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INFLUENCE OF CROP ROTATION PATTERNS ON Ralstonia solanacearum POPULATION IN THE SOIL AND ON THE POTATO CROP IN THE SUBSEQUENT SEASON

PENGARUH ROTASI TANAMAN TERHADAP POPULASI *Ralstonia solanacearum* DI TANAH DAN TERHADAP TANAMAN KENTANG PADA MUSIM BERIKUTNYA

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INTISARI

Percobaan untuk mengetahui pengaruh pola rotasi tanaman terhadap populasi Ralstonia solanacearum dan terhadap tanaman kentang pada musim berikutnya telah dilakukan di kebun percobaan Balai Penelitian Tanaman Sayuran (Balitsa) Lembang-Jawa Barat (1250 m dpl.). Percobaan dilakukan selama empat musim tanam secara berurutan. Tomat, jagung, kubis, kacang merah, wortel dirotasikan dengan tanaman kentang dalam enam pola rotasi tanaman berbeda. Populasi R. solanacearum diestimasi sebelum tanam dan setelah panen pada setiap musim tanam. Tanaman kentang yang layu pada musim berikutnya diamati. Selain itu, pertumbuhan dan hasil tanaman kentang juga diamati.

Hasil penelitian menunjukkan bahwa setelah panen pada musim kedua, semua perlakuan rotasi tanaman mengurangi populasi R. solanacearum, dan populasi patogen pada perlakuan kentang-jagung secara nyata lebih rendah daripada perlakuan rotasi tanaman lainnya. Sehingga, hasil penelitian mengindikasikan bahwa rotasi tanaman dengan jagung adalah yang terbaik untuk mengurangi populasi pathogen di tanah. Perlakuan Kentang-Tomat-Kentang dan Kentang-Kentang-Kentang pada musim tanam ketiga menunjukkan lebih banyak tanaman kentang yang layu daripada perlakuan rotasi tanaman lainnya, walaupun perbedaan yang nyata hanya terjadi pada umur 11 minggu setelah tanam (MST). Hasil umbi kentang pada perlakuan Kentang-Tomat-Kentang dan Kentang-Kentang-Kentang secara nyata lebih rendah daripada perlakuan rotasi tanaman lainnya. Rotasi tanaman dengan jagung, kubis, kacang merah dan wortel secara nyata mempunyai persentase tanaman layu yang lebih rendah dan secara nyata memberikan hasil umbi kentang yang lebih tinggi pada musim berikutnya dibandingkan dengan rotasi

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tanaman dengan tanaman solanaceae yaitu tomat dan kentang. Hasil penelitian juga mengindikasikan bahwa rotasi tanaman dengan jagung, kubis, kacang merah dan wortel efektif dalam mengurangi timbulnya penyakit layu bakteri pada tanaman kentang. Diperlukan penelitian lebih lanjut dasar pengurangan populasi patogen di tanah pada percobaan rotasi tanaman yaitu bakteri antagonistik.

Kata kunci: *Rotasi tanaman, Ralstonia solanacearum, Kentang.*

ABSTRACT

An experiment was conducted to determine the influnce of crop rotation patterns on Ralstonia solanacearum population in the soil and on the potato crop in the subsequent season. The experiment was conducted at the experimental station of Indonesian Vegetable Research Institute (IVEGRI) in Lembang-West Java (1250 m asl.). The experiment was conducted in four successive seasons. Tomato, maize, cabbage, beans, carrot were rotated with potato in six different crop rotation patterns. R. solanacearum population was estimated before planting and after harvest in each season. Occurrence of wilt in subsequent potato crops was also recorded. In addition, the growth and yield of potato crops were recorded.

The results after harvest in season 2 indicated that all rotation treatments reduced the R. solanacearum population, and the pathogen population in Potato-Maize treatment was significantly lower than those of the other rotation treatments. Thus, the results suggest that rotation with maize is the best method to reduce the pathogen population in the soil. The Potato-Tomato-Potato and Potato-Potato-Potato treatments in season 3 had more wilting plants than other treatments although significant difference only occurred at 11 week after planting (WAP). Tuber yields of potatoes in Potato-Tomato-Potato and Potato-Potato-Potato treatments were significantly lower than those of other treatments. Rotation with maize, cabbage, beans and carrot had a significantly lower percentage of wilting plants and a significantly higher tuber yields of potato in the subsequent season compared with those of rotations with tomato and potato, the solanaceae crops. These results also suggest that rotation with maize, cabbage, beans and carrot are effective in reducing the bacterial wilt incidence in the potato crop. The basis for the reduction of the pathogen population in the soil in crop rotation experiments, e.g. antagonistic bacteria, needs research.

Key words: Crop rotation, Ralstonia solanacearum, Potato.

INTRODUCTION

Bacterial wilt caused by *Ralstonia solanacearum*, also known as brown rot is an important disease of potato in Indonesia. Hutagalung in 1984 estimated that the incidence of bacterial wilt on potato in production centers in Java ranged from 4 to 32% (Machmud, 1986). Another survey, conducted in April 1996 at Pangalengan, the largest potato production area in West Java indicated that bacterial wilt ranked first according to their importance as perceived by farmers in most villages that had been surveyed. Farmers estimated that plant wilt incidence reached 25% in the field, whereas tuber loss in the form of rotten tubers was estimated to range from 3 to 25% and 5 to 20% at harvest and during storage, respectively (Chujoy *et al.*, 1996).

Bacterial wilt, as pointed out by Kelman (1981), is also an important limitation to growing potatoes and other susceptible crops in parts of Asia, Africa and South and Central America. In addition, the disease becomes a major constraint to expanding potato production at elevations of 500 to 1000 m where the climate is favourable for both potatoes and the disease (Van Der Zaag, 1985).

Several studies indicated that crop rotation is an effective method in reducing bacterial wilt incidence in the subsequent potato crop (Devaux *et al.*, 1987; Kloos *et al.*, 1991; Bang and Wiles, 1994). French (1994a; 1994b) reviewed a strategy for integrated control at bacterial wilt and pointed out that crop rotation ranks four after soil free from *R. solanacearum*, fumigation and suppressive soils in term of factors that judged to contribute to good control of the disease.

The present research aims to determine the effect of crop rotation patterns on *Ralstonia solanacearum* population in the soil and on potato crop in the subsequent season.

MATERIALS AND METHOD

The experiment was conducted at the experimental station of the Indonesian Vegetable Research Institute (IVEGRI) in Lembang-West Java (1250 m asl.). The field of the experiment was selected due to the incidence of bacterial wilt in the potato crop the previous season. Tomato, maize, cabbage, beans, carrot and potato were used in the rotation experiment. These crops were selected because they are commonly planted by the farmers in the area.

The experiment was conducted in four successive seasons. The following treatments are used in the experiment:

Treatment	Season 1	Season 2	Season 3	Season 4
1	Potato	Tomato	Potato	Tomato
2	Potato	Maize	Potato	Maize
3	Potato	Cabbage	Potato	Cabbage
4	Potato	Beans	Potato	Beans
5	Potato	Carrot	Potato	Carrot
6	Potato	Potato	Potato	Weed fallow

The experiment was dessigned in a randomized complete block design with five replications. Each plot was 4.5 x 6.0 m^2. Plant spacing was 0.75 x 0.30 m for potato, 0.75 x 0.50 m for tomato, maize and cabbage, and 0.75 x 0.25 m for beans. Carrot was planted by broadcasting the seed in beds. Each crop received adequate fertilizer either organic or inorganic. Pests and diseases were also controlled. The first season (potato in all treatments) was planted on 14 April 1997 and harvested in the first week of August 1997. In the second season, all crops were transplanted /planted on 20 December 1997. Beans were harvested on 27 February 1998. Tomato was harvested six times and final harvest was conducted on 27 March 1998, the same day as the other crops i.e. carrot, potato, cabbage and maize. The third season crops i.e. potato in all treatments were planted on 5 May 1998 and harvested on 22 July 1998. The fourth season crops were transplanted / planted in August 1998 and harvested in December 1998.

Bacterial wilt infected potato plants were counted at weekly intervals in season 1 and 3. Soil samples were also collected at the beginning of the experiment (before planting the crops) and after harvest the yield of the crops in order to estimate the population of *R. solanacearum* in the soil using Kiraly (1970) method. In addition, the growth and yield of potato crops were recorded.

RESULTS AND DISCUSSION

The experiments were conducted in four successive seasons, but only the first three season's results were presented. In order to have uniformity in the *R. solanacearum* population distribution in the experimental field, potatoes were planted in all treatments in season 1. In this season, the overall mean percent of wilting plants increased from 1.3% at week 4 to 27.3% at week 7. The percentage of hills harvested and percentage of rotten hill at harvest were also determined and averaged 87% and 30%, respectively.

Development of *R. solanacearum* population in the soil under the different crop rotation treatments in season 2 is presented in Table 1. Before planting, the population of *R. solanacearum* was lowest in Potato-Carrot

(treatment 5) and highest in Potato-Tomato (treatment 1), but the difference was not significant. The mean *R. solanacearum* population in the soil in this season was 1499 x 10^7 cfu/ml. In season 2, all rotation treatments reduced the *R. solanacearum* population. The pathogen population in Potato-Maize (treatment 2) was significantly lower than those of the other rotation treatments (Table 1).

Table 1. Comparison of population of *R. solanacearun* in the soil among crop rotation patterns before planting and after harvest in season 2, Lembang-West Java, December 1997 – March 1988 (Values were analysed using data transformation of log *x*+1)

Treatment	*R. solanacearum* population in the soil (x 10^7 cfu/ml)	
	Before planting	After harvest
Potato-Tomato	2152 a	463 a
Potato-Maize	1120 a	263 b
Potato-Cabbage	1680 a	415 a
Potato-Beans	1525 a	399 a
Potato-Carrot	1045 a	478 a
Potato-Potato	1475 a	404 a
Mean	1499	404
Significance	ns	*
CV (%)	2.26	1.41

Note: cfu = colony per unit; CV = Coefficient of Variation; ns = non significant; * = significant at 5%

The occurrence of remarkably reduction of bacterial wilt population after maize in this experiment as indicated in Table 1 is consistent with other reports (CIP, 1990; Elphinstone and Aley, 1992; Bang and Wiles, 1994). Elphinstone and Aley (1992) reported that a decline in *R. solanacearum* level in the maize rhizosphere may be related to an increased population of *Pseudomonas cepacia* which was an antagonistic bacteria to *R. solanacearum*.

A comparison of *R. solanacearum* population before planting and after harvest in season 2 is presented in Table 2. The *R. solanacearum* population after harvest was always significantly lower than those before planting in all rotation treatments.

Table 2. Comparison of population of *R. solanacearum* in the soil before planting and after harvest in each rotation treatment in season 2, Lembang-West Java, December 1997 – March 1998 (Values were analysed using data transformation of log *x*+1)

Observation	*R. solanacearum* population in the soil (x 10^7 cfu/ml) in					
	Potato-Tomato	Potato-Maize	Potato-Cabbage	Potato-Bean	Potato-Carrot	Potato-Potato
Before planting	2152 a	1120 a	1680 a	1525 a	1045 a	1475 a
After harvest	463 b	263 b	415 b	399 b	478 b	404 b
Mean	1307	691	1047	962	761	939
Significance	**	*	**	*	*	**
CV (%)	1,96	2,51	0,86	2,49	1,73	1,62

Note: cfu = colony per unit; CV = Coefficient of Variation; * = significant at 5%; ** = significant at 1%

The effect of rotation on plant emergence, canopy cover, percent of wilting plant and tuber yield components of potatoes in season 3 is presented in Table 3.

Table 3. Effect of crop rotation treatments on plant emergence, canopy cover, percent of wilting plant and tuber yield components of potato cv. Granola in season 3, Lembang-West Java, May 1998 to July 1998

Treatment	Emergence	Canopy cover	Percent of wilting plant			Hill harvested	Tuber yield		Marketable tuber
	4 WAP		9 WAP	10 WAP	11 WAP		per ha	per plant	
	(#)	(%)	(%)	(%)	(%)	(%)	(ton)	(g)	(%)
Pot-Tom-Pot	72 a	97 a	17 b	30 b	74 ab	56 a	11,0 bc	264 bc	69 b
Pot-Mai-Pot	72 a	98 a	17 b	26 b	69 b	62 a	12,9 ab	309 ab	75 a
Pot-Cab-Pot	72 a	99 a	10 b	16 b	54 b	65 a	13,9 a	334 a	78 a
Pot-Bea-Pot	72 a	99 a	17 b	24 b	66 b	59 a	14,4 a	345 a	79 a
Pot-Car-Pot	73 a	97 a	14 b	26 b	51 b	60 a	14,1 a	338 a	73 ab
Pot-Pot-Pot	73 a	96 a	38 a	57 a	89 a	45 a	9,4 c	227 c	76 a
Mean	72	97	19	30	67	58	12,7	303	75
LSD (5%)	3	4	5	4	3	10	2,5	61	6
CV (%)	3	3	29	24	20	14	15,2	15	6

Note: WAP = Week After Planting; LSD = Least Significant Difference; CV = Coefficient of Variation; pot

The Potato-Tomato-Potato and Potato-Potato-Potato treatments had a higher percentage of wilting plants than other treatments although significant

differences only occurred at 11 week after planting (WAP). At harvest, tuber yields of potatoes were also affected by the crop rotation patterns. Tuber yields of potatoes in Potato-Tomato-Potato and Potato-Potato-Potato treatments were significantly lower than those of other rotation treatments (Table 3). The data of percent of wilting plant and tuber yield components of potatoes in season 3 (Table 3) is not consistent with the data of *R. solanacearum* population after harvest in season 2 (Table 1). Although the *R. solanacearum* populations in all treatments, except Potato-Maize-Potato treatment, were not significantly different, the treatments affected the percent of wilting plant and tuber yield components of potatoes in season 3. Rotation with maize, cabbage, beans and carrot had a significantly lower percentage of wilting plants and a significantly higher tuber yield of potato in the subsequent season compared with those of rotation with tomato and potato, the solanaceae crops. Thus, the results suggest that rotation with maize, cabbage, beans and carrot are effective in reducing the bacterial wilt incidence in the potato crop.

The population of *R. solanacearum* in all treatments increased after planting potato in season 3 (Table 4). Potato-Beans-Potato had a higher *R. solanacearum* population but the difference was not significant compared to other treatments.

Table 4. Comparison of population of *R. solanacearun* in the soil among crop rotation patterns before planting and after harvest in season 3, Lembang-West Java, May 1998 – July 1988 (Values were analysed using data transformation of log *x*+1)

Treatment	*R. solanacearum* population in the soil (x 10^7 cfu/ml)	
	Before planting	After harvest
Potato-Tomato-Potato	463 a	1702 a
Potato-Maize-Potato	263 b	1393 a
Potato-Cabbage-Potato	415 a	1820 a
Potato-Bean-Potato	399 a	2151 a
Potato-Carrot-Potato	478 a	1755 a
Potato-Potato-Potato	404 a	1311 a
Mean	404	1688
Significance	*	ns
CV (%)	1.41	2.07

Note: cfu = colony per unit; CV = Coefficient of Variation; ns = non significant; * = significant at 5%

The mean pathogen population before planting and after harvest in season 3 is presented in Table 5. The pathogen population after harvest was always significantly higher than those before planting in all rotation treatments.

Table 5. Comparison of population of *R. solanacearum* in the soil before planting and after harvest in each rotation treatment in season 3, Lembang-West Java, May 1998 – July 1998 (Values were analysed using data transformation of log *x*+1)

Observation	*R. solanacearum* population in the soil (x 10^7 cfu/ml) in					
	Pot-Tom-Pot	Pot-Mai-Pot	Pot-Cab-Pot	Pot-Bea-Pot	Pot-Car-Pot	Pot-Pot-Pot
Before planting	463 b	263 b	415 b	399 b	478 b	404 b
After harvest	1702 a	1393 a	1820 a	2151 a	1755 a	1311 a
Mean	1082	828	1117	1275	1116	858
Significance	**	**	*	**	**	*
CV (%)	1.65	1.85	2.61	1.99	1.70	2.51

Note: cfu = colony per unit; CV = Coefficient of Variation; * = significant at 5%; ** = significant at 1%

CONCLUSION

The research results until season 3 indicated that rotation with maize reduced the population of *R. solanacearum* in the soil. The result also suggests that rotation with maize, cabbage, beans and carrot are effective in reducing the bacterial wilt incidence in the subsequent potato crop. The basis for the reduction of the pathogen population in the soil in crop rotation experiments, e.g. antagonistic bacteria, needs further research.

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PENGARUH SUHU ZONA PERAKARAN TERHADAP PERTUMBUHAN DAN STATUS KLOROFIL TANAMAN SELADA SISTEM HIDROPONIK

EFFECT OF ROOT ZONE TEMPERATURE ON GROWTH AND CHLOROPHYLL CONTENT IN LETTUCE WITH HYDROPONIC SYSTEM

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ABSTRACT

Amount of oxygen able to be dissolved in nutrient solution decreases with increasing temperature. Insufficient oxygen reduces the permeability of roots to water and there will also be an accumulation of toxins. Both water and minerals cannot be absorbed in sufficient quantities to support plant growth. The objective of this experiment was to get optimum nutrient solution temperature for the best growth and chlorophyll content in lettuce. The setting at 15, 20 and 25 °C artificial temperatures in nutrient solution or rooting medium with NFT hydroponic system were conducted. The temperature levels and daily effective time as treatments were put in the factorial experiment design.

There are relationships between temperature and electrical conductivity and oxygen dissolves (predicted). Increasing in nutrient solution temperature caused increasing in electrical conductivity. In contrast, increasing in temperature was predicted decreasing in oxygen dissolve in medium or rooting zone. There is crossing point of two regression lines between 25 to 30 °C in temperature, where were found positions of electrical conductivity between 2.5 to 3.0 mS and oxygen dissolve between 7 to 8 mg.litre^{-1}. More dry matter and chlorophyll content of lettuce were found on about 25 °C of nutrient solution temperatur which was controlled at the day only.

***Key words**: lettuce, temperature, root zone.*

INTISARI

Peningkatan suhu dalam larutan nutrisi dapat menyebabkan oksigen terlarut di dalamnya berkurang. Kandungan oksigen yang tidak cukup mengakibatkan permeabilitas akar terhadap air menurun dan menimbulkan terjadinya penimbunan bahan beracun. Kondisi tersebut berakibat pada penyerapan air dan hara yang tidak cukup untuk mendukung pertumbuhan

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