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Efficacy of Salt Tolerant Bacterial and Biological Products on Growth and Yield of Green Onion Cultivated in Tran De District, Soc Trang Province, Vietnam

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Abstract: Currently, the chemical agrochemicals including fertilizers and pesticides were used very much on green onions, leading to contamination of agrochemicals on agricultural products, soil and water and seriously affecting consumer health, the environment and ecology. Therefore, the research focused on using microbial and biological products in the cultivation and production of green onion in order to limit the use of inorganic fertilizers and pesticides, contributing on improving the value of onions is really necessary. The objective of the study was to evaluate the efficacy of salt tolerant bacterial product, NPISi containing biologically nitrogen fixing, phosphate solubilizing, IAA synthesizing, and Si solubilizing bacteria in a combination with spraying plant protection biological product (PPBP) from garlic, chili, ginger, lemongrass, anise, and cinnamon on growth, yield, pest and disease control ability on green onion, and soil properties in Tran De district, Soc Trang province, Vietnam. The experiment was arranged in a completely randomized block design with 8 treatments and 4 replications on the in two consecutive crops. The results showed that the treatment applied of 80 kg/ha of NPISi inoculant combined with 6% PPBP sprayed every 10 days enhanced plant height, number of buds/hill, number of leaves/hill, stem diameter and yield of green onion up to 45% as compared to the control treatment received the same amount of recommended NPK dose. Moreover, the treatment applied with NPISi and PPBP in combination with 50% NP + 100% K had green onion yield equivalent to the treatment received recommended 100% NPK fertilizer after two consecutive crops. Besides, the use of NPISi inoculant and PPBP also improved pH and the number of bacteria in soil. Concurrently, the use of PPBP also effectively controlled of the tube borer numbers on green onion.

Keywords: Beet Armyworm, Biological Products, Green Onions, Salt-Tolerant Bacterial Products, NPISi

1. Introduction

Green onion production in Tran De district, Soc Trang province, Vietnam is progressing, contributing to household income increase. Green onion brings farmers 5-7 times higher profits than the rice cultivation. Thus, farmers normally overuse the chemical fertilizers and pesticides to protect green onion production and yield [1]. The cultivation practices of farmers for green onion cultivation not only boost production expenses but also cause the bad effects on agricultural product quality and environment surrounding. Pesticide residues in green onion's product, soil degradation and human health are found to be harmful by chemical practices. As a consequence, the use of microbial products and biological products in the control of pests and diseases on green onion towards chemical fertilizer and pesticide mitigation and being eco-friendly is considerably attracted a big attention [2]. The methodologies of the biological and non-chemical methods used to control pests and diseases are organic based approaches and sustainable integrated pest management principles [3].

Salt tolerant bacterial product, NPISi containing beneficial bacteria including *Bacillus aquimaris* KG6-3, *Burkholderia* sp. BL1-10, *Bacillus megaterium* ST2-9, and *Citrobacter* *freundii* RTTV_12. They are nitrogen fixing bacteria, phosphorous solubilizing bacteria, Indole-3-Acetic Acid synthesizing bacteria, and silicate solubilizing bacteria, respectively [4, 5]. This product has been tested on several crops including rice, green onion, sweet potato, and indicating good effects on increasing crop growth and productivity. Especially, it has reinforced yield of "Mot Bui Do" rice cultivar when grown in salt-affected soil in Phuoc Long District, Bac Lieu province, Vietnam by 12.8% as compared to the control treatment [6].

Many previous studies applying extracts from popular spice plants such as onion, garlic, lemongrass, chili, and ginger for plant growth boost showed a good effect of these biological products on controlling pest, diseases, growth and yield of crops [7-9]. Among them, garlic and ginger showed a good effect on plant protection of many different crops to repel the attacks of pests and diseases as well as plant growth and yield amelioration [10-13]. However, in Vietnam in particular and in the world in general, still limited amount of researches focusing on the efficacy of these extracts on controlling pests and diseases of green onion.

Consumer's demand for the safer green onion production for farmers in the Mekong Delta, Vietnam has increased, therefore, the use of biological plant protection approaches by using extracts from garlic, ginger, chili, lemongrass, onion, anise, and cinnamon to inhibit and repel plant pests and diseases together with application of salt tolerant bacterial product, NPISi is considered as a promising approach for sustainable green onion development through soil fertility enhancement, stimulation of growth and yield as well as protection of green onion from attacking of pests and diseases. Thus, this study was conducted to evaluate efficiency of salt tolerant bacterial product, NPISi and plant protection biological product from extracts of garlic, ginger, chili, lemongrass, onion, anise, and cinnamon on green onion growth and yield, and soil properties under the field condition in order to reduce the chemical fertilizers, and pesticide application, improving commercial green onion quality, household incomes, and eco-friendly and environmental agriculture practice.

2. Materials and Methods

2.1. Experimental Design

The experiment was conducted in a completely randomized block design with eight treatments and four replicates in two consecutive green onion crops under the field condition. Crop 1 was done from April to June 2022 and crop 2 was established from June to September 2022 in Vien Binh ward, Tran De district, Soc Trang province, Vietnam. The pilot area was about 960 m^2, divided into 32 plots, and each plot had an area of 30 m^2 (2 m x 15 m). The name of treatments is listed detailly in Table 1.

The salt tolerance bacterial product NPISi containing four bacterial strains *Bacillus aquimaris* KG6-3, *Burkholderia* sp. BL1-10, *Bacillus megaterium* ST2-9, and *Ochrobactrum ciceri* TCM_39. They are nitrogen fixing bacteria, phosphate solubilizing bacteria, IAA synthesizing bacteria, and silicate solubilizing bacteria, respectively. The NPISi product was a powder form containing the number of the total bacterial cell around 10^9 $CFU.g^{-1}$ product. NPISi was amended at dose of 80 $kg.ha^{-1}$ at day 0, 15, 22, 29, and 36 after seedling for the treatments applied several times with this product.

Table 1. *The treatment names of the green onion field experiment conducted in Tran De district, Soc Trang province, Vietnam.*

Treatments	Description
T1	100N-85P_2O_5-40K_2O (positive treatment, recommended chemical fertilizer formula, 100% NPK)
T2	100% NPK + one time NPISi application at day 0 + PPBP (6%, every 10 days)
T3	100% NPK + two time NPISi application at day 0 and 15 + PPBP (6%, every 10 days)
T4	100% NPK + five time NPISi application at day 0, 15, 22, 29, and 36 + PPBP (6%, every 10 days)
T5	50N-42,5P_2O_5-40K_2O (50% recommended NP + 100% recommended K)
T6	50% NP + 100% K + one time NPISi application at day 0 + PPBP (6%, every 10 days)
T7	50% NP + 100% K + two time NPISi application at day 0 and 15 + PPBP (6%, every 10 days)
T8	50% NP + 100% K + five time NPISi application at day 0, 15, 22, 29, and 36 + PPBP (6%, every 10 days)

Notes: *PPBP: plant protection biological product, NPISi: salt tolerance bacterial product NPISi

Table 2. *Chemical fertilizer application schedule for green onion in the field experiment in Tran De district, Soc Trang province, Vietnam.*

Treatments	The first (15 DAP)	The second (22 DAP)	The third (29 DAP)	The fourth (36 DAP)
	-	33.3% N	33.3% N	33.3% N
T1, T2, T3, T4	33.3% P_2O_5	33.3% P_2O_5	33.3% P_2O_5	-
	25% K_2O	25% K_2O	25% K_2O	25% K_2O
	-	16.7% N	16.7% N	16.7% N
T5, T6, T7, T8	16.7% P_2O_5	16.7% P_2O_5	16.7% P_2O_5	-
	25% K_2O	25% K_2O	25% K_2O	25% K_2O

*Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment.

The plant protection biological product from extracts of garlic, ginger, chili, lemongrass, and onion with a ratio of

1:1:1:1:1 (weight). One kg of each material was milled by blender, and then evenly mixed together. Hundred gram of each anise, and cinnamon were added. Finally, all materials were transferred to a plastic container, and five liters of alcohol (65^o) were filled. The mixture was incubated for ten days, and then was filtered through a net cloth. PPBP was preserved in a plastic container at 7°C. PPBP was sprayed at concentration 6% and every 10 days. Weed was controlled by handwork. Water irrigated for green onion during the experiment came from the canals in this experimental area. The chemical fertilizer application schedule for green onion during the experimental time was presented detailedly in Table 2.

Hanh Huong is the local green onion cultivar used commonly by farmers in Tran De district, Soc Trang province was selected in this experiment.

The initial characteristics of soil for this experiment including pH, EC, Organic content, N_{total}, NH_4^+, P_{total}, $P_{available}$, $K_{exchange}$, texture soil, number of bacteria, fungi and actinomycetes were also analyzed and presented in Table 3. The results of soil analysis indicated that soil pH and EC was 6.53, and 0.64, respectively. The organic matter content and N_{total}, NH_4^+, K_{ex} were 1.85%, 0.05% N, 1.74 mg/kg NH_4^+ and 0.32 meq/100 g, respectively. Meanwhile, the amount of P_{total} and P_{avai} was high, 0.13% and 45.8 mg/kg, respectively. The density of bacteria, fungi and actinomycetes in soil was 5.48, 3.47, and 4.15 log (CFU/g), respectively. The soil texture of this soil was identified as sandy loam when the proportion of sand, silt, and clay was 52.4%, 33.9%, and 16.7%, respectively.

Table 3. *Physical, chemical and biological properties of soil before the experiment conducted in Tran De district, Soc Trang province, Vietnam.*

Properties	Value
pH_{H2O}	6.53
EC, (mS/cm)	0.64
Orgaic, (%)	1.85
N_{ts}, (%N)	0.05
NH_4^+-N, (mg/kg)	1.71
P_{ts}, (%P_2O_5)	0.13
$P_{available}$, (mg/kg)	45.8
$K_{exchange}$, (meq/100g)	0.32
Number of Bacteria (log(CFU/g))	5,48
Number of Fungi (log(CFU/g))	3,47
Number of Actinomycetes (log(CFU/g))	4.15
Texture soil	Sandy loam (52.4% sand, 33.9% silt, 16.7% clay)

2.2. Collected Parameters

2.2.1. Pests and Diseases

Parameters of pests and diseases on the green onion were collected at day 15, 30, and 50 days after transplanting.

1) Pests: pest density, a ratio of buds attacked by pest/hill (%), a ratio of leaves attacked by pest/hill (%).
2) Diseases: a ratio of infested buds by plant pathogen/hill (%), a ratio of infested leaves by plant pathogen/hill (%).

2.2.2. Agronomy

Nine hills were collected fixedly in a frame containing an area of 0.25 m^2. Each plot had randomly two frames which were used to collect the parameters including plant height, numbers of buds/hill, numbers of leaves/hill, and stem diameter at day 15, 30, and 50 after transplanting. Stem circuit, stem length, root length, fresh root biomass, dried root biomass, and fresh/dry yield of green onion at the harvest time (50 days after transplanting).

1) Crop height (cm): crop height was measured from the soil surface to the highest top of nine green onion hill in 0.25 m^2 frames.
2) Numbers of buds/hill (buds/hill): all buds isolated from leaf sheath of each hill in 0.25 m^2 frames were counted.
3) Numbers of leaves/hill (leaves/hill): all leaves of each hill in 0.25 m^2 frames were counted.
4) Stem diameter (cm): using a caliper of to determine stem diameter of green onion and the position to measure was 1 cm above the soil surface.
5) Stem perimeter (cm): using a rope to wrap around stem at the position of 1 cm above the soil surface finally, matched the rope length into a tape ruler to determine the perimeter of the stem.
6) Stem length (cm): using a ruler to measure length from a root crown to a leaf neck.
7) Root length (cm): by using a ruler to measure length from the highest root top.
8) Fresh root biomass (g): after root length measured, root of each hill was cut off, and then a total of root mass of nine hills was weighed.
9) Dried root biomass (g): after fresh root biomass determined, the root was dried at 75°C in 48 hours, and then weighed by a digital scale.
10) Yield of green onion: collected on 50 days after transplanting by harvesting all hills in two 0.25 m^2 frames of each plot, finally the yield of green onion was calculated in tons/ha.

2.2.3. Soil Properties

At the end of the experiment, the soil sample was collected at 0-20 cm depth from many places in each plot, and then mixed thoroughly into a bigger soil sample. Some soil parameters were analyzed as follows:

1) pH and EC (electrical conductivity): pH and EC were determined by 744 pH Meter-Metrohm and EC Schott model 960, respectively. A ratio of soil: water (1.0: 2.5, w/w) was applied. Soil solution was shaken at 150 rpm in two hours, then centrifuged at 2000 rpm in 3 min. The supernatant was used for soil pH and EC determination.
2) Number of microorganisms in soil: The number of microorganisms in the soil was determined according to the method of Pepper and Gerba (2004). Soil samples were extracted with buffer phosphate solution at a ratio of 1:10 (soil: buffer, v/v) for 1 hour at 150 rpm. Dilute a series of different concentrations of the microbial suspension was mad with factor of 10. An aliquot 50 µL of the suspension at various concentrations was spread on Tryptone Soya Agar (TSA), Potato Dextrose Agar, (PDA) and Starch Agar contained in Petri dishes for the determination of bacterial, fungal, and actinomycetes populations, respectively. Petri dishes containing

samples were placed in an incubator at 30°C to allow microorganisms to grow and the number of bacterial colonies growing on different types of media was determined [14-17].

2.3. Data Analysis

The data were analyzed through one-way ANOVA, and Tukey's Multiple Comparison test using Minitab 16.2 software.

3. Results and Discussions

3.1. Efficacy of Bacterial Product NPISi and Biological Product on Soil Properties

3.1.1. pH and EC in Soil

Efficacy of salt tolerant bacterial product, NPISi and plant protection biological product on soil properties in Tran De district, Soc Trang province, Vietnam after two consecutive crops is presented Table 4. pH in soil at the end of the experiment varied from 5.80 to 6.37, significant differences among the treatments at level 5% through Tukey test. The treatments applied with 50% NP + 100% K regardless of NPISi application time significantly had higher pH than the treatments applied with 100% NPK (ranged from 6.07 to 6.37), however, they were not significantly different when compared with each other ($p>0.05$). The soil pH values of treatments applied with 100% NPK varied from 5.80 to 5.99, and were not significantly different from each other ($p>0.05$). In short, NPISi and PPBP did not boost soil pH. Moreover, when reducing 50% NP fertilizer, the soil pH was increased strongly, being compatible to green onion growth because optimal soil pH for green onion growth is 6.5 [18].

Table 4. *Soil pH and EC after two consecutive green onion crops in Tran De district, Soc Trang province, Vietnam.*

Treatments	pH	EC (mS/cm)
T1	5.99^{bcd}	0.09^{ab}
T2	5.93^{cd}	0.12^{a}
T3	5.97^{bcd}	0.07^{bc}
T4	5.80^{d}	0.06^{bc}
T5	6.24^{abc}	0.06^{bc}
T6	6.07^{a-d}	0.07^{bc}
T7	6.37^{a}	0.05^{c}
T8	6.27^{ab}	0.05^{c}
F	*	*
CV (%)	3.62	35.9

*Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment; *: a significant difference at the 5% level and in the same column and numbers followed by the same letters are not significant difference at the 5% level by Tukey test.

The soil EC of the treatments ranged in 0.05-0.12 mS/cm. The treatments with two time and five time NPISi application in combination with the application of 50% NP+100% K+PPBP had the lowest soil EC, 0.05 mS/cm, however, these treatments were not significantly different from the others including the treatments received 50% NP + 100% K and the treatments with two and five time NPISi application plus 50% NP + 100% K. The control treatment (100% NPK) and treatment of 100% NPK + one time NPISi application + PPBP had the highest EC values (0.09-0.12 mS/cm) ($p<0.05$). In summary, the application of NPISi in several times could reduce the soil EC when cultivated with green onion in Tran De district, Soc Trang province, Vietnam.

3.1.2. Number of Microorganisms in Soil

Number of microorganisms in soil at the end of two consecutive crops in Tran De district, Soc Trang province, Vietnam is showed in Table 5. The data indicated that number of soil bacteria ranged from 6.84 to 7.55 $\log_{10}$ (CFU/g). The treatment with 100% NPK + five tim NPISi application + PPBP had the highest number of soil bacteria, 7.55 $\log_{10}$CFU/g, however, it was not significantly different from the treatment with 100% NPK + two time NPISi application + PPBP and with 50% NP + 100% K + five time NPISi application + PPBP. The treatment without NPISi and PPBP application had the lowest microbial density ($p<0.05$). In conclusion, utilization of the salt tolerant bacterial and biological products helped to reinforce the number of microorganisms in soil, and several application times helped to increase microbial density in soil.

Moreover, number of fungi and actinomycetes in soil of the treatments was not significantly different in comparison with each other, ranged in 2.79-2.92 $\log_{10}$ (CFU/g) and 5.15-5.31 $\log_{10}$ (CFU/g), respectively. To sum up, application of salt tolerant bacterial product, NPISi enhanced the number of bacteria in soil cultivated with green onion in Tran De district, Soc Trang province, Vietnam.

Table 5. *Number of soil microorganisms at the end of two consecutive crops in Tran De district, Soc Trang province, Vietnam.*

Treatments	Microbial density ($\log_{10}$ CFU/g)		
	Bacteria	Fungi	Actinomycetes
T1	6.97^{d}	2.84	5.29
T2	7.33^{bc}	2.79	5.24
T3	7.40^{ab}	2.86	5.23
T4	7.55^{a}	2.94	5.18
T5	6.84^{d}	2.81	5.22
T6	7.07^{c}	2.99	5.21
T7	7.17^{b}	2.95	5.31
T8	7.36^{ab}	2.92	5.28
F	*	*ns*	*ns*
CV (%)	2.35	8.71	1.52

*Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment; *: a significant difference at the 5% level and in the same column and numbers followed by the same letters are not significant difference at the 5% level by Tukey test.

3.2. Effect of NPISi and PPBP on Growth and Yield of Green Onion Over 2 Experimental Crops Under the Field Conditions

3.2.1. The Crop Height

The results of evaluating the efficacy of salt tolerant product NPISi and biological plant protection product on the green onion height under the field scale at Tran De district, Soc Trang province, Viet Nam during two consecutive crops was showed at Table 6.

Treatments applied salt-tolerant bacterial product had a significant increase in the height of green onion as compared with the control treatment fertilized with 50% NP + 100%K. However, the green onion's height of these treatments was still lower than control treatment applied with 100% NPK.

Two treatments fertilized two and five times with salt-tolerant bacterial product, NPISi combined with biological plant protection product on base of 50% NP + 100% K showed that the height of green onion varied from 21.7 to 40 cm, significantly higher than the control treatment fertilized with 50% NP + 100K (22.2-33.9 cm) throughout the experimental time. Meanwhile, treatments applied with 100% NPK were not statistically different ($p>0.05$) from each other in all sampling points and varied between 23.1 and 48.8 cm. Besides, treatments applied with salt-tolerant bacterial product NPISi (50% NP + 100% K) in different application times had no significantly difference when compared with each other ($p>0.05$). Thus, dividing into several application times of salt-tolerant bacterial product, NIPSi did not impact on green onion's height.

Table 6. *Green onion's height of the field experiment in Tran De district, Soc Trang province, Vietnam in two experimental crops.*

Treatments	Crop 1			Crop 2		
	15 DAP	30 DAP	Harvest time	15 DAP	30 DAP	Harvest time
T1	23.1	35.6^{a}	41.7^{ab}	24.7^{abc}	34.0^{ab}	41.2^{bc}
T2	24.0	36.8^{a}	41.1^{ab}	27.2^{a}	34.6^{ab}	44.7^{ab}
T3	23.7	35.9^{a}	42.5^{a}	25.9^{ab}	36.3^{a}	46.4^{a}
T4	23.3	35.7^{a}	41.5^{ab}	25.2^{abc}	34.5^{ab}	48.8^{a}
T5	22.2	28.5^{c}	32.1^{d}	22.7^{c}	27.6^{d}	33.9^{d}
T6	23.0	30.0^{bc}	35.3^{cd}	23.4^{bc}	29.8^{cd}	37.7^{cd}
T7	23.2	31.7^{b}	38.2^{bc}	23.2^{bc}	31.9^{bc}	39.3^{c}
T8	21.7	31.4^{b}	38.4^{bc}	22.7^{c}	31.6^{bc}	40.0^{c}
F	*ns*	*	*	*	*	*
CV (%)	7.36	9.56	9.62	7.93	9.25	4.89

*Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment; *: a significant difference at the 5% level and in the same column and numbers followed by the same letters are not significant difference at the 5% level by Tukey test.

3.2.2. Buds/Hill

The results of evaluating the efficacy of salt-tolerant bacterial products NPISi and plant protection biological products on green onion's buds/hill under the field scale in Tran De district, Soc Trang province, Vietnam during two consecutive crops are showed at Table 7.

Table 7. *Green onion's buds/hill of the field experiment in Tran De district, Soc Trang province, Viet Nam in two experimental crops.*

Treatments	Crop 1			Crop 2		
	15 DAP	30 DAP	Harvest time	15 DAP	30 DAP	Harvest time
T1	4.4	7.2^{a}	11.5^{ab}	3.0	6.7^{cd}	10.7^{b}
T2	4.3	7.5^{a}	12.1^{a}	3.0	8.8^{a}	12.3^{a}
T3	4.2	7.3^{a}	12.0^{a}	3.1	8.0^{ab}	13.0^{a}
T4	4.7	7.2^{a}	12.0^{a}	3.0	7.3^{bc}	13.3^{a}
T5	3.9	5.7^{c}	7.4^{d}	2.8	5.1^{e}	8.4^{c}
T6	4.6	6.2^{bc}	9.3^{cd}	2.8	6.1^{de}	10.1^{b}
T7	4.2	6.4^{b}	9.6^{bc}	3.0	6.5^{cd}	10.6^{b}
T8	4.4	6.2^{bc}	9.9^{bc}	3.2	6.5^{cd}	10.9^{b}
F	*ns*	*	*	*ns*	*	*
CV (%)	8.76	9.81	16.72	9.82	17.1	14.46

*Notes: *Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment; *: a significant difference at the 5% level in the same column and numbers followed by the same letters are not a significant difference at the 5% level by Tukey test; ns: not significant.

The results showed that treatment applied with two times and five times of salt-tolerant bacterial products NPISi on base of 50% NP and 100% K + PPBP had the buds/hill vary between 6.2 and 10.9, higher and significantly difference ($p<0.05$) than the control treatment in two experiment crops at day 30 after transplanting and harvest time (5.1-8.4 buds /hill).

Meanwhile, the treatments with salt-tolerant bacterial product and PPBP on the base of 100% NPK gave a higher number of shoots/hill than the control treatment applied with only 100% NPK ($p<0.05$) at day 30 and harvest time in crop 2. Specifically, the number of buds/hill of green onion in 4 treatments applied with 100% NPK was ranged from 4.2-12.1 buds/hill ($p>0.05$) in crop 1. However, in the crop 2 the number of buds/hill of these treatments (salt-tolerant bacterial products) varied in the range of 12.3-13.3 buds/hill and significantly differed from the treatment applied with 100% NPK (10.7 buds/hill) ($p<0.05$).

3.2.3. Leaves/Hill

The results of evaluating the efficacy of plant protection biological product and salt-tolerant bacterial product NPISi on leaves/hill of green onion in the field at Tran De district, Soc Trang province, Viet Nam during two experiment crops are showed in Table 8.

The results indicated that the treatment with salt-tolerant bacterial products NPISi + PPBP (6% and 10 days/time) did not help to increase the number of leaves/hill in the crop 1, varied from 19 to 35.4 for l 50% NP +100% K treatments. The values of leaves/hill in 100% NPK treatment were ranged from 19.2 to 43.9. Besides, it can be seen that with a reduction of 50% NP, the leave numbers of green onions also reduced significantly. This infers that the application of 50% NP caused a reduction of numbers of onion leaves in crop 1.

Table 8. *Green onion's leaves/hill of the field experiment in Tran De district, Soc Trang province, Vietnam in two experimental crops.*

Treatments	Crop 1			Crop 2		
	15 DAP	30 DAP	Harvest time	15 DAP	30 DAP	Harvest time
T1	19.2	31.7^{a}	40.2^{ab}	11.3	30.9^{bc}	40.8^{b}
T2	19.4	32.0^{a}	43.9^{a}	11.8	33.3^{ab}	44.7^{a}
T3	18.2	33.1^{a}	42.1^{a}	11.8	35.1^{a}	46.1^{a}
T4	20.6	32.2^{a}	42.6^{a}	11.7	34.7^{a}	46.6^{a}
T5	20.6	23.2^{c}	30.4^{c}	11.3	22.4^{e}	32.9^{d}
T6	21.0	24.5^{bc}	32.8^{c}	10.8	27.0^{d}	37.0^{c}
T7	20.3	26.9^{b}	34.4^{c}	11.5	28.9^{cd}	39.1^{bc}
T8	19.0	27.4^{b}	35.4^{bc}	12.0	26.3^{d}	40.1^{b}
F	*ns*	*	*	*ns*	*	*
CV (%)	10.85	13.28	13.93	8.94	14.84	11.24

*Notes: T1: $100N-85P_2O_5-40K_2O$; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment; *: a significant difference at the 5% level in the same column and numbers followed by the same letters are not a significant difference at the 5% level by Tukey test; ns: not significant.

However, in the second crop, a combined fertilization treatments of these two products helped to increase the number of green onion's leaves, and at the same time, the leaves of green onion were significantly different ($p<0.05$) when compared with the control treatment which received the same chemical fertilizer formula at 2 sampling times: 30 DAP and harvest time. Particularly, the leaves in treatment of 100% NPK + salt tolerant bacterial product NPISi + PPBP varied between 30.9 and 40.8 leaves/hill, significantly higher than control treatment of 100% NPK (30.9-40.8 leaves/hill) ($p<0.05$). Similarly, the number of leaves in the treatments applied with 50% NP + 100% K + PPBP + NPISi varied between 26.3-40.1 leaves/hill, significantly higher than the control treatment (50% NP + 100% K).

In particular, at the time of harvest, the two treatments applied with salt-tolerant bacterial product NPISi 2 times and 5 times on the base of 50% NP + 100% K had the same number of leaves and was not significantly from the control treatment (100% NPK) ($p>0.05$). This may be because the applied bacteria from the NPISi salt tolerant bacteria product could survived and grew well in crop 1 and the bacterial inoculants were continued to be applied into the soil in crop 2, thus introduced bacteria in soil after 2 crops increased significantly in density to perform the functions of fixing nitrogen, solubilizing phosphorus, solubilizing Si and synthesizing IAA, enhancing nutrient mobilization and availability for green onions.

3.2.4. Stem Diameter

The results of survey on the effectiveness of salt-tolerant bacterial product NPISi and plant protection biological product on the stem diameter of green onion under field conditions through two experimental crops in Tran De district, Soc Trang province, Vietnam are presented in Table 9.

The results showed that the treatments applied with 50% NP + 100% K had stem diameters ranging from 0.42-0.79 cm over 2 experimental crops and at the same time, the treatments with 50% NP + 100% K were not significantly different in stem diameter from the 100% NPK treatments.

In addition, only at the time of harvest of the 2nd crop the treatments with NPISi had a significant higher diameter of green onion as compared with the control treatments without bacterial and biological product application regardless of the number of product application.

Specifically, the treatments fertilized with salt-tolerant bacterial product, NPISi and plant protection biological product on the base of 100% NPK application had stem diameters ranged from 0.70-0.79 cm, while the stem diameter of the control treatment was 0.63 cm. Similarly, the stem diameter of green onion in the treatments with salt-tolerant bacterial product, NPISi on the base of 50% NP+100% K varied 0.65-0.71 cm, while the stem diameter of the control treatment applied with 50% NP + 100 % K was 0.55 cm ($p<0.05$). Thus, the salt-tolerant bacterial product, NIPSi + plant protection biological product helped to increase the stem diameter of green onion.

***Table 9.** Green onion's stem diameter of the field experiment in Tran De district, Soc Trang province, Vietnam in two experimental crops.*

Treatments	Crop 1			Crop 2		
	15 DAP	30 DAP	Harvest time	15 DAP	30 DAP	Harvest time
T1	0.46^{abc}	0.62^{abc}	0.64^{ab}	0.28	0.52^{bcd}	0.63^{c}
T2	0.48^{a}	0.65^{ab}	0.72^{a}	0.35	0.59^{abc}	0.71^{ab}
T3	0.48^{a}	0.67^{a}	0.68^{a}	0.32	0.68^{a}	0.70^{bc}
T4	0.48^{a}	0.63^{ab}	0.65^{ab}	0.36	0.62^{ab}	0.79^{a}
T5	0.43^{bc}	0.55^{c}	0.55^{b}	0.35	0.48^{d}	0.55^{d}
T6	0.47^{ab}	0.61^{abc}	0.65^{ab}	0.34	0.51^{cd}	0.65^{bc}
T7	0.48^{a}	0.67^{a}	0.63^{ab}	0.34	0.58^{a-d}	0.69^{bc}
T8	0.42^{c}	0.57^{bc}	0.63^{ab}	0.32	0.52^{bcd}	0.71^{ab}
F	*	*	*	*ns*	*	*
CV (%)	6.52	8.41	9.50	13.65	13.44	10.48

*Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment; *: a significant difference at the 5% level in the same column and numbers followed by the same letters are not a significant difference at the 5% level by Tukey test; ns: not significant.

3.2.5. Stem Length and Stem Perimeter

The results of the survey on the effect of salt-tolerant bacterial product NPISi and plant protection biological products on the length and perimeter of green onion in Tran De district, Soc Trang province, Vietnam are presented in Table 10. The treatment applied with NPISi salt-tolerant bacterial product in 5 times on the base of 50% NP + 100% K in first crop and the treatment applied with NPISi salt-tolerant bacterial product in 5 times in both 50% NP + 100% and 100% NPK in the second crop helped to increase the length and perimeter of the stem of green onion. Specifically, the stem length in the treatment with 5 time NPISi, salt tolerant bacterial product application on the fertilizer formula of 50% NP + 100% K reached 9.8 cm (crop 1) and 10.5 cm (crop 2), respectively, significantly higher ($p<0.05$) when compared with the control treatment (50% NP+100% K) (9.1 cm in crop 1 and 9.7 cm in crop 2). In addition, the treatment with 100% NPK+PPBP+NPISi (5 time application) had a stem length of 11.3 cm (crop 2), significantly higher from the control treatment applied with 100 % NPK (10.0 cm) ($p<0.05$).

As for stem perimeter, the experimental treatments were not statistically different when compared with each other in the crop 1, however, in the second crop, the NPISi salt-tolerant bacterial product applied treatments had a higher stem perimeter ($p<0.05$) when compared with the control treatment without bacterial product. In which, 100% NPK treatment together with 5 time NPISi salt-tolerant bacterial product application was 2.72 cm, significantly higher from the rests (2.03-2.45 cm).

For 2 treatments applied with 50% NP + 100% K together with 2 and 5 time NPISi application gave higher stem perimeter of green onion (1.95 and 2.01 cm, respectively) in the second crop as compared to the remained treatments (1.75 and 1.91 cm). Thus, the results of this study showed that with 5 application times of the salt tolerant bacterial product, NPISi it was highly effective to increase the stem length and stem perimeter of green onion during 2 experimental crops in the Tran De district, Soc Trang province, Vietnam.

***Table 10.** Green onion's stem length and stem perimeter of the field experiment in Tran De district, Soc Trang province, Vietnam in two experimental crops.*

Treatments	Stem length		Stem perimeter	
	Crop 1	Crop 2	Crop 1	Crop 2
T1	9.8^{bc}	10.0^{de}	1.98	2.03^{c}
T2	9.7^{cd}	10.9^{ab}	1.92	2.39^{b}
T3	10.6^{a}	11.1^{a}	1.99	2.45^{b}
T4	10.4^{ab}	11.3^{a}	1.96	2.72^{a}
T5	9.1^{d}	9.7^{e}	1.87	1.75^{d}
T6	9.5^{cd}	10.0^{de}	1.87	1.91^{cd}
T7	9.7^{cd}	10.2^{cd}	1.93	1.95^{c}
T8	9.8^{bc}	10.5^{bc}	1.86	2.01^{c}
F	*	*	*ns*	*
CV (%)	5.32	5.66	4.85	9.32

*Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment; *: a significant difference at the 5% level in the same column and numbers followed by the same letters are not a significant difference at the 5% level by Tukey test; ns: not significant.

3.2.6. Root Length and Root Biomass

The results of the survey on the effect of plant protection biological product and salt-tolerant bacterial product, NPISi on the root length and root biomass of green onion under the field conditions in 2 experimental crops in Tran De district, Soc Trang province, Vietnam are presented in Table 11.

The results showed that the treatments with NPISi product did not increase the root length of green onion compared to the control treatment without NPISi application regardless of the amount of chemical fertilizer ($p>0.05$). Meanwhile, the treatment with NPISi product on the base of 50% NP + 100% K and regardless of the application time of NPISi had a higher biomass of fresh and dry green onion and significantly different ($p<0.05$) from the control treatment without bacterial product. Root biomass of bacterial product treatments ranged from 163.5 to 166.8 g/0.5 m^2 and from 55.1 to 57.1 g/0.5 m^2 (dry biomass). In particular, the treatments with NPISi products on the base of 50% NP + 100% K had similar fresh root biomass and the difference was not statistically significant ($p>0.05$) when compared with the treatments applied with 100% NPK.

Table 11. *Green onion's root length and root biomass of the field experiment in Tran De district, Soc Trang province, Vietnam in two experimental crops.*

Treatments	**Root length (cm)**		**Fresh root biomass (g/0.5 m^2)**		**Dry root biomass (g/0.5 m^2)**	
	Crop 1	**Crop 2**	**Crop 1**	**Crop 2**	**Crop 1**	**Crop 2**
T1	28.8^{ab}	24.7^{ab}	223.3^{a}	167.5^{a}	88.3^{a}	63.1^{a}
T2	29.7^{ab}	26.9^{a}	219.0^{a}	174.0^{a}	87.4^{a}	66.4^{a}
T3	30.9^{ab}	26.5^{a}	239.0^{a}	171.5^{a}	91.6^{a}	66.6^{a}
T4	31.8^{a}	27.2^{a}	225.9^{a}	179.3^{a}	87.5^{a}	67.3^{a}
T5	26.3^{b}	22.5^{b}	144.4^{b}	140.6^{b}	60.4^{b}	49.4^{c}
T6	27.0^{ab}	23.0^{b}	160.1^{b}	163.5^{a}	69.4^{b}	55.1^{b}
T7	26.2^{b}	23.9^{ab}	163.5^{b}	164.5^{a}	65.3^{b}	57.1^{b}
T8	28.0^{ab}	23.9^{ab}	162.4^{b}	166.8^{a}	63.3^{b}	56.7^{b}
F	*	*	*	*	*	*
CV (%)	9.63	8.6	19.12	8.76	16.60	10.78

Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment: a significant difference at the 5% level in the same column and numbers followed by the same letters are not a significant difference at the 5% level by Tukey test.

3.2.7. Yield of Green Onion

The results of the fresh yield of green onions over two experimental crops under field conditions are presented in Table 12, Figure 1 and Figure 2.

Figure 1. *Green onion of 8 experimental treatments under the field conditions in Tran De district, Soc Trang province, Vietnam in crop 1 (04/2022-06/2022).*

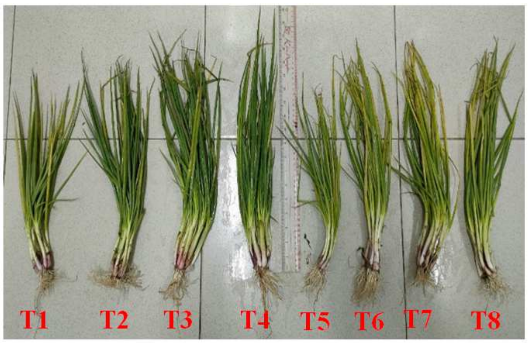

Figure 2. *Green onion of 8 experimental treatments under the field conditions in Tran De district, Soc Trang province, Vietnam in crop 2 (06/2022-09/2022).*

*Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); T: treatment.

Table 12. *Green onion's fresh yield of the field experiment in Tran De district, Soc Trang province, Vietnam in two experimental crops.*

Treatments	**Fresh yield (tons/ha)**	
	Crop 1	**Crop 2**
T1	31.1^{a}	32.6^{b}
T2	32.5^{a}	36.7^{a}
T3	32.2^{a}	38.2^{a}
T4	31.1^{a}	39.0^{a}
T5	17.1^{d}	26.8^{c}
T6	21.4^{c}	30.2^{bc}
T7	22.3^{bc}	31.3^{b}
T8	24.8^{b}	32.3^{b}
F	*	*
CV (%)	21.53	14.69

*Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment; *: a significant difference at the 5% level in the same column and numbers followed by the same letters are not a significant difference at the 5% level by Tukey test.

The NPISi application treatment helped increase fresh yield and dry biomass of scallions over 2 experimental crops, especially when used together with 50% NP + 100% K. In two experimental crops, two treatments with NPISi applied 2 times and 5 times on the base of 50% NP + 100% K had green onion yields ranging from 22.3 to 32.3 tons/ha, higher and significantly different ($p<0.05$) when compared with the control treatment with only 50% NP+100% K, ranging from 17.1-26.8 tons/ha ($p<0, 05$).

However, based on 100% NPK in the first crop, the treatments with NPISi salt-tolerant bacterial product had no significantly difference on the fresh yield of green onion ($p<0.05$) when compared with the control treatment without salt-tolerant bacterial product, NPISi. The yield of fresh green onion of these treatments were ranged from 31.1 to 32.5 tons/ha ($p>0.05$). This could be explained by the fact that the bacterial strains in the NPISi salt-tolerant bacterial product applied in first crop were not stable and not adapted well to multiply the density in the field soil because the introduced bacterial strains need some times to adapt well to the actual field conditions. In addition, in the first crop experiment, the harsher weather appeared like dry conditions, the amount of freshwater to irrigate for green onion was limited, so the growth of onion was reduced, so the demands for nutrients by green onion was also lower. Therefore, when applying 100% NPK, it was enough to meet the nutritional needs of green onion in this crop, so even though the bacteria in the NPISi salt-tolerant bacterial products could provide some more nutrients to the soil, green onion still can't uptake more to increase productivity. Meanwhile, in the treatments with 50% NP reduction, soil nutrients were lacked as compared to the needs of green onions, so the bacteria present in the NPISi salt-tolerant bacterial product helped to compensate the reduced amount of chemical fertilizer, thereby, helping to increase the fresh green onion yield in the treatments with 50% NP reduction.

However, in the second crop, the yield of fresh green onion of the treatments with NPISi salt tolerant bacterial product was higher and significantly different ($p<0.05$) when compared with the control treatments. In which, the yields of these treatments of salt-tolerant bacterial products NPISi on the base of 100% NPK were ranged from 36.7 to 39 tons/ha, significantly higher ($p<0.05$) than the control treatment (100% NPK (32.6 tons/ha). In particular, three treatments with NPISi salt-tolerant bacterial product on the base of 50% NP+100% K had the same yield of green onion, but no significant difference ($p>0.05$) when compared with control treatment (100% NPK). This can be seen that the application of 80 kg/ha of NPISi salt-tolerant bacterial product could compensate for the nutritional content through a 50% reduction in the recommended amount of chemical NP fertilizers.

Thus, decreasing of 50% NP according to the recommended chemical fertilizer formula helped the beneficial bacteria in the NPISi product to activate well, so it increased the yield of green onion higher from 25.1%. up to 45% compared to the control treatment without salt-tolerant bacterial product (17.1 tons/ha) in crop 1 and 12.6-20.3% in crop 2. This increase in yield was due to efficiency. of bacterial strains with functions of nitrogen fixation, phosphate solubilization, Si solubiozation and IAA synthesis in microbial product, helping to increase yield components such as number of leaves/hill, number of buds/hill, stem diameter, crop height, thereby contributing to the increase of green onion yield over the two experimental crops. The results of this study are similar to many previous studies, notably the study of [6] showing that the use of inoculants containing many strains of beneficial bacteria helped to increase rice yield Mot Bui Do in Phuoc Long district, Bac Lieu province, Vietnam and increase in green onion yield in Tran De district, Soc Trang province, Vietnam.

3.3. Efficacy of Biological Product and NPISi Bacterial Product on the Pest and Disease on Green Onion

3.3.1. Density of Beet Armyworm

The results of evaluating the effectiveness of PPBP and NPISi salt-tolerant bacterial product on the density of green onion beet armyworm (*Spodoptera exigua*) in Tran De district, Soc Trang province, Vietnam after two consecutive crops presented in Table 13 showed that the beet armyworm appeared only in crop 1 but crop 2. The treatments sprayed with PPBP in a combination with NPISi salt-tolerant bacterial product application had lower density of green onion beet armyworm in the field at day 30 after transplanting and at the harvest time the numbers of beet armyworm was significantly lower ($p<0.05$) in treatments applied with microbial and biological products as compared to the control treatment without PPBP and NPISi.

Table 13. *Density of green onion's beet armyworm in Tran De district, Soc Trang province, Vietnam in crop 1.*

Treatments	Density of beet armyworm (larvae/m^2)		
	15 DAP	30 DAP	Harvest time
T1	6^{a}	18^{a}	17^{a}
T2	5^{ab}	8^{b}	10^{b}
T3	3^{ab}	8^{b}	9^{b}
T4	3^{ab}	8^{b}	5^{c}
T5	5^{ab}	8^{b}	11^{b}
T6	3^{b}	9^{b}	4^{c}
T7	4^{ab}	8^{b}	9^{b}
T8	4^{ab}	7^{b}	8^{bc}
F	*	*	*
CV (%)	40.3	32.4	46.8

*Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment; *: a significant difference at the 5% level in the same column and numbers followed by the same letters are not a significant difference at the 5% level by Tukey test.

Specifically, the density of green onion beet armyworm in the treatment of 100% NPK (without PPBP and NPISi) was always highest in 3 different sampling points: 15 days after planting (DAP), 30 DAP and harvesting day (6, 18 and 17 larvae/m^2, respectively). Meanwhile, the lower density of this pest was found in the treatments sprayed with PPBP from lemongrass, chili, ginger, anise, garlic, anise and cinnamon together with salt tolerant bacterial product as compared to the control treatment (100% NPK) ($p<0.05$), ranging from 3-10 larvae/m^2. Especially, in the control treatment (50% NP + 100% K) the density of beet armyworm was also significantly lower than the control treatment (100% NPK). This result indicated that there may be a correlation between the fertilizer application dose with the density of beet armyworm on green onion.

3.3.2. Rate of Buds and Number of Leaves/Hill Attacked by Beet Armyworm

The results presented Table 14 showed that there was a statistically significant difference ($p<0.05$) between the experimental treatments in terms of the percentage of buds and leaves/hill that were attacked by beet armyworm, in which, treatment applied with PPBP + NPISi had a lower percentage of buds and leaves/hill attacked by green onion beet armyworm ($p<0.05$).

Table 14. *Rate of green onion's buds/hill and leaves/hill damaged by beet armyworm in Tran De district, Soc Trang province, Vietnam in crop 1.*

Treatments	Rate of buds /hill attacked (%)			Rate of leaves/hill attacked (%)		
	15 DAP	30 DAP	Harvest time	15 DAP	30 DAP	Harvest time
T1	13.2^{ab}	16.8^{b}	37.8^{a}	6.7	20.5^{a}	20.0^{a}
T2	6.1^{b}	12.4^{bcd}	16.6^{c}	3.2	10.8^{b}	9.8^{cd}
T3	9.8^{ab}	13.7^{bc}	14.3^{c}	4.4	7.6^{bc}	6.9^{e}
T4	8.4^{b}	9.1^{d}	14.3^{c}	3.8	5.2^{c}	7.5^{de}
T5	17.8^{a}	30.6^{a}	35.3^{a}	6.8	12.0^{bc}	13.2^{b}
T6	9.3^{ab}	12.0^{cd}	24.5^{b}	2.8	4.7^{c}	11.0^{bc}
T7	9.0^{ab}	9.7^{cd}	24.6^{b}	2.6	5.4^{c}	10.1^{cd}
T8	11.9^{ab}	10.2^{cd}	24.8^{b}	4.6	5.2^{c}	8.6^{cde}
F	*	*	*	*ns*	*	*
CV (%)	45.78	48.28	31.50	50.34	61.21	37.66

*Notes: T1: 100N-85P_2O_5-40K_2O; T2: 100% NPK + one time NPISi application + PPBP (6%, every 10 days); T3: 100% NPK + two time NPISi application + PPBP (6%, every 10 days); T4: 100% NPK + five time NPISi application + PPBP (6%, every 10 days); T5: 50% NP+100% K; T6: 50% NP + 100% K + one time NPISi application + PPBP (6%, every 10 days); T7: 50% NP + 100% K + two time NPISi application + PPBP (6%, every 10 days), T8: 50% NP + 100% K + five time NPISi application+ PPBP (6%, every 10 days); DAP: day after planting; T: treatment; *: a significant difference at the 5% level in the same column and numbers followed by the same letters are not a significant difference at the 5% level by Tukey test; ns: not significant.

The two control treatments without PPBP and NPISi application having a higher percentage of buds/hill attacked by beet armyworm. They were ranged from 17.8-35.3% (50% NP + 100% K) and from 13.2-37.8% (100% NPK), respectively, significantly higher when compared with treatments treated with PPBP + NPISi at most of the sampling times ($p<0.05$), ranging from 9-24.8%.

The parameter of percentage of leaves/hill attacked by beet armyworms is presented in Table 14 showed that the treatments with PPBP + NPISi had a higher percentage of leaf/hill attacked by beet armyworms. The percentage of damaged leaves was significantly lower ($p<0.05$) in the treatments with PPBP + NPISi as compared with the two control treatments without PPBP and NPISi ($p<0.05$) at day 30 DAP and harvest day (50 DAP). The control treatment on base of 100% NPK had the highest percentage of leaves/hill affected by beet armyworms, ranging from 20-20.5%, significantly different as compared to the other treatments ($p<0.05$). Next, the treatment with 50% NP + 100% K had the second highest percentage of beet armyworms, ranging from 12-13.2%, significantly higher ($p<0.05$) than the treatment with PPBP + NPISi (5.2-11%). At the same time, the treatments sprayed with PPBP + NPISi on the base of 50% NP + 100% K had a higher percentage of pest as compared to the treatments sprayed with PBP + NPISi on base of 100% NPK. This may be because the total number of leaves of the treatments with 50% NP + 100% K in crop 1 was lower than that of the treatments with 100% NPK, leading to a higher percentage of leaves/hill attacked by the beet armyworms, so the treatments with reduction 50% NP was higher in this pest.

3.3.3. Leaf Blight Disease

The results of the experiment to evaluate the effectiveness of PPBP and NPISi on the prevention of green onion leaf blight in 2 experimental crops in Tran De district, Soc Trang province, Vietnam showed that the density and prevalence of this disease in treatments were not significantly different ($p>0.05$) when compared with each other (data not shown).

In summary, the experimental results showed that spraying a plant protection biological product with a concentration of 6% (v/v) at every 10 days in combination with the application of NPISi salt-tolerant bacterial product helped control the green onion beet armyworm well, but not effective in the prevention and controlling of leaf blight on green onions. This may be because the smell of the plant protection biological product could make a good repellence to the adult butterfly of the onion beet armyworm, limiting the egg laying of the adult in the sprayed treatments, thereby helping to control the population of the beet armyworm in green onion field. Many studies have shown that extracts of ingredients in plant protection biological pesticide including chili, onion, lemongrass, and ginger had a great ability to repel many insects, including green onion beet armyworm. In particular, typical research [19] showed that lemongrass extract had the great ability to repel many important insects such as aphids and beet armyworm or [20] showed that the active ingredients allicin and allin in garlic have the ability to repel many pests on vegetables.

4. Conclusion

Applying with a dose of 80 kg/ha of NPISi salt-tolerant bacterial product in a combination with spraying 6% of plant protection biological product at every 10 days helped to increase plant height, number of buds/hill, number of leaves/hill, stem diameter, root biomass and increase soil bacterial density, and pH after 2 experimental crops, good control of harmful beet armyworm and helped to increase the yield of green onion up to 45% after 2 experimental crops under the field in Tran De district, Soc Trang province, Vietnam.

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