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Research Article

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Performance of Biopesticides in the Management of Black Rot (*Xanthomonas campestris* pv. *campestris*) for Sustainable Cabbage Production

Shivanand Sharanayya Hiremath and Praveen Yadhalli
ICAR-KLE Krishi Vigyan Kendra, Mattikopp, Bailhongal Taluk, Belagavi District 59114, Karnataka State, India
**Corresponding author e-mail:* klekvkpc@gmail.com
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ABSTRACT
On Farm Testing in cabbage at farmers' fields in the adopted village Kadoli and Honaga of Belagavi taluk for three years, using bio-pesticide i.e., *Pseudomonas fluorescens*@ 5 kg/ha, seed treatment 4 g/kg and seedling dip in *Pseudomonas fluorescens solution* technology recommended by TNAU, Coimbatore and Seed treatment with streptomycin sulphate@ 100ppm technology recommended by UAS, Dharwad. The field study revealed that soil application of Pseudomonas *fluorescens* @ 5kg/ha, followed by seed treatment and seedling dip @ @5g/l and foliar spray of Streptomycin @ 0.2g/l showed the lowest per cent disease index (9.61) and highest yield (4.5t/ha) when compared to the control (30.75t/ha)
Keywords: Black rot, Cabbage, Pseudomonas *fluorescens*, Seed treatment, On-Farm Testing

INTRODUCTION

Cabbage (*Brassica oleracea var. capitata* L.) is one of the most widely cultivated and popular vegetable crops in India, particularly during the cooler seasons. It is an important source of essential nutrients, including proteins, carbohydrates, minerals, ascorbic acid, and glycoalkaloids. Additionally, cabbage is rich in antioxidants. More recently, cabbage and other cruciferous vegetables (members of the Brassicaceae) have been recognised as important sources of chemoprotective phytochemicals in the diet. the production of cabbage in Karnataka was 221.27 thousand tonnes from 10.49 thousand ha area with the productivity of 21.09 mt (Anonymous 2016). In the Belagavi district, cabbage occupies an area of 1432.62 ha and produces 45210.05 mt. However, the average yield is too low in the district (31.56t/h). And that is due to the incidence of black rot disease, *Xanthomonas campestris*. Black rot caused by *Xanthomonas campestris pv campestris* is one of the causes that limit the commercial production. The bacteria can attack the crops at both the seedling and planting stages, and the infection results from infected seeds. The causal agent of black rot, *Xanthomonas campestris pv. campestris* is a rod-shaped, aerobic, gram-negative, non-spore-forming bacterium belonging to the Proteobacteria class. Seven races of *X. campestris pv. campestris* have been documented worldwide (Taylor et al., 2002). The disease is particularly aggressive in low-lying areas where plants remain wet for extended periods and during episodes of high temperature and high relative humidity. Under cool temperatures in late winter and early spring, the disease is less problematic; however, warm conditions can trigger severe outbreaks (Gupta,1991).

Black rot caused by the seed-borne bacterium Xcc is one of the most devastating diseases of brassicas (Vicente and Holub, 2013), responsible for severe economic losses worldwide (Rimmer et al., 2007). Xcc is mainly a seed-borne pathogen, but can alive in crop residues and cruciferous weeds and ornamentals (Roberts et al. 1999; Lema et al. 2011). The crop may be affected at any stage during the growth period, i.e., from the stage of young seedling till maturity. Initial symptoms include chlorotic lesions along leaf margins that progress towards the midrib, forming characteristic "V" shaped lesions (Gupta et al., 2013). The pathogen's infection may be followed by secondary infections from the soft rot bacterium *Erwinia carotovora* or the fungus *Sclerotinia sclerotiorum.* Advanced systemic infections can cause darkened leaf veins and stem vascular tissues, extensive leaf yellowing, wilting, and necrosis (Popovic et al., 2013). Infected seedlings become yellow, drop lower leaves, and may die. Leaves may be affected on only one side of a seedling. Contaminated seed may not develop symptoms for many weeks. The classic symptom of black rot is caused by a local infection that results when bacteria enter leaves through natural openings of leaf margins. The bacterial cells infect cabbage through hydathodes at the leaf margins. In cabbage, typical V-shaped chlorotic lesions or through stomata, causing round lesions. The bacterium can survive in the soil if infected plant residues are not decomposed, since temperature generally remains low during the vegetative growth stage of crucifer plants.

The infected tissue turns pale green-yellow and then turns brown and dies. Affected areas are usually wedge- or V-shaped. These areas enlarge as the disease progresses, and severely affected leaves may drop off. The veins in infected leaves, stems, and roots sometimes become black. The heads of the infected plants remain small, and their quality is reduced, making them unfit for marketing. The present study was undertaken to know the performance of biopesticide, and also evaluated the efficacy of different chemicals against the growth of *Xanthomonas campestris pv. Compestris* under in vivo conditions. Vegetable-based cropping systems are one of the predominant farming systems in the Belagavi district, on which the majority of farmers depend as their source of livelihood. Among the vegetables, Cole crops, i.e. cabbage, occupy an area of 1432.62 ha and produce 45210.05 MT However, the average yield is too low in the district (31.56t/h). And that is due to the incidence of black rot disease, *Xanthomonas campestris*. Black rot caused by *Xanthomonas campestris* pv campestris is one of the causes that limit the commercial production. The bacteria can attack the crops at both the seedling and planting stages, and the infection results from infected seeds. Due to the diseases, there is an extensive loss in the field and quality of curds and yield, as well as vigour of the seed crop (Kashyap and Dhiman, 2009). Under severe attack of this disease, a substantial reduction in the yield to 5 to 70% has been reported (Sharma and Ramchandra, 1991). Management of the disease is restricted to the use of resistant cultivars, hot water treatment of seeds followed by application of antibiotics or protectant fungicides (Hilderbrand, 1994), but the control has been only partial. Farmers often rely on chemical pesticides to combat the pest menace, but indiscriminate application of highly toxic chemical pesticides not only damages/threatens the sustainability of agro-ecosystems but also endangers human health due to residual toxic effects and increased resistance to chemicals in target pathogens and environmental pollution. Realising the gravity of this problem, Krishi Vigyan Kendra, Mattikopp, implemented On Farm Testing in cabbage at farmers' fields.

MATERIALS AND METHODS

On-farm testing was conducted to check the efficacy of biopesticide against the cabbage black rot pathogen *Xanthomonas campestris pv. campestris* under field conditions at Kadoli and Honaga of Belagavi taluk during *rabi* seasons for three years in the same field continuously with three treatments:

Technology Option 1: being farmers practices (chemical management with Spraying of COC/ Carbendazim/Mancozeb after incidence of disease), **Technology Option 2:** Seed treatment with streptomycin sulphate@ 100ppm Spray with streptomycin sulphate 0.5g + COC 3g/l immediately after incidence and 15 days after first spray recommended by UAS Dharwad

Technology Option 3: Soil application of *P. florescence* @ 5kg/ha, Seed treatment (4g/kg) and seedling dip in *Pseudomonas florescence* solution (50g/lit), Spray with streptomycin sulphate0.5g + COC 3g/l immediately after incidence and 15 days after first spray technology recommended by TNAU, Coimbatore.

The treatments were imposed before the transplanting of cabbage seedlings during June. *Pseudomonas fluorescens was* purchased from ICAR-KLE KVK Mattikopp, streptomycin sulphate and COC were purchased from KLE KVK Kisan Bajar Mattikopp, Karnataka. Soil application of *Pseudomonas florescence*(5kg/ha) was done before planting of cabbage seedlings, and Seed treatment (4g/kg) and seedling dip in *Pseudomonas florescence* solution (50g/lit) was carried and seedlings were planted with a spacing of 60 cm X 30 cm. The variety used was Saint. Three treatments comprising seed treatment with streptomycin sulphate and *Pseudomonas fluorescens*, combination of soil application, seed treatment and spraying with streptomycin sulphate, copper oxychloride, and combination of seed treatments, root dipping and foliar spray, were evaluated for disease. The treatments were imposed in the farmer's fields. The first spraying was done after the appearance of the disease symptoms in the field. The second and third spraying were done 15 and 20 days after spraying, and the observations were recorded after each spraying. The last observation was recorded 30 days after the first spraying. The disease intensity (PDI) was calculated as a percentage of infected leaves of cabbage. The per cent disease intensity (PDI) was computed as (Kashyap and Dhiman, 2009): PDI for severity For computing the PDI, 0-5 scale was used as follows: 0 = No disease 1 = Up to 20 per cent leaf area under symptoms,2 = between 21-40 per cent leaf area under symptoms, 3 = between 41-60 per cent leaf area under symptoms, 4 = between 61-80 per cent leaf area under symptoms, 5 = > 80 per cent leaf area under symptoms.

$$\text{Per cent Disease Index} = \frac{Sum\ of\ all\ disease\ rating}{Total\ number\ of\ leaves{:}\ Maximum\ rating\ value} x100$$

RESULTS AND DISCUSSION

The results of the field experiment revealed that the integration of soil application of *P. flourescence* @5kg/ha, seed treatment and seedling dip in *Pseudomonas fluorescence* solution (50g/l) followed by spray with Streptomycin sulphate (0.5g) + Copper oxychloride (3g/l) helped in reducing the disease incidence. The highest yield of cabbage was recorded in plots treated with *Pseudomonas* bio-agent (45.5 t/ha), followed by TO-1 (39.0 t/ha) and farmers' practice (30.75 t/ha). The lowest PDI was found in TO-3 (9.61), and the highest PDI was recorded in the farmer's practice. The yield increased in TO-3 was by 47.96 % over the farmer's practice. This is attributed to the efficient reduction in the PDI by the use of bio-agents. The mean per cent disease index (PDI) of three seasons as exhibited by the aforesaid treatment was 9.61 as compared to untreated control exhibiting a PDI of 25.87(Table-1) followed by seed treatment with streptomycin sulphate @ 100 ppm followed by one spraying with Streptomycin @ 100ppm + Copper oxychloride @ 0.3% manifesting a PDI of 16.56. Yield data also exhibited a similar trend where the aforementioned best treatment recorded 45.5% higher marketable yield of cabbage as compared to the untreated control (Table 1). The present investigation confirms the findings of (Jorgensen and Walter, 1995; Rimmer et. al., 2013) & Delahaut and Stevenson (2004). Streptomycin and copper-based compounds are generally recommended against black rot, and seed treatment was also reported to be equally effective against the disease. The results showed maximum plant growth and yield parameters like leaf area (0.72 cm2), root length (16.37 cm), head diameter (25.4cm) and head weight (1780 g) (Table 2).

Table 1. Comparative performance of bio pesticide in the management of black rot disease in cabbage

Parameter	Year	TO1	TO2	TO3
Yield (t/ha)	1st Year	30.00	38.00	45.00
	2nd Year	31.50	40.00	46.00
	3rd Year	30.74	39.00	45.65
	Pooled	30.75	39.00	45.50
% Increase in Yield	1st Year	-	26.66	50.00
	2nd Year	-	26.98	46.03
	3rd Year	-	26.90	48.50
	Pooled	-	26.82	47.96
Percent Disease Index (PDI)	1st Year	30.00	20.69	11.61
	2nd Year	21.75	12.44	7.32
	3rd Year	25.88	16.55	9.92
	Pooled	25.87	16.56	9.61
Cost of Cultivation (Rs./ha)	1st	69,580	66,750	62,857
	2nd	71,265	66,750	61,900
	3rd	70,716	68,540	64,273
	Average	70,520	67,346	63,010
Gross Income (Rs./ha)	1st Year	1,93,500	2,45,100	2,90,250
	2nd Year	1,73,250	2,20,000	2,53,000
	3rd Year	2,02,392	2,56,776	3,00,600
	Pooled	1,93,500	2,45,100	2,90,250
Net Income (Rs./ha)	1st Year	1,23,920	1,78,350	2,27,393
	2nd Year	1,01,985	1,53,250	1,91,100
	3rd Year	1,31,676	1,88,236	2,36,327
	Pooled	1,23,920	1,78,350	2,27,393
B:C Ratio	1st Year	2.78	3.67	4.61
	2nd Year	2.43	3.29	4.08
	3rd Year	2.86	3.74	4.67
	Pooled	2.69	3.56	4.45

TO1- Technology Option 1, TO2-Technology Option 2, TO3-Technology Option 3

Table 2. Effect of *Pseudomonas florescence* solution on growth and yield parameters of cabbage

Treatment details	Growth parameter		Yield parameter	
	Leaf area index (cm^2)	Root length (cm)	Head diameter (cm)	Head weight (Kg)
Technology Option 1	0.38	12.62	21.54	0.95
Technology Option 2	0.69	14.93	23.68	1.59
Technology Option 3	0.72	16.37	25.40	1.78

This might be due to the presence of secondary metabolites (Deepa and Kanika, 2014). Application of bio-control agents like *P. fluorescens and B. subtilis* initiates number of biochemical changes, which triggers plant defines responses (Verma and Saharan 1994)[17]Cost of cultivation of cabbage was more in the farmers practice(Rs.69580),may be because of high cost of chemicals used to apply for the management of black rot disease in cabbagefollowed by treatment with soil application of *P.flourescens*(Rs.62,857) and treatment applied with Seed treatment with streptomycin sulphate@ 100 ppm Spray with streptomycin sulphate 0.5g + COC 3g/l (Rs. 66,750). Application of *Pseudomonas fluorescens* to soil and seeds was found to be profitable when compared to application of chemicals, maybe because application of *Pseudomonas fluorescens* suppresses the bacteria drastically & its efficacy would be for a longer period, and multiplication would happen in the soil for a year, hence not need to be applied frequently. While the chemical method for controlling the black rot has efficacy for a shorter time and it suppresses the bacteria immediately, it needs to be used frequently. The present investigation suggests that the application of *Pseudomonas fluorescens* involving various methods of application (soil and seed) significantly reduced the disease incidence under field conditions. In addition, it helped to increase the cabbage yield significantly compared to untreated fields. Hence, it is concluded that *Pseudomonas fluorescens* could be a potential biological control for the sustainable management of black rot disease of cabbage

CNCLUSION

Biopesticides are safe, eco-friendly and cost-effective means of managing crop diseases effectively. *Pseudomonas fluorescens* was found to be the best treatment to reduce cabbage black rot disease incidence, thereby enhancing the plant growth and yield, which is mainly due to the presence of secondary metabolites. Therefore, certainly biopesticides represent a potentially valuable and eco-friendly crop protection tool for sustainable cabbage production. The analysis of gaps: total yield gap, technological gap, extension gaps and extent of adoption after On Farm Testing revealed that there is a need to bridge the gaps through proper training, method demonstration, dissemination of technological interventions, instilling coordination and removal of circumstantial differences between the farmers, researchers, and scientists, and convincing the farmers to adopt improved practices for management of black rot disease in cabbage.

CONFLICT OF INTEREST

The author here declares that there is no conflict of interest in the publication of this article.

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