Bangladesh J. Bot. **51**(4): 807-812, 2022 (December) DOI: https://doi.org/10.3329/bjb.v51i4.63500

CORRELATION ON POPULATION DYNAMICS AND DISEASE INCIDENCE OF BACTERIAL WILT INSTIGATING PATHOGEN (*RALSTONIA SOLANACEARUM*) UNDER DIFFERENT INTERCROPPING SYSTEM

R YONZONE*, S KHALKO[1], BR SHARMA[2], S HEMBRAM[1], M SONIYA DEVI[3] AND B DAS[4]

Department of Plant Pathology, College of Agriculture (Extended Campus), U.B.K.V, Majhian, West Bengal, India

Keyword: Bacterial wilt, Ginger, *Ralstonia solanacearum*, Intercropping

Abstract

Ginger (*Zingiber officinale* Rose) is one of the important spice crops grown organically in the hill zone of West Bengal. Among the various diseases that cause constrains to the organic ginger production *Ralstonia solanacearum* causes serious threats to the ginger growers. An experiment was conducted to study the influence of different intercropping patterns on yield, population dynamics, and disease incidence of *R. solanacearum*in ginger crop under organic management practice. Observation on population dynamics of *R. solanacearum* under different intercropping patterns revealed that the marigold when intercropped with ginger had a maximum influence on population build-up during 2019 and 2020. Also, it has the potentialities to reduce the population load thereby reducing the disease incidence and increasing the rhizome yield. Therefore, marigold can be incorporated as an intercrop in organic ginger cultivation for reducing the bacterial wilt disease.

Introduction

Ginger (*Zingiber officinale* Rose) is one of the important spice crops commonly grown in India. It is an important source of spices to every kitchen (Nigist and Asfaw 2003) and is used in both fresh and dry forms in food, medicinal purposes (Haniadka *et al.* 2013), beverage and confectionery industries (Mesomo *et al*. 2013). Ginger in hill zone of West Bengal are mostly cultivated organically by the farmers. Organic ginger production is constrained by various pathogens of soil, rhizome, and air-borne nature (Rajan *et al*. 2002). Among those bacterial wilt diseases caused by *Ralstonia solanacearum* possesses serious threats causing considerable economic loss to the growers (Joshi and Sharma1982, Sharma *et al.* 2010, Guji *et al.* 2019). The intensification of this disease on susceptible hosts is mostly in tropical, subtropical, and even in warm temperate zones (Kelman 1953, Smith 1920). The infection is manifested by the production of internal symptoms with vascular discoloration to external symptom Green wilt followed by yellowing of the leaves (Boucher *et al.* 2001) depending upon the environmental condition prevailing. Therefore, due to the wide distribution of these pathogens, management has always been very challenging.

Ginger is mainly grown as a mono-crop by farmers in hills, due to which many soil-borne pathogens (Liu *et al.* 2014) such as *R. solanacearum* causes heavy losses of the crop. Previous reports of prevention and/or control of soil borne pathogens through intercropping are popular among the farming communities worldwide (Ratnadass *et al*. 2012, Boudreau 2013). Therefore, to successfully prevent or manage this dynamic pathogen and to reduce losses, location-specific

*Author for correspondence: <rakesh_yonzone@yahoo.com>. [1]Department of Plant Pathology, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal, India. [2]Department of Plant Pathology, Regional Research Station (Hill Zone), UBKV, Kalimpong, West Bengal, India. [3]Department of Entomology, Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh, India. [4]Department of Genetics and Plant Breeding, College of Agriculture (Extended Campus), U.B.K.V, Majhian, West Bengal, India.

studies are very much necessary to formulate eco-friendly and sustainable management practices. In the present study, different crop which are commonly grown in the region *viz*., soyabean, cowpea, okra, marigold and maize were used as intercrop to check their effect on population dynamics and disease incidence of *R. solanacearum.*

Materials and Methods

The field experiment was conducted for two consecutive years from April to December (2019 and 2020) at the Farm, Regional Research Station (Hill Zone) of Uttar Banga Krishi Viswavidyalaya, West Bengal. The field preparation of the entire experimental plot was done by plowing with a desi indigenous plow and was leveled off manually. After final land preparation, FYM @ 20t/ha were thoroughly incorporated within the soil. The experiment was designed in Random Block Design (RBD) with six treatments viz., Ginger + Soyabean (T1), Ginger + Cow Pea (T2), Ginger + Okra (T3), Ginger + Marigold (T4), Ginger + Maize (T5) and Ginger Sole Crop (T6) and four replications with plot size measuring about 3 m× 1 m. The commonly grown ginger variety Gorubathaney was used and the experiment was completely planned with organic management practice following recommended measures and no chemical fertilizer was applied.

The quantitative assay of the bacterial population was done following the protocol described by Kelman (1954) in Triphenyl Tetrazolium Chloride (TTC) medium at 30±2ºC. Colonies formed were counted using a plate counter and multiplied by the appropriate dilution factor to determine the number of CFU/mL in the original sample.

The enumeration of the bacterial population of *R. solanacearum* was done before sowing, at active tillering, and after harvestof the ginger crop.

The disease incidence was scored after every fifteen days interval *viz*., 70, 85, 100, and 115 days after sowing (DAS) as per method described Tarafdar and Saha (2007).

To predict the disease development, multiple regression equations were computed by using SPSS var.16 software computer software. The value of Coefficient of determination (R^2) was calculated and significance was tested at 1% level of probability.

Result and Discussion

The data obtained on the population density of *R. solanacearum* as influenced by different intercropping pattern under organic management practices is presented in Table 1. The results of the analysis of variance showed that there was significant variation in population among all the treatments understudy. The mean initial population of bacterium ranged from 57.00 to 76.50 cfu x 10^4 and 48.00 to 68.75 cfu x 10^4 before sowing of the crop during 2019 and 2020 respectively. However, at the active tillering stage and after harvest of crop, maximum effect in population reduction among the treatments was recorded in T4 (37.25; 26.50 and 35.00; 27.00 cfu x 10^4) during both the year under study. Our finding is at par with the reports of Terblanche (2007), and Li *et al*. in (2020) where they reported similar antimicrobial properties of marigold.

The data presented in Table 2 clearly indicates the significant effect of different treatments on *R. solanacearum* disease incidence and rhizome yield of ginger during 2019 and 2020. After 115 DAS the pooled data shows the minimum disease incidence on T4 (37.05) as compared to T6 (78.44) which recorded maximum disease incidence. Also the maximum yield was recorded on T4 (2.64 tons/ha) as compared to T6 (1.20 t/ha) during both the year of study.

R. solanacearum is one of the important soil-borne pathogens **(**Li *et al*. 2020) causing devastating losses in many hosts (Denny 2006). The negative impact of mono-cropping on plant growth and increase in various soil-borne diseases has been reported by Hiddink *et al*. (2009) and

Zhang *et al*, 2013. The dynamic change in antagonistic microorganism microbial biomass, their activity, abundance, composition, and structure due to influenced by intercropping has also been reported by Zhang *et al*. (2018), Li *et al*. (2016a), Li and Wu (2018).

Table 1. Population of *R. solanacearum* as influenced by different intercropping at various crop growth stages in ginger field.

Treatments	2019 (CFU X10^4)			2020 (CFU X10^4)		
	Before sowing	Active tillering	After harvesting	Before sowing	Active tillering	After harvesting
T1	71.50	43.75	33.75	65.00	46.75	45.25
T2	57.00	61.25	45.75	55.25	59.00	51.00
T3	76.50	65.75	47.75	51.50	66.25	63.00
T4	60.75	37.25	26.50	48.00	35.00	27.00
T5	68.25	51.25	38.50	58.25	44.25	42.75
T6	64.75	87.75	73.50	68.75	84.00	78.25
C.D (5%)	N/A	17.05	12.35	N/A	12.06	16.39
SE(m) ±	4.24	5.61	4.06	5.38	3.97	5.39
SE(d)	6.00	7.93	5.74	7.60	5.61	7.62
C.V %	12.76	19.38	18.33	18.61	14.19	21.05

The correlation coefficient analysis of *R. solanacearum* population density (pooled data) under different growth stages resulted in a significant and positive response with disease incidence (Table 3). However, these were significant and negatively correlated with the rhizome yield of ginger. On the other hand, rhizome yield was found to be significantly and negatively correlated with the percentage of disease incidence This may be due to the maximum population density of *Ralstonia solanacearum* under different growth stages that causes higher *Ralstonia* infection of ginger field.

The multiple regression analysis between population dynamics and disease incidence has been presented in Table 4 The results clearly depict the population dynamics at before sowing, active tillering and after harvest of the crop have functional relationship existed between disease incidence and population dynamics at different growth stages with coefficient of determination of 0.906 and 0.965 respectively in 2019 and 2020. The coefficient of determination signifies fitness of regression equation and indicates proportion of variation in dependent variable Y (disease incidence) explained by independent variables X (population dynamics at different growth stages of crop) for a linear regression model.

The present research finding shows that the marigold has a significant effect in managing the *R. solanacearum* population reducing the disease incidence and increasing the yield. Li *et al*. (2020) in their finding suggest that the management of the soil-borne pathogen may be due to the diversity and richness of bacterial community that are mostly influence by the marigold intercropping system and can be an important biological indicator to differentiate tobacco mono-cropping system from tobacco- marigold intercropping system. They further reported the abundance of the bacterial genus, Lysobacter as a compared mono-cropping system. The antimicrobial effect of Lysobaceter in managing various soil-borne diseases such as phytophthora blight of pepper, sugar been, and damping-off of cucumber due to the secretion of various

Table 2. Wilt incidence of ginger owing to different intercropping practices at different intervals and rhizome yield.

Treatments	70 (DAS)			85 (DAS)			100 (DAS)			115 (DAS)			Yield (tons/ha)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T1	10.00 (3.27)	11.25 (3.44)	10.63 (18.71)	20.00 (4.57)	21.25 (4.64)	20.63 (26.82)	48.75 (7.01)	36.25 (6.06)	42.50 (40.59)	56.25 (7.48)	48.75 (7.02)	52.50 (46.49)	2.07	2.13	2.10
T2	20.00 (4.57)	17.50 (4.27)	18.75 (25.54)	33.75 (5.89)	27.50 (5.31)	30.63 (33.54)	50.00 (7.10)	41.25 (6.49)	45.63 (42.48)	73.75 (8.61)	60.00 (7.80)	66.88 (54.95)	1.56	1.45	1.51
T3	21.25 (4.70)	20.00 (4.57)	20.63 (26.94)	36.25 (6.07)	31.25 (5.68)	33.75 (35.48)	55.00 (7.48)	45.00 (6.77)	50.00 (45.00)	76.25 (8.76)	71.25 (8.49)	73.75 (59.26)	1.49	1.34	1.42
T4	6.25 (2.48)	2.68 (1.85)	4.46 (10.42)	17.86 (4.33)	10.71 (3.40)	14.29 (22.13)	26.79 (5.26)	21.43 (4.69)	24.11 (29.31)	45.54 (6.80)	28.57 (5.41)	37.05 (37.44)	2.58	2.70	2.64
T5	11.25 (3.44)	7.50 (2.88)	9.38 (17.56)	22.50 (4.84)	18.75 (4.42)	20.63 (26.96)	53.75 (7.35)	35.00 (5.99)	44.38 (41.75)	67.50 (8.25)	45.00 (6.78)	56.25 (48.62)	1.81	2.39	2.10
T6	13.75 (3.82)	11.25 (3.49)	12.50 (20.67)	28.75 (5.43)	26.25 (5.21)	27.50 (31.62)	51.25 (7.22)	50.63 (7.17)	50.94 (45.54)	80.63 (9.03)	76.25 (8.77)	78.44 (62.48)	1.15	1.22	1.20
C.D (5%)	1.10	0.68	6.52	1.08	1.37	3.91	0.04	0.87	5.56	0.84	0.78	7.44	0.22	0.22	0.16
SE(m) ±	0.36	0.222	2.14	0.36	0.45	1.29	0.01	0.29	1.86	0.28	0.26	2.45	0.07	0.07	0.05
SE(d)	0.51	0.31	3.03	0.50	0.64	1.82	0.01	0.40	2.63	0.39	0.36	3.46	0.10	0.10	0.08
C.V %	19.43	8.56	21.46	10.28	11.06	8.74	2.00	16.72	9.11	11.52	8.23	9.49	8.28	7.82	5.86

NB: *Figure in the parentheses are arc sine transformed values.

antibiotics have also been reported by Folman *et al*. (2003), Islam *et al*. (2005), Kobayashi and Yuen (2005). Similar reports have also been given by Kennedy and Smith (1995), Avidano *et al*. (2005), Zhou and Wu (2012).

Table 3. Estimation of correlation coefficient with population density of *Ralstonia solanacearum*, disease incidence and yield of ginger (Pooled)

	BS	AT	AH	PDI	YIELD
BS	1.00				
AT	0.419	1.00			
AH	0.516	0.993**	1.00		
PDI	0.457	0.941*	0.933*	1.00	
YIELD	-0.398	-0.944**	-0.930*	-0.991**	1.00

*=significant at 5% level and **= Correlation is significant at 1% level. BS=Before sowing, AT= Active Tillering, AH=After harvesting, PDI= Per cent disease incidence

Table 4. Multiple regression of population dynamic with the incidence of bacterial wilt.

Year	Model	R^2	Adjusted R^2	F Value	MSE
2019	**Y=**9.786+0.098(BS)+2.104(AT)-0.610(AH)	0.906**	0.764	6.397	42.120
2020	**Y=**25.617-0.428(BS)-.307(AT)+1.393(AH)	0.965**	0.913	18.385	27.613

**= Correlation is significant at 1% level.

In conclusion, the intercropping of ginger with marigold is effective in reducing the population of *R. solanacearum*, decreasing the disease incidence and increasing the rhizome yield and can be incorporated in ginger cultivation under organic management practice to reduce the losses caused by this pathogen.

Reference

Asfaw N and Abegaz B 2003. Chemical constituents of the essential oils of *Zingiber officinale* Roscoe cultivated in Ethiopia. SINET: Ethiop. J. Sci. **18**:133-135.

Avidano L, Gamalero E, Cossa GP and Carraro E 2005. Characterization of soil health in an Italian polluted site by using microorganisms as bioindicators. Appl Soil Ecol. **30**: 21-33.

Boucher C, Genin S and Arlat M 2001. Current concepts of pathogenicity in plant pathogenic bacteria.Comptes Rendus de l' Academie des Sciences Serie III: Sci. de la Vie Life Sci. **324**: 915-922.

Boudreau MA 2013. Diseases in intercropping systems. Annu Rev Phytopathol. 499-519.

Denny T 2006. Plant pathogenic *Ralstonia* species. In: Gnanamanickam SS (ed.) Plant-associated Bacteria. Springer Netherlands, Dordrecht. pp 573-644.

Folman LB, Postma J and van Veen JA 2003. Characterization of *Lysobacter*enzymogenes (Christensen and Cook. 1978) strain 3.1T8, a powerful antagonist of fungal disease of cucumber. Microbiol Res. **158**: 107-115.

Guji M, Yetayew H and Kidanu E 2019. Yield loss of ginger (*Zingiber officinale*) due to bacterial wilt (*Ralstonia solanacearum*) in different wilt management systems in Ethiopia. Agric. Food Secur. **8**:1-11.

Haniadka R, Saldanha E, Sunita V, Palatty PL, Fayad R, and Baliga M. S 2013. A review of the gastro protective effects of ginger (*Gingiber officinale* Roscoe). Food Funct. **4**: 845-855.

Hiddink GA, Termorshuizen AJ and van Bruggen AHC 2009. Mixed cropping and suppression of soilborne diseases. *In:* Lichtfouse E. (ed.). Genetic engineering, biofertilisation, soil quality and organic farming. Sus. Agril. Rev. 119-146.

Islam MT, Hashidoko Y, Deora A , Ito T and Tahara S 2005. Suppression of damping-off disease in host plants by the rhizoplane bacterium *Lysobacter* sp. strain sb-k88 is linked to plant colonization and antibiosis against soil borne Peronosporomycetes. Appl Environ Microbiol. **71**: 3786-3796.

Joshi LK and Sharma ND 1982. Diseases of ginger and turmeric. In: proceeding of the National Seminar on ginger and turmeric. (Nair MK, Prem TK, Ravindran PN and Sharma YR, Eds.) Calicut, Kasargod.258.

Kelman A 1953. The bacterial wilt caused by *Pseudomonas solanacearum*: A literature review and bibliography. North Carolina Agric. Exp. Station Tech. Bull. **99**: 194-196.

Kelman A 1954. The relationship of pathogenicity in *Pseudomonas solanacearum* to colony appearance on a tetrazolium medium. Phytopathol.**44**: 693-695.

Kennedy AC and Smith KL 1995. Soil microbial diversity and the sustainability of agriculture soils. Plant Soil. **170**: 75-86.

Kobayashi DY and Yuen GY 2005. The role of clp-regulated factors in antagonism against *Magnaporthe poae* and biological control of summer patch disease of Kentucky bluegrass by *Lysobacter* enzymogenes C3. Can. J. Microbiol. **51**: 719-723.

Li S and Wu F 2018. Diversity and co-occurrence patterns of soil bacterial and fungal communities in seven intercropping systems. Front Microbiol. **9**: 1521-1533.

Li X, Sun ML, Zhang HH, Xu N and Sun GY 2016a. Use of mulberry soybean intercropping in salt-alkali soil impacts the diversity of the soil bacterial community. Microb Biotechnol. **9**: 293-304.

Li Y, Feng J, Zhen L, Huang J, Yang Y and Li X 2020. Intercropping with marigold promotes soil health and microbial structure to assist in mitigating tobacco bacterial wilt. J. Plant Pathol. **102**: 731-742.

Liu X, Zhang J, Gu T, Zhang W, Shen Q and Yin SH 2014. Qiu microbial community diversities and taxa abundances in soils along a sevenyear gradient of potato monoculture using high throughput pyrosequencing approach. PLoS One, **9**: e86610.

Mesomo CM, Corazza LM, Ndiaye MP, Dalla Santa RO, Cardozo L and Paula Scheer AD 2013. Supercritical CO_2 extracts and essential oil of ginger (*Zingiber officinale* R.) Chemical composition and antibacterial activity. J. Super. Fluids. **80**: 44- 49.

Rajan PP, Gupta SR, Sharma YR and Jackson GVH 2002. Diseases of ginger and their control with *Trichoderma harzianum*. Indian Phytopath. **55**: 173-177.

Ratnadass A, Fernandes P, Avelino J, Habib R 2012. Plant species diversity for sustainable management of crop pests and diseases in agroecosystems: a review. Agron Sustain Dev. **32**: 273-303.

Sharma BR, Dutta S, Roy S, Debnath A and Roy MD 2010. The effect of soil physico chemical properties on rhizome rot and wilt disease complex incidence of ginger under hill agro climatic region of West Bengal. J. Plant Pathol. **26**: 198-202.

Smith EF 1920. An introduction to bacterial diseases of plants. WB Saunders. https://doi.org/10.5962/ bhl. title. 41862.

Tarafdar J, Saha N 2007. Correlation study on population dynamics of ginger soft rot inciting pathogens under different organic amendments, disease incidence and its survival in Darjeeling hill soils. Proc. of the 13th ISTRC Symposium. 165-169.

Terblanche J 2007. Biological control of bacterial wilt in tobacco caused by *Ralstonia solanacearum*, Master's thesis, University of the Free State, Bloemfontein, South Africa.

Zhang M, Wang N, Hu Y and Sun G 2018. Changes in soil physicochemical properties and soil bacterial community in mulberry (*Morus alba* L.)/*alfalfa* (*Medicago sativa* L.) intercropping system. Microbiolopen. **7**: e555.

Zhang W, Long X, Huo X, Chen Y and Lou K 2013. 16s rRNA-based PCR DGGE analysis of actinomycete communities in fields with continuous cotton cropping in Xinjiang, China. Microb Ecol. 66: 385-387.

Zhou X and Wu F 2012. Dynamics of the diversity of fungal and Fusarium communities during continuous cropping of cucumber in the greenhouse, FEMS, Microbiol Ecol. **80**: 469-478.

(Manuscript received on 15 August, 2022; revised on 26 November, 2022)