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ABSTRACT
In Egypt potato is the most popular solanaceous vegetables either for local consumption and exportation. Previous investigations showed that potato have been attacked by many plant parasitic nematodes. The root-lesion nematodes (*Pratylenchus* spp.) are economically the most important plant pathogens after root knot nematodes. They cause an average growth inhibition of 59.6% of infected potato seedlings with losses in tuber yields of 20-50% and in total plant weight of 50%. Producers have relied mainly on nematicides and chemical fertilizers to control plant parasitic nematodes and improved soil fertility, but their applications are associated with myriads of problems on human health and environment. Due to the consumer demand for chemicals-free food the main goal of this work is to evaluate the potentialities of some commercial bioproducts in controlling root lesion nematodes *Pratylenchus* spp. infecting potato cv. Spunta and improving yield production, under field conditions. The bioagents that have been assessed and their commercial name are Microbien containing the N2 fixing bacteria *Pseudomonas* spp. and *Bacillus megatherium*, Potassiumag containing the potassium solubilizing bacterium *Bacillus circulanes* and Phosphorine contain the phosphorus solubilizing bacterium *Bacillus megatherium* Nemafree containing Serratia spp. ,theStanes Symbion VAM Plus containing the vascular arbuscular miccorhiza *Glomus fasciculatum* and the Stanes Sting containing the rhizobacteria *Bacillus subtilis*. A field experiment was conducted at Kafr-kandeel village, Giza governorate, Egypt to investigate the integration effects between these products to control *Pratylenchus* spp. and improve potato yield production cv. Spunta. The combined treatments are 1- Biofertilizers (Microbien, Phosphorine, Potassiumag) 2- Biofertilizers plus Stanes Symbion, 3- Biofertilizers plus Nemafree- Biofertilizers, plus Stanes Sting 5- untreated plant using as control. Obtained results after three months showed that all the tested combinations reduced *Pratylenchus* spp. both in soil and rootsby different rates, as well as increased potato yield production as compared to untreated control treatment. The highest increase in potato yield production 30% over control resulted from the application of the biomaticides Stanes Sting containing *Bacillus subtilis* in combination with the biofertilizers Microbien, Phosphorine and Potassiumag.

INTRODUCTION
Potato, *Solanum tuberosum* L. is a good source of carbohydrates. Root-lesion nematodes of the genus *Pratylenchus* are recognized worldwide as one of the major constraints of potato cultivation mainly in light soil (Philis, 1995). These nematodes are migratory endoparasite, moving in and out of the host plant roots, leaving a trail of necrotic tissue in its walk causing an average growth inhibition of 59.6% of infected potato seedlings with losses in tuber yields of 20-50% and in total plant weight of 50% (Bernard and Laughlin, 1976).

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In addition, association of these nematodes with other soil borne pathogens caused more economic losses to agricultural crops (Powell and Nusbaum, 1960). Chemical nematicides have been the primary management tool of plant parasitic nematodes for over fifty years but their applications are associated with myriads of problems. Consequently, chemical control may no longer be a good option (Ploeg, 2002). The recent drive to produce vegetables free of chemical residues and increased concern for the environment and human health led to innovate and develop alternative control approaches which are environmentally safe. One possible alternative is the use of biocontrol strategies which involve the application of microbes antagonistic to nematodes.

The main goal of this work is to evaluate the potentialities of some microorganisms which known to have potential as biocontrol and biofertilizer agents against nematodes in their commercial products (Stanes Sting contains \textit{Bacillus subtilis}, Nemafree contains \textit{Serratia} spp. and Stanes Sambion contains the vesicular-arbuscular mycorrhizal \textit{Glomus fasciculatum}, and that play as biofertilizers Microbien contain the N\textsubscript{2}-fixing bacteria \textit{Pseudomonas} spp. and \textit{Bacillus megatherium}, Phosphorine contains the phosphate solubilizing bacteria \textit{Bacillus megatherium} and Potassiumag contains potassium solubilizing bacteria \textit{Bacillus circulanans} to manage potato cv. Spunta production grown in field naturally infested with root lesion nematode \textit{Pratylenchus} spp.

**MATERIALS AND METHODS**

Field experiments were carried out at Kafr-kandeel village, Giza governorate to evaluate the effectiveness of certain commercial bionematicides combined with some biofertilizers for controlling root lesion nematode \textit{Pratylenchus} spp on potato cv. Spunta. The chosen field area was naturally infested with \textit{Pratylenchus} spp. The experimental field was divided into plots, each of 6m long, 1m apart and the distance between hills was 0.5m where potato eyes were planted in rows. Bionematicides and biofertilizers combined treatments were designed as shown in Table (1) and each one was replicated four times in completely randomized block design. Tested formulations were applied, as labeled using rate equivalent to field application rate. Soil population densities of \textit{Pratylenchus} spp. were initially determined prior to planting time and at the end of the growing season of such treatments. Each treatment was represented by ten compressed samples each comprised three samples. Nematode extraction and counting were done as described by (Barker, 1985). Means of the ten compressed samples were used to calculate the numbers of nematode population per 1kg soil, for each treatment. At harvest time; three months after application, potato tubers were hand-harvested and yield was determined as tons /Feddan, for each treatment and the nematode final population were expressed as nematodes/kg soil.

<table>
<thead>
<tr>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Untreated control</td>
</tr>
<tr>
<td>2 Microbien, Phosphorine, Potassiumag (Biofertilizers)</td>
</tr>
<tr>
<td>3 Biofertilizers plus Stanes Symbion</td>
</tr>
<tr>
<td>4 Biofertilizersplus Nemafree</td>
</tr>
<tr>
<td>5 BiofertilizersplusStanes Sting</td>
</tr>
</tbody>
</table>
Control of root lesion nematode *Pratylenchus* spp. infesting potato cv. *spunta* under field conditions

Plants were carefully dug out and gently washed to remove the adhering soil particles from the root surface. Excess water was removed by blotting-paper before weighing shoots and roots separately. Nematode population from 5g roots was extracted and counted as mentioned by (Southey 1970).

Percentage nematode reduction in soil was determined according to Henderson and Tilton formula (Puntener, 1981) as follows:

\[
\text{Nematode population reduction (\%) = } \left[1 - \left( \frac{\text{PTA} \times \text{PCB}}{\text{PTB} \times \text{PCA}} \right) \right] \times 100
\]


RESULTS

Table (2) illustrates the effects of the aforementioned bioproducts in controlling the lesion nematodes *Pratylenchus* spp. infecting potato cv. *Spunta* under field conditions. Data revealed that all treatments reduced *Pratylenchus* spp. numbers in soil and roots with different rates as compared with the untreated control. At harvest time (three months after application) the application of biofertilizers with *B. subtilis* exhibited the highest efficacy in reducing *Pratylenchus* spp soil population (91.7%) followed by 89.98% in soil treated by biofertilizers as compared with the untreated control plots.

Table 2: Efficacy of certain commercial bioproducts in controlling nematode population of the root lesion nematode *Pratylenchus* spp. infecting potato cv. *Spunta* under field conditions.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Population densities of <em>Pratylenchus</em> spp.</th>
<th>% *Red. Efficacy</th>
<th>Number of <em>Pratylenchus</em> spp. in 5g roots</th>
<th>% Red.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated control</td>
<td>1001</td>
<td>759</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Biofertilizers(Microbien+Phosphorine+Potassuimag)</td>
<td>978</td>
<td>75</td>
<td>89.98</td>
<td>16</td>
</tr>
<tr>
<td>Biofertilizers + Stanes Symbion</td>
<td>932</td>
<td>105</td>
<td>85.14</td>
<td>17</td>
</tr>
<tr>
<td>Biofertilizers + Nemafree</td>
<td>985</td>
<td>175</td>
<td>76.75</td>
<td>17</td>
</tr>
<tr>
<td>Biofertilizers + Stanes Sting</td>
<td>960</td>
<td>65</td>
<td>91.7</td>
<td>16</td>
</tr>
</tbody>
</table>

*Percentage reduction in soil population of *Pratylenchus* spp. according to Henderson &Tilton Formula Puntener, 1981.

*Efficacy of treatment in reducing nematode population of *Pratylenchus* spp.

The mentioned treatments reduced *Pratylenchus* spp. roots population at the end of the growing season (Table 3) by 38.46%. All studied combinations affected positively potato yields production by different rates (Table 3) the application of biofertilizers plus *B. subtilis* induce 30% increase over control followed by 20% due to the biofertilizers plus *Serratia* spp. Results showed that not all combinations exhibited an increase in weights of potato roots. The highest percentage increase 20% was achieved by the application of biofertilizers followed by 11% increase with the application of biofertilizers plus *B. subtilis*. All combinations under investigation enhanced potato shoot weights more than the untreated control plants with varied rates (Table 3). Results are in agreement with (Bevivino et al., 1998) who reported that rhizobacteria can stimulate plant growth directly by producing growth hormones and improving nutrient uptake or indirectly by changing microbial balance in the
rhizosphere in favour of beneficial microorganisms. The remarkable reduction in nematode population with the application of *Bacillus subtilis* was explained with more than one mechanism produce the antibiotic bulbiformin directly affect nematodes, also (Qiuhong et al., 2006) found that the extracellular cuticle-degrading proteases were involved in the processes to penetrate nematode cuticle and eventually digest them and improving plant growth by solubilizing phosphate and other nutrients and making them available to the plants (Gaur, 1990). Mercer et al., 1992 found that chitinase from *Serratia marcescens* induced premature hatch of nematode eggs. Kamensky et al., 2003 stated that inhibitory metabolites produced by *Serratia* isolates including serrawettin as well as chitinase and other cell wall and cell-membrane degrading enzymes had significant suppressive effect on nematodes.

Table 3: Effect of certain commercial biofornaticides and biofertilizers on plant growth response and yield of potato cv. Spunta infected with *Pratylenchus* spp. under field conditions.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Root Weight/plant g</th>
<th>% Incr.</th>
<th>Shoot Weight/plant g</th>
<th>% Incr.</th>
<th>Yield/Feddan Ton</th>
<th>% Incr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated control</td>
<td>9</td>
<td>53</td>
<td>7000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biofertilizers(Microbien+Phosphorine+Potassuimag)</td>
<td>10.8</td>
<td>20</td>
<td>70</td>
<td>32.1</td>
<td>7700</td>
<td>10</td>
</tr>
<tr>
<td>Biofertilizers +Stanes Symbion</td>
<td>7.4</td>
<td>69</td>
<td>30.2</td>
<td>7700</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Biofertilizers +Nemafree</td>
<td>8.8</td>
<td>74</td>
<td>39.6</td>
<td>8400</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Biofertilizers + Stanes Sting</td>
<td>10</td>
<td>11</td>
<td>64</td>
<td>20.8</td>
<td>9100</td>
<td>30</td>
</tr>
</tbody>
</table>

It is clear from Table 2 that *Pratylenchus* spp. are much more found in soil than in roots at harvest time this is refer to general trend of lesion nematodes, where many reniform *Pratylenchus* individuals leave the roots and enter the soil at the end of the growing season of the annual crops and remain until a new crop is planted as reported by Timper and Brodie, 1993.

Results showed that treated soil with the three biofertilizers; Microbien, Phosphorine and Potassiumag containing each of the rhizobacteria *Pseudomonas* pp., *B. megatherium*, *B. circulanes* that had involved in the biological processes of N₂ fixation Nitrogen and solubilizing phosphate and potassium improved plant production and gave a remarkable reduction in nematode population. The same results were discussed in previous studies of Kirkpatrick et al. (1964) who reported that the greater availability of phosphorus made the host plant strong enough to tolerate pathogen attack and also phosphorus itself played a vital role in building self-defense of plants against nematodes. Al-Rehiayani et al., 1999 found that *B. megatherium* reduced penetration of *Pratylenchus penetrans* in potato by 50%, Padgham and Sikora, 2007 stated that treatment with *B. Megatherium* resulted in a greater than 40% reduction in nematode penetration. Also Siddiqui and Akhtar, 2007 reported that Phosphate-solubilizing microorganisms have potential for the biocontrol of plant pathogens as they change insoluble phosphatic compounds into soluble forms thus increasing the growth and yield of crop plants. The Arbuscular mycorrhizal fungi (AMF) *Glomus fasciculatum* are endophytic fungi that grow within plant tissues without causing disease and can play a protective role against parasitic nematodes by forming distinct symbiotic structures and are of great value in promoting the uptake of phosphorus, minor elements and water (Allen, 1996 and Ibijbijen et al., 1996). They also influence the severity of several plant pathogens by altering plant–pathogen interactions (Akkopru and Demir, 2005).
We can conclude that two or more biopreparations in such treatment give potential to the biological control of plant parasitic nematode and produce food free from chemical residues.

REFERENCES


يعتبر محصول البطاطس من أهم محاصيل الخضر التي تتمتع بالعائلة البانجانية لما له من أهمية اقتصادية كبيرة سواء للاستهلاك المحلي أو التصدير. تعتبر نيماتودا التتردق الجذري من أهم الافات التي تسبب ضرراً لمحصول البطاطس في مصر بعد نيماتودا تغطية الجذور. وقد اعتمد المنتجين لفترة طويلة على المبيدات الكيميائية لمكافحة هذه الافات مع الأسمدة الكيمائية لخصوبية التربة. مما تسبب في العديد من المشاكل الناتجة من استخدام هذه المبيدات الكيمائية الكثيرة. سواء على صحّة الإنسان والحيوان أو البيئة. و مع زيادة الطلب على المنتجات الزراعية الخالية من أثار المواد الكيمائية دفعت ذلك العلماء للبحث عن بدائل أمنة لمقاومة الأفات النيماتودية وتحسين المحصول. فكان الغرض من هذه الدراسة هو تقدير فاعلية بعض المنتجات الحيوية التكاثارية لمكافحة نيماتودا التتردق الجذري التي تسبب نيبات البطاطس من صنف اسميدا وزيادة المحصول تحت ظروف الخلة. كانت المركبات الحيوية المستخدمة هي المستحضرات الحيوية مكروبيون المثبت للنتروجين الجوفي، وفسفورين، وبراتيلنكس والبكتيريا المعتمدة، وÁmosida بحل محل جميع المبيدات الكيميائية المعروفة. وتعد هذه الدراسة جزءاً من مشروع أنشطة جمعية مصر للخدمات الفلاحية والتكنولوجيا بجامعة عين شمس. وتهدف الدراسة إلى استخدام المبيدات الحيوية لتقديم حلول مستدامة للمشاكل النيماتودية التي تواجه نبات البطاطس من نيبات اسميدا. وتهدف الدراسة إلى استخدام المبيدات الحيوية لتقديم حلول مستدامة للمشاكل النيماتودية التي تواجه نبات البطاطس من نيبات اسميدا.