO3 followed by K2HPO4 recorded highly protection against damping-off and root rot/wilt severity more than the other tested potassium salts. Under field conditions, all these potassium salts at different concentrations significantly submitted to various growth and yield parameters viz. root length, root diameters, fresh and dry weights compared with control during growing seasons 2013-14 and 2014-15. While, % dry maters was no significant in both growing seasons. The applied treatment K2SiO3 achieved the highest increase in all the mentioned parameters over the other entire three potassium salts during both growing seasons.

In physiological studies, activity of defense-related enzymes, including peroxidase (PO), polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL), and tyrosine ammonia lyase (TAL) and total phenols content were increased in inoculated plants with R. solani, F. solani, and F. oxysporum individually and treated with potassium salts compared with untreated plants. K2SiO3 at 20 mM showed the highest level of all oxidative enzymes activity and total phenols content followed by K2HPO4 and K2SO4 at 20 mM. Whereas, the least enzymes activity was recorded with KHCO3 at 10 mM. These results suggested that these chemicals may be play an important role in controlling the fodder beet damping-off, root rot and wilt diseases; through they have induction of systemic resistance in fodder beet plants.

Keywords: Fodder beet; Root rot and wilt; Potassium salts; Induced resistance

Introduction

Fodder beet (Beta vulgaris L. var. rapacea Koch.) offers a higher yield potential than any other “arable” fodder crop. The roots have an excellent feed quality and they are very palatable to ruminant stock. The leaf can be utilized if required to boost the total fodder output even further. Fodder beet when grown under suitable conditions, can produce almost 20 t ha-1 dry matter yield compared with 13 ± 15 t DM/ha-1 from four harvests of grass. Approximately 75% of fodder beet dry matter is in the root component [1]. Including fodder beet in diet of cattle increases intake of dry matter that is quantitative and qualitative factors affecting intake of the basal diet [2,3].

Plant diseases caused by soil-borne plant pathogens considered the major problems in agricultural production throughout the world, reducing yield and quality of crops. Plant pathogens have caused an almost 20% reduction in the principal food and cash crops worldwide [4]. Root rot and wilt caused by soil-borne pathogenic fungi is one of the most serious diseases affected several cultivated plants in worldwide. It results in poor production, poor quality, poor milling returns and reduced agriculture income. This has a negative impact on the livelihood of farmers [5]. Fungal disease control is achieved through the use of fungicides which is hazardous and toxic to both people and domestic animals and leads to environmental pollution [6]. Therefore, a more balanced, cost effective and eco-friendly approach must be implemented and adopted farmers. In order to overcome such hazardous control strategies, scientists, researchers from all over the world paid more attention towards the development of alternative methods which are, by definition, safe in the environment, non-toxic to humans and animals and are rapidly biodegradable.

*Corresponding author: Montaser F Abdel-Monaim, Plant Pathology Research Institute, Agriculture Research Center, Giza 12619, Egypt, Tel: +20927936364; E-mail: fowzy_2008@yahoo.com

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The present research focuses on finding compounds that are safe to humans and the environment, viz. potassium salts are recorded by several investigators to have antimicrobial inhibitor effect as well as they play important role to induce plant resistance against damping-off, root rot and wilt diseases of fodder beet either in vitro or in vivo as well as its effective on plant growth and yield components in field.

Materials and Methods

Seeds and growth of plants

Fodder beet (Beta vulgaris L. var. rapacea Koch.) cultivar Starmon used in this study was obtained from the Forage Research Dep., Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Seeds were planted in plastic pots 30 cm diameter (2.4 kg soil), filled with a pasteurized mixture of soil and sand (4:1 w/w). Five seeds were sown in each pot and these pots were irrigated every three days.

Fungal isolation and pathogenicity tests

Samples of fodder beet plants showing root rot and wilt symptoms were collected from different farms of New Valley governorates. All samples were thoroughly washed with tap water several times, cut in small pieces and surface sterilized for 2 min in 2% sodium hypochlorite solution; then rinsed several times in sterilized distilled water and dried between sterilized filter papers. The surface sterilized samples were plated onto potato dextrose agar (PDA) medium and incubated at 25 ± 1°C. After 3-7 days incubation, the developed fungal colonies were purified by hyphal tip and/or single spore isolation techniques. The obtained fungal isolates were identified according to their cultural and microscopical characteristics as described by Booth [7] and Barnett and Hunter [8]. Subcultures of the obtained isolates were then kept on PDA slants and stored at 5°C for further studies.

Inoculum of the obtained isolates of soil borne pathogens was prepared on autoclaved barley medium (75 g washed dried barley grains, 100 g washed dried coarse sand and 75 ml tap water) in 500 ml glass bottles. Each bottle was inoculated with five discs (0.7 cm in diameter) of 4-day-old cultures of each isolate. Bottles were incubated at 25 ± 1°C for 15 days [9]. For each isolate, the contents of 20 bottles were thoroughly mixed in a plastic container and used as a source of inoculum. Soil and pots were sterilized with a 5% formalin solution for 15 min. Soil was covered with a polyethylene sheet for 7 days to retain the gas and left to dry for 2 weeks until all traces of formaldehyde disappeared. Pathogen inocula were added to the potted soil at a rate of 3% (w/w) and mixed thoroughly with the soil one week before planting. Three pots were used as replicates for each isolate (1-16) as well as control (uninfested soil). Fodder beet seeds of cv. Starmon were surface sterilized using 1% sodium hypochlorite for 2 min, rinsed in distilled water several times and sown in pots at rate 5 seeds pot⁻¹. These pots were irrigated every three days.

Assessment of disease severity

Percentage of damping-off was recorded after 35 days after planting. While severity of root rot and wilt was determined 90 days after planting according to Abou et al. [10] using a rating scale of 0-5 on the basis of root discoloration or leaf yellowing as follows, 0=neither root discoloration nor leaf yellowing, 1=1-25% root discoloration or one leaf yellowed, 2=26-50% root discoloration or more than one leaf yellowed, 3=51-75% root discoloration plus one leaf wilted, 4=up to 76% root discoloration or more than one leaf wilted, and 5=completely dead plants. For each replicate a disease severity index (DSI) similar to that described by Liu et al. [11] was calculated as follows:

\[
DSI = \frac{\sum d}{d_{max} \times n} \times 100
\]

Whereas: d is the disease rating possible, d max is the maximum disease rating and n is the total number of plants examined in each replicate.

In vitro antifungal activity

The inhibitory effect of potassium salts viz. potassium phosphate dibasic (K₃PO₄), potassium bicarbonate (KHCO₃), potassium sulfate (K₂SO₄), potassium silicate (K₂SiO₃) at different concentrations 5,10 and 20 mM (listed in Table 1) on the linear growth of Rhizoctonia solani, Fusarium solani and F. oxysporum, the fodder beet root rot and wilt pathogens, was evaluated. Tested solutions were added to conical flasks containing sterilized PDA medium before solidifying to obtain the proposed concentrations and shaken gently, then dispensed into sterilized Petri dishes (9-cm diameter). Petri dishes were individually inoculated with equal disks (7-mm-diam.), taken from 7-day-old cultures of tested fungi. The Petri dishes containing the PDA medium inoculated with the tested pathogens alone served as control. All plates were incubated at 25 ± 1°C. Each treatment was represented by 3 plates as replicates. Linear growth of tested fungi was measured when the control plates (medium free of potassium salts) reached full growth and the average growth diameter was calculated. Mycelial growth inhibition was calculated by using the formula:

Mycelial growth inhibition (\%) = \left(\frac{C}{T}\right) \times 100

Where C=growth in control and T=growth in treatment.

Evaluation effect of potassium salts on damping-off, root rot and wilt diseases under greenhouse conditions

The fungal inoculum of R. solani (isolate FB1), F. solani (isolate FB7) and F. oxysporum (isolate FB11) were prepared as described before in pathogenicity test. Plastic pots (30 cm diameter) were packed with sterilized sandy clay soil infested with fungal inocula at the rate 3% (w/w), seven days before planting. Fodder beet cv. disinfested seeds were soaked in the solutions of each potassium salts (Table 1) for 12 hr. [12], then sown in infested pots at rate 5 seeds pot⁻¹. Also, in control treatment, fodder beet seeds soaked in water for the same time and seedling in infested soil with the pathogen at the same rate. Three pots were used per treatment as a replicates. Percentages of damping-off, root rot and wilt severity were recorded after 35 and 90 days from planting, respectively.

Evaluation effect of potassium salts on damping-off, root rot and wilt diseases under greenhouse conditions

This experimental, factorial block design experiment was conducted at sowing date of 1st November of two successive growing seasons 2013/14 and 2014/15 in a field naturally infected with the causal organisms of root rot and wilt diseases of fodder beet located at the experimental farm of Kharga Agric. Station, New Valley Governorate. The main plots were potassium salts tested, sub plots were concentrations. Healthy fodder beet seeds were soaked in the solutions of the potassium salts for 12 hrs.

| Materials             | Chemical Composition | Molecular Weight | Used Concentration | 
|-----------------------|----------------------|-------------------|--------------------|
| Potassium phosphate dibasic | K₃PO₄                | 174.18 g/mol      | 5,10,20 mM         |
| Potassium bicarbonate  | KHCO₃                | 100.12 g/mol      | 5,10,20 mM         |
| Potassium sulfate      | K₂SO₄                | 174.26 g/mol      | 5,10,20 mM         |
| Potassium silicate     | K₂SiO₃               | 154.28 g/mol      | 5,10,20 mM         |

Table 1: Chemical formula of potassium salts.
[12]. A plot was 3 × 3.5 m with five rows; 50 cm row spacing, seeds were sown in hills (2 seeds hill-1 and 25 cm apart). In the control treatment, fodder beet seeds were soaked in water for the same time and sown with the same method. Fertilizers application at the rate of recommended doses. The crop was irrigated at 12-15 days intervals. Hand thinning to one plant per hill after 5 weeks from planting [3]. Percentages of damping-off and root rot/wilt disease index were calculated after 35 and 120 days from planting, respectively. At harvesting, 10 plants from the central ridges were pulled up to determine the following growth traits and forage yield.

1. Root length (cm)=distance between the beginning of the root to an end.
2. Root diameter (cm)= Circumference of circle when the maximum width of root divided on 2.14.
3. Fresh and dry weights of roots (ton/fed.).
4. Dry maters (%)=Dry weight of roots/Fresh weight of roots × 100

Biochemical changes associated with induced resistance

Activities of peroxidase (PO), polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL) and tyrosine ammonia lyase (TAL) and total phenols content was studied in tissue extracts of fodder beet plants surviving treatment with K₂HPO₄, KHCO₃ and (TAL) and total protein content was studied in tissue extracts of fodder beet plants cv. Starmon with isolates. The isolates were pathogenic to fodder beet plants cv. Starmon with Rhizoctonia solani (4 isolates), Fusarium equiseti (4 isolates), F. solani identified as Fusarium equiseti (4 isolates), Rhizoctonia solani (5 isolates), F. solani (4 isolates), Fusarium equiseti (1 isolates), F. oxysporum (4 isolates), F. semitectum (2 isolates). These fungi were maintained as pure cultures on agar slants kept in refrigerator at 5 °C until using in further studies.

Pathogenicity tests

Pathogenicity tests of the isolated fungi (Figure 1) reveal that all the isolates were pathogenic to fodder beet plants cv. Starmon with different degrees caused damping-off and root rot/wilt symptoms. In this respect R. solani isolate FB1 caused the highest damping-off (60%) followed by R. solani isolate FB2 and F. solani isolate FB7 (53.33%) while F. equiseti isolate FB10 caused the lowest damping-off (6.67%). On the other hand, F. oxysporum isolate FB11 recorded the highest severity of wilt disease (60.33%) followed by R. solani isolate FB3 (45.36% root rot). Generally, R. solani isolate FB1, F. solani isolate FB7 and F. oxysporum isolate FB11 were the highest pathogenic fungi isolated from fodder beet while recorded the lowest survival plants (9.65, 14.11 and 13%, respectively) since these isolates were used in following studies in vitro and/or in vivo. While, both F. semitectum isolates showed the lowest damping-off and root rot severity therefore they were neglected from the following studies.
Effect of potassium salts on mycelial growth of *R. solani* pathogenic fungi

Effect of different concentrations of potassium salts on mycelial growth of *R. solani* followed by *F. oxysporum* in vitro.

**Table 2:** Effect of different concentrations of potassium salts on mycelial growth of *R. solani*, *F. solani* and *F. oxysporum* in vitro.

Effect of potassium salts of damping-off and root rot/wilt under greenhouse conditions

Fodder beet seeds soaking in tested potassium salts reduced significantly damping-off and root rot/wilt caused by *R. solani*, *F. solani* and *F. oxysporum* compared with control (Table 3). The reduction in damping-off and root rot/wilt increased with increasing of potassium salts concentration except K$_2$SO$_4$ while concentration 10 mM was more effective for reducing damping-off and root rot/wilt severity than 20 mM. K$_2$SiO$_3$ followed by potassium phosphate dibasic (K$_2$HPO$_4$) recorded highly protection against damping-off and root rot/wilt severity more than the other tested potassium salts. K$_2$SiO$_3$ and K$_2$HPO$_4$ at 20 mM recorded the highest reduction of damping–off caused by *R. solani* (6.67, 13.33%), *F. solani* (6.67, 6.67) and *F. oxysporum* (6.67 and 13.33%) compared with 66.67, 40, 26.67% in control, respectively. Similar results were obtained with root rot/wilt incidence caused by *R. solani* and *F. solani* and *F. oxysporum* while, fodder seeds treated with K$_2$SiO$_3$ and K$_2$HPO$_4$ at 20 mM reduced root rot/wilt severity from 22.14, 33.29 and 56.39% in control to 4.59, 5.67, 10.58 in case of K$_2$SiO$_3$ and 6.36, 8.52 and 6.54 in case of K$_2$HPO$_4$, respectively.

**Table 3:** Effect of fodder beet seeds treatment with potassium salts on damping-off and root rot/wilt under field conditions

Data present in Table 4 show that all tested concentrations of potassium salts significantly reduced damping-off and root rot/wilt diseases under nutrition infection in field during growing seasons (2013-14 and 2014-15) compared with control. The reduction in damping-off and root rot/wilt increased with increasing of potassium salts concentration except K$_2$SO$_4$ while concentration 10 mM was more effective for reducing damping-off and root rot/wilt severity than 20

**Potassium salts**

**Concen. (mM)**

| Potassium salts | 5 | 10 | 20 | Mean |
|-----------------|---|----|----|------|
| K$_2$HPO$_4$    | 25.36 | 33.26 | 36.25 |
| KHCO$_3$        | 32.55 | 41.25 | 44.14 |
| K$_2$SO$_4$     | 36.47 | 46.25 | 50.14 |
| K$_2$SiO$_3$    | 31.36 | 40.25 | 43.51 |

**LSD at 0.05 for:**

| Potassium salts (A)= | 3.47 |
|----------------------|------|
| Concentrations (B)= | 4.85 |
| Pathogenic fungi (C)= | 7.59 |

**Table 4:** Effect of different concentrations of potassium salts on mycelial growth of *R. solani*, *F. solani* and *F. oxysporum* in vitro.

**Effect of potassium salts on the radial growth of pathogenic fungi**

Data in Table 2 show that all concentrations of the tested potassium salts resulted in a significantly suppressed radial growth of the tested pathogenic fungi (*R. solani*, *F. solani*, *F. oxysporum*) compared with the check treatment (control). The growth inhibition (%) of the tested fungi was increased with the increasing of concentrations of all tested substances. KHCO$_3$ showed superior higher inhibitory effect on radial growth of the tested pathogenic fungi especially at higher concentration (20 mM). In this regard, the recorded reduction in the growth of *R. solani*, *F. solani*, *F. oxysporum* was 50.12, 52.36 and 62.14%, respectively. On the other hand, the growth of *F. oxysporum* followed by *F. solani* showed the most affective then *R. solani*.

**Figure 1:** Pathogenicity tests of soil borne fungi isolated from fodder beet roots under the greenhouse conditions. Mean ± SDs per isolate are shown. Different letters indicate significant differences among treatments within the same color column according to least significant difference test (P ≤ 0.05). Percentages of damping-off were recorded 35 days after planting, while root rot/wilt disease severity was determined 90 days after planting.
The effect of potassium salts on fodder beet vigor and yield under field conditions

Fodder beet seed soaking in any of these potassium salts at different concentrations were significantly submitted to various growths and yield parameters viz. root length, root diameters, fresh and dry weights, except % dry maters was no significant, compared with control during growing seasons 2013-14 and 2014-15 (Tables 5 and 6). The enhancement in growth and yield parameters were increased by increasing potassium salts concentration except K2SO4 at 10 mM reduced damping off from 35.26 and 30.25% to 5.28, 5.28% under field conditions.

from 4.49 and 5.32 ton per fed. In control to 9.71 and 10.06 in treated with K2SiO3 at 20 mM. The percentage of dry mater increased from 11.46 and 12.42 in control to 14.03 and 14.24% in seed treated with K2SiO3 at 20 mM in both growing seasons respectively. On the other hand, fodder seeds treated with KHCO3 recorded the lowest increased of various growths and yield parameters in both growing seasons.  

Potassium salts

| Potassium salts | Concent. (g/L) | Season 2013-2014 | Season 2014-2015 |
|----------------|---------------|------------------|------------------|
|                | % Damping-off | % Root rot/wilt | % Damping-off | % Root rot/wilt |
| **K2HPO4**     | 5 15.24       | 15.24            | 12.35         | 12.24         |
|                | 10 12.35      | 10.32            | 10.33         | 8.25          |
|                | 20 10.33      | 7.36             | 8.21          | 6.36          |
| **Mean**       | 12.64         | 10.97            | 10.30         | 8.95          |
| **KHCO3**      | 5 25.26       | 19.35            | 24.14         | 18.52         |
|                | 10 20.55      | 15.34            | 18.25         | 12.36         |
|                | 20 14.86      | 16.23            | 13.24         | 14.96         |
| **Mean**       | 20.26         | 16.98            | 18.54         | 15.28         |
| **K2SO4**      | 5 20.14       | 18.69            | 17.67         | 17.25         |
|                | 10 14.25      | 10.24            | 10.25         | 9.58          |
|                | 20 16.36      | 12.36            | 13.24         | 12.36         |
| **Mean**       | 16.92         | 13.76            | 13.72         | 13.06         |
| **K2SiO3**     | 5 10.25       | 12.38            | 8.56          | 10.25         |
|                | 10 7.36       | 6.36             | 6.25          | 5.36          |
|                | 20 5.28       | 5.45             | 5.28          | 5.56          |
| **Mean**       | 7.63          | 8.06             | 6.70          | 7.06          |
| **Control**    | 35.26         | 25.38            | 30.25         | 26.35         |

LSD at 0.05 for:

Potassium salts (A)= 4.36 2.69 3.45 1.67 ns
Concentrations (B)= 3.96 2.55 3.47 1.19 ns
Pathogenic fungi (C)= 4.55 2.64 3.97 1.25 ns
Interaction (A×B)= 7.99 4.95 6.85 2.47 ns

Table 4: Effect of fodder beet seeds treated with potassium salts on damping-off, root rot/wilt diseases during 2013/14 and 2014/15 growing seasons under field conditions.

Table 5: Effect of fodder beet seeds treated with potassium salts on growth and yield parameters during 2013/14 growing season under field conditions.

Table 6: Effect of fodder beet seeds treated with potassium salts on growth and yield parameters during 2014/15 growing season under field conditions.
Biochemical changes associated with inducers PO, PPO, PAL and PAT activities

The effect of potassium salts viz. K2HPO4, KHCO3, K2SO4 and K2SiO3 as inducers chemicals on the activities of PO, PPO, PAL and TAL of the fodder beet plants grown in soil infested with R. solani, F. solani, F. oxysporum separately was studied. The data are presented in Figures 2-5 showing that all tested potassium salts increased the activity of PO, PPO, PAL and TAL in the fodder beet plants grown in soil infested with R. solani, F. solani, and F. oxysporum. The least enzyme activity was recorded with KHCO3 at 10 mM and K2SiO3 at 20 mM showed the highest level of all oxidative enzymes activity followed by K2HPO4 at 20 mM and K2SO4 at 20 mM. Whereas, the least enzymes activity was recorded with KHCO3 at 10 mM. On the other hand, fodder beet plants inoculated with F. solani were recorded the high level of PO, PAL, TAL enzymes more than plants inoculated with F. solani or F. oxysporum either in treated and untreated fodder beet plants. While, PPO enzyme was more activity in case of fodder plants inoculated with F. oxysporum than the other tested fungi.

Effect of potassium salts on total phenols content

Data present in Figure 6 show that all tested potassium salts increased the activity of PO, PPO, PAL and TAL enzymes in the fodder beet plants compared with untreated plants (control). K2SiO3 at 20 mM showed the highest level of all oxidative enzymes activity followed by K2HPO4 at 20 mM and K2SO4 at 20 mM. Whereas, the least enzymes activity was recorded with KHCO3 at 10 mM. On the other hand, fodder beet plants inoculated with F. solani were recorded the highly level of PO, PAL, TAL enzymes more than plants inoculated with F. solani or F. oxysporum either in treated and untreated fodder beet plants. While, PPO enzyme was more activity in case of fodder plants inoculated with F. oxysporum than the other tested fungi.

Effect of potassium salts on total phenols content

Data present in Figure 6 indicate that total phenolic compounds were higher in fodder beet plants treated with all the tested potassium salts than those of untreated infected control. The higher total phenolic contents were recorded plants treated with K2SiO3 at 20 mM followed by K2HPO4 at 20 mM. While, the lowest content of total phenolic compounds was recorded in plants treated with K2SO4 at 10 mM. On the other hand, fodder beet plants inoculated with R. solani gave highly content of phenolic compounds than plants inoculated with F. solani or F. oxysporum either in treated plants with potassium salts or untreated.

Discussion

Plant diseases caused by soil-borne plant pathogens considered the major problems in agricultural production throughout the world, reducing yield and quality of crops. Plant pathogens have caused an almost 20% reduction in the principal food and cash crops worldwide [4,22].

Control of soil-borne pathogens with chemicals is difficult because of their ecological behavior, their extremely broad host range and the high survival rate of resistant forms such as sclerotia and chlamydomospores under different environmental conditions [23]. In recent years, public demands to reduce pesticide use, stimulated by greater awareness of environmental and health issues as well as the development of fungicide resistant strains of pathogens, have created...
Many investigations reported the use of potassium salts as a chemical agent for induction of plant resistance [27,28]. Furthermore, there has been considerable interest in the use of potassium bicarbonate and potassium phosphate, potassium sulfate and potassium silicate for controlling various fungal diseases in plants [29-32].

Potassium is a mobile element with multiple functions in the plant. It acts as a counter-ion for anion transport, regulates stomatal aperture and the water potential of plant cells, affects cell wall plasticity, as well as other roles [33]. It promotes wound healing and decreases frost injury [34]. Potassium deficiency has been found to be linked to diseases in a number of temperate crops [34] and a high K supply can improve resistance of plants to fungal and bacterial pathogens [35,36]. The mechanism of resistance in some disease-resistant genotypes might be related to a greater efficiency in K uptake [37]. The potassium bicarbonate causes the collapse of hyphal walls and shrinkage of conidia, [38].

In general, potassium application improves plant health and vigour, making infection less likely or enabling a quick recover [39]. 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 [40,41].

In conclusion, the present study provides further evidence that may facilitate applying simple non-toxic chemicals as potassium salts for controlling damping-off, root rot and wilt diseases in fodder beet. Their low cost, low toxicity to the man and environmental pollution make them ideal seed soaking for disease control under field conditions and increased root yield and dry mater.

References
1. DAF (Department of Agriculture and Food) (1998) Root, fodder crop, pulse and oilseed varieties. Irish recommended list. Government Stationary Office, Dublin, p. 17.
2. Turk M (2010) Effects of fertilization on root yield and quality of fodder beet (Beta vulgaris var. crassa Mansf.). Bulgarian Journal of Agricultural Science 16: 212-219.
3. Abdel -Naby ZM, Shafie WWM, Sallam AM, El-Nahrawy SM, Abdel-Ghawad MF (2014) Evaluation of seven fodder beet genotypes under different Egyptian ecological conditions using regression, cluster models and variance measures of stability. Int J Curr Microbiol App Sci 3: 1086-1102.
4. Oerke EC, Dehne HW, Schonbeck F, Weber A (1994) Crop Production and Crop Protection – Estimated Losses in Major Food and Cash Crops, Elsevier Science, Amsterdam, pp 808.
5. El-Mohamedy RSR, Abdel-Kader MM, Abd-El-Kareem F, El-Mougy NS (2013) Essential oils, inorganic acids and potassium salts as control measures against the growth of tomato root rot pathogens in vitro. Journal of Agricultural Technology 9: 1507-1520.
6. De Waard A, Georgopoulos SG, Hollomon DW, Ishii H, Leroux P, et al. (1993) Chemical control of plant diseases: problems and prospects. Ann Rev Phytopathol 31: 403-423.
7. Booth C (1985) The genus Fusarium. Surrey: Commonwealth Mycological Institute.
8. Barnett HL, Hunter BB (1986) Illustrated Genera of Imperfect Fungi. 4 th Ed., Macmillan Publishing Co., New York.
9. Abo-Elyoury KAM, Mohammed H (2009) Biological Control of Fusarium Wilt in Tomato by Plant Growth-Promoting Yeasts and Rhizobacteria. The Plant Pathology J 25: 199-204.
10. Abdou El-S, Abd-Alla HM, Galal AA (2001) Survey of sesame root rot/wilt disease in Minia and their possible control by ascorbic and salicylic acids. Assalt J Agric Sci 32: 135-152.
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