Ann. Agric. Res. New Series Vol. 42 (4) : 439-444 (2021)

Metalaxyl and Mancozeb— An efficient combination to control soft rot in ginger

Amit Trivedi[1], R. K. Fagodiya[2*], B. L. Fagodia[3] and Suresh Kumar[4]

Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan-313 001, India

e-mail: fagodiyarajkumar@gmail.com

Received: July 2021 ; Revised Accepted: December 2021

ABSTRACT

Soft rot is also referred to as Pythium rot or rhizome rot in scientific literature incited by *Pythium aphanidermatum*. The disease is more destructive in all the ginger growing countries across the world as well as India. In present context, the performance of fungicide, Metalaxyl and Mancozeb was evaluated alone and as combined product at different concentration for the control of soft rot ginger. Two experiments were realized in the growing season 2019 and 2020 after disease severity was evaluated for the soft rot disease. The experimental design was a randomized block with three replications. The combined formulation of Metalaxyl and Mancozeb (8% + 64% WP) was evaluated at three doses viz., 2, 3 and 4 ml/lit. All the three concentrations reduced the disease severity and provided an increase productivity as compared with treatment without fungicide. Sole application of Metalaxyl 35% WS and Mancozeb 75% WP was found less effective as compared to combined formulation. The addition of protective fungicides contributed to less disease severity and increased productivity. Under the above circumstances an attempt was made to identify a suitable fungicide for control the soft rot of ginger in present scenario.

Key words: Disease severity, Ginger, Fungicide, *Pythium aphanidermatum,* Soft rot

India is also known as a *'magical land of spices'* with diverse variety of spices. Ginger (*Zingiber officinale* Rosc.) belonging to family Zingiberaceae with 47 genera and 1,400 species and occupies a valuable position among the cultivated widely both as a fresh vegetable and dried spices across the world (Guji *et al.*, 2019). It is closely related to two other spices, turmeric and cardamom. India is the leading producer and exporter of ginger in the world. Ginger is one of the important cash crops for small farmers and used to folk medicine and spices (Sharma *et al.*, 2010; Momina *et al.*, 2011). The crop has been introduced to Ethiopia as in the thirteenth century (Guji *et al.*, 2019). China and India are leading producer and exporter of ginger and today it is cultivated widely throughout tropical and subtropical regions (Kavitha and Thomas, 2008). Fresh ginger rhizome contains 80.9% moisture, 0.9% fat, 2.3% protein, 2.4% fiber, 1.2% minerals and 12.3% carbo-hydrates. Some minerals are present in ginger like iron, calcium, phosphorous and vitamins contains as thiamine, riboflavin, niacin and vitamin C. The composition differs with the type, variety, agronomic conditions, curing methods, drying and storage conditions. In the fresh ginger rhizome, the

**Correspondence address : fagodiyarajkumar@gmail.com*

[1] *Professor & Head, Department of Plant Pathology, MPUAT, Udaipur; amit2_trivedi@yahoo.co.in*

[2*] *Senior Research Fellow, Directorate of Research, MPUAT, Udaipur; fagodiyarajkumar@gmail.com*

[3] *Technical Officer (PP), Central IPM Centre, Jaipur, Rajasthan (India); blfagodia25@gmail.com*

[4] *Research Scholar, Department of Plant Pathology, MPUAT, Udaipur; drskg8888@gmail.com*

gingerols (5-hydroxy1-(4-hydroxy-3-methoxy-phenyl) was observed as the major active components and the powdered rhizome contains 3-6% fatty oil, 9% protein, 60-70% carbohydrates, 3-8% crude fiber, about 8% ash, 9-12% water and 2-3% volatile oil (Zadeh and Kor, 2014).

Despite the production of ginger is mainly affected by several diseases incited by fungi, bacteria, viruses, nematodes and mycoplasma which cause severe economic losses. (Sharma *et al.*, 2010; Paret *et al.*, 2010. In present scenario the farmer are facing heavy crop losses due to this disease as it is a seed and soil borne disease and difficult to manage. Among the diseases that affect ginger crop in the world, soft rot is the more destructive in all stages of its growth. The disease generally often causes losses of more than 50% in seed crops. In Australia, the disease was observed for the first time during the wet summer of 2007-08, almost totally destroying the immature ginger crop in one field and causing 8-30% losses in other fields (Stirling *et al.*, 2009).

The impact of *Pythium* spp. can also be high in storage; losses ranging from 24-50% have been reported with rates occasionally exceeding 90% in India. The disease occurs during the months of July and September in India, the time coinciding with the onset of the southwest monsoon in India. High soil moisture and low optimum temperature (25-28°C) in this period are highly susceptible for the spread of the disease. Pythium is a large genus of the class Oomycetes, including more than 120 described species (Dick, 1990). *Pythium* species often infect immature and undifferentiated parts of the plant. Roots, rhizomes, emerging sprouts, and the pseudo stem of ginger are all prone to infection, depending on the stage of their maturity.

About six *Pythium* species, namely, *P. aphanidermatum, P. butleri, P. deliense, P. myriotylum, P. pleroticum, P. ultimum,* and *P. vexans* have been reported to cause soft rot ginger in different regions of India (Behera *et al.*, 2020). The most commonly incited the disease are *P. aphanidermatum* and *P. myriotylum* (Goswami and Syiem, 2021). As the pathogen perpetuates in soil, so it is very difficult to control. Thus, the present study was undertaken to find out the combination of novel fungicides to control rhizome rot ginger under field conditions.

Materials and Methods

Experimental design: The field experiments were carried out in an Horticulture Farm, Rajasthan College of Agriculture, Udaipur, Rajasthan, India (longitude- 73º42'54.96" E and latitude- 24º33'24.58" N) in sandy, clay loam soil in texture (sand 39.49, silt 26.94 and clay 33.57%) low in available nitrogen (301 kg/ha), medium in phosphorus (18.5 kg/ha) and potassium (580 kg/ha) with pH 7.5. Electrical conductivity of soil was 0.98 dSm^{-1} having 0.58% soil organic carbon with irrigated condition. Ginger planting of the first and second experiment was carried out on May 5^{th}, 2019 and May 8^{th}, 2020, respectively, both with the local cultivar.

For all experiments fertilizers and rhizome treatments were performed as recommended for ginger crop. Weed and pest control that eventually appeared during the experiment was also carried out. For fungicide applications, soil drench methods involve placing chemicals in liquid form near the roots in the soil for root uptake. Fungicides should be applied to moist (but not saturated) soil. The experimental design was a randomized block design with three replications. The experimental plots consisted of 9 rows with a spacing of 50 cm between rows and 15 cm between plants, for a total of 27 m^2 for each plot.

Field experiments: The experiment consisted of eight fungicides treatments and no application of fungicide as a control. The Metalaxyl and Mancozeb (8% + 64% WP) were applied three doses, 2.0 g a.i. L^{-1}, 3.0 g a.i. L^{-1} and 4.0 g a.i. L^{-1} at different time of applications. These treatments were compared with sole application of fungicide formulations, Metalaxyl 35%WS were applied two doses, 0.7 g a.i. L^{-1}, 0.91 g a.i. L^{-1}, Mancozeb 75% WP 2.56 g a.i. L^{-1}, 3.41 g a.i. L^{-1} and Metalaxyl-M 4%+ Mancozeb 64% WP applied one dose 2.5 g a.i. L^{-1} at different time of applications. In field experiment 2019, the first drenching of the fungicides was done soon after appearance of disease on 05 August 2019, second on 25 August, 2019 and third on 14 September, 2019. In field experiment 2020, the first drenching of the fungicides was done soon after appearance of disease on 08 August 2020, second on 28 August 2020 and third on 17 September 2020 in evening hours at 6.00 PM. Fungicide drenching was given at the interval of 20 days after first drenching. There were three drenching done after sowing.

Evaluation: To evaluate the severity, within the useful area of each plot, five plants chosen at random were evaluated. The extent of the disease severity was recorded at before drenching, 10 and 20 days after first, second and third drenching during both years based on the following disease scoring scale.

Standard disease scoring scale for soft rot of ginger.

Score	Description/Symptoms
0	100% Shoots green and Healthy
1	1-24% Shoots yellow or dead
2	25-49% Shoots yellow or dead
3	50-74% Shoots yellow or dead
4	75-99% Shoots yellow or dead
5	100% Shoots yellow or dead

The per cent disease intensity (PDI) was calculated by using following formula given by Chester, 1959 and Wheeler, 1969:

$$\text{PDI} = \frac{n\times1 + n\times2 + n\times3 + n\times4 + n\times5}{N} \times \frac{100}{\text{Maximum disease score (5)}}$$

Where,

n = Number of plants in each score, 1-5 = disease score

N = Total number of plant under observation

The yield of ginger rhizome was recorded at the time of harvest for each treatment separately and yield per hectare was calculated.

Results and Discussion

The effects of different concentration of combined and sole application of fungicides on disease incidence of soft rot of ginger had significant reduction of the disease severity as compared to control. The disease severity of soft rot was recorded at before drenching, 10 and 20 days after first, second and third drenching during both the years.

May 2019 planted experiment: Differences were observed between treatments in

Table 1: Efficacy of fungicides on severity of soft rot in ginger during *Kharif* 2019.

S. No.	Treatments	Dosage (ml/lit)	Per cent Disease Index* (PDI)							PEDC** @ 20 DATD
			Before Drenching	10 DAFD	20 DAFD	10 DASD	20 DASD	10 DATD	20 DATD	
1.	Metalaxyl 8% + Mancozeb 64% WP	2.00	2.50 (9.10)	5.40 (13.44)	6.30 (14.54)	9.90 (18.34)	12.34 (20.56)	14.33 (22.24)	18.5 (25.47)	43.68
2.	Metalaxyl 8% + Mancozeb 64% WP	3.00	2.80 (9.63)	3.80 (11.24)	5.00 (12.92)	6.90 (15.23)	7.67 (16.08)	9.12 (17.58)	12.5 (20.70)	61.95
3.	Metalaxyl 8% + Mancozeb 64% WP	4.00	3.00 (9.98)	3.33 (10.52)	4.75 (12.59)	6.50 (14.77)	6.75 (15.06)	8.80 (17.26)	11.50 (19.82)	64.99
4.	Metalaxyl 35% WS	0.70	2.50 (9.10)	6.20 (14.42)	8.90 (17.36)	13.20 (21.30)	17.49 (24.72)	18.55 (25.51)	23.10 (28.73)	29.65
5.	Metalaxyl 35% WS	0.90	2.00 (8.13)	5.58 (13.66)	7.80 (16.22)	11.40 (19.73)	16.79 (24.19)	17.5 (24.73)	19.50 (26.20)	40.64
6.	Mancozeb 75% WP	2.50	1.80 (7.71)	6.40 (14.65)	8.94 (17.40)	12.50 (20.70)	16.59 (24.03)	21.49 (27.62)	24.54 (29.70)	25.26
7.	Mancozeb 75% WP	3.40	1.75 (7.60)	5.95 (14.12)	7.30 (15.67)	11.40 (19.73)	15.90 (23.50)	19.01 (25.80)	20.44 (26.87)	37.78
8.	Metalaxyl 4% + Mancozeb 64% WP	2.50	2.00 (8.13)	4.80 (12.66)	5.80 (13.94)	7.12 (15.48)	8.75 (17.21)	10.23 (18.65)	14.00 (21.93)	57.36
9.	Untreated control	-	2.50 (9.10)	8.49 (16.84)	14.46 (22.32)	19.05 (25.82)	24.67 (29.75)	28.94 (32.47)	32.84 (34.95)	0.00
	CD at 5%	NS	1.2	0.73	1.43	1.55	2.28	1.28	-	
	SEm±	NS	0.46	0.23	0.47	0.55	0.76	0.42	-	

DAFD: Days after first drenching, DASD: Days after second drenching, DATD, Days after third drenching
Figures in parenthesis are √arcsine percent angular transformed values
*Mean of three replications, **Per cent efficacy of disease control

Table 2: Efficacy of fungicides on severity of soft rot in ginger during *Kharif* 2020.

S. No.	Treatments	Dosage (ml/lit)	Per cent Disease Index* (PDI)							PEDC** @ 20 DATD
			Before Drenching	10 DAFD	20 DAFD	10 DASD	20 DASD	10 DATD	20 DATD	
1.	Metalaxyl 8% + Mancozeb 64% WP	2.00	1.80 (7.71)	4.83 (12.61)	5.80 (13.94)	8.66 (17.10)	10.69 (19.08)	13.49 (21.55)	14.47 (22.36)	49.43
2.	Metalaxyl 8% + Mancozeb 64% WP	3.00	1.50 (7.04)	3.99 (11.51)	4.63 (12.40)	5.92 (14.06)	7.75 (16.13)	8.80 (17.25)	9.97 (18.36)	65.16
3.	Metalaxyl 8% + Mancozeb 64% WP	4.00	1.55 (7.15)	3.07 (10.06)	3.88 (11.36)	5.61 (13.68)	7.27 (15.63)	8.13 (16.56)	9.26 (17.7)	67.64
4.	Metalaxyl 35% WS	0.70	1.20 (6.29)	6.00 (14.18)	7.40 (15.78)	11.45 (19.78)	14.46 (22.35)	16.14 (23.67)	19.5 (26.18)	31.83
5.	Metalaxyl 35% WS	0.90	1.60 (7.27)	4.80 (12.66)	6.20 (14.42)	10.88 (19.26)	12.38 (20.60)	13.69 (21.72)	17.64 (24.83)	38.35
6.	Mancozeb 75 % WP	2.50	1.00 (5.74)	6.60 (14.89)	7.80 (16.22)	12.44 (20.65)	13.80 (21.78)	15.22 (22.96)	21.23 (27.44)	25.78
7.	Mancozeb 75 % WP	3.40	1.22 (6.34)	5.83 (13.97)	6.50 (14.77)	10.89 (19.27)	15.00 (22.78)	14.99 (22.78)	19.34 (26.06)	32.40
8.	Metalaxyl -4 % + Mancozeb 64% WP	2.50	1.65 (7.38)	3.56 (10.87)	4.50 (12.25)	6.23 (14.44)	7.56 (15.95)	9.12 (17.56)	11.78 (20.03)	58.84
9.	Untreated control	-	1.47 (6.97)	9.87 (18.28)	12.94 (21.76)	17.34 (24.56)	21.00 (27.23)	25.17 (30.08)	28.6 (32.24)	0.00
	CD at 5 %	NS	1.51	0.87	1.82	1.99	1.17	1.32	-	
	SEm±	NS	0.5	0.29	0.6	0.66	0.37	0.45	-	

DAFD: Days after first drenching, DASD: Days after second drenching, DATD, Days after third drenching
Figures in parenthesis are √arcsine percent angular transformed values
*Mean of three replications, **Per cent efficacy of disease control

productivity and disease severity of soft rot of ginger in the May 2019 planted experiment (Table 1). First drenching was done at first appearance of disease, second and third drenching at 20 days after first drenching. In the control treatments, the maximum disease severity was noted for evaluated disease, since fungicide treatments significantly reduced the severity of disease with increase productivity. The combined treatments with Metalaxyl 8% + Mancozeb 64% WP with 4.0 ml a.i. L^{-1} recorded lowest per cent disease index (11.50%), higher percent efficacy of disease control (64.99%) and maximum yield with (22.20 t ha^{-1}) followed by Metalaxyl 8% + Mancozeb 64% WP with 3.0 ml a.i. L^{-1} resulted in the lowest PDI (12.52%), PEDC (61.95%) and yield (21.81 t ha^{-1}) during 20 days after third drenching compared to control and provided greater yield and better economic return, which differed significantly from the other individual applications. However, individual application of Metalaxyl 35% WS with 0.91 ml a.i. L^{-1} with PDI (19.50%), PEDC (40.64%) and yield (19.46 t ha^{-1}) followed by Mancozeb 75% WP at 3.4 ml/liter with PDI (20.44%), PEDC (37.78%) and yield (19.13 t ha^{-1}) (Fig. 1) found less effective as compared to combined applications of fungicides as well as control. The present findings do agree with Avinash *et. al.*, (2018) reported the rhizomes were treated with fungicidal combinations were proved best compared to single fungicide except carbendazim + copper oxychloride, metalaxyl-M 4% + mancozeb 68%, metalaxyl 8% + mancozeb 64% and carbendazim + tebuconazole at 0.2% were found best and equally effective for control of soft rot of ginger. Furthermore, the similar results also obtained by Hosain *et al.*, 2018. Chowdhury *et al.*, 2009 recorded that combined dose of Darsbun and Ridomil gave the highest yield followed by single treatment of Ridomil and Mataril.

Fig. 1. Symptoms of soft rot disease in gingr

May 2020 planted experiment: In the May 2020 planted experiment, soft rot disease severity was significantly reduced for application of fungicide treatments as compared to control (Table 2). First drenching was done at first appearance of disease, second and third drenching at 20 days after first drenching. In the control treatments, the maximum disease severity were noted for evaluated disease, since fungicide treatments significantly reduced the severity of disease with increase productivity. The combined treatments with Metalaxyl 8% + Mancozeb 64% WP with 4.0 ml a.i. L^{-1} recorded lowest PDI (9.26%), higher PEDC (67.64%) and maximum yield with (23.82 t ha^{-1}) followed by Metalaxyl 8% + Mancozeb 64% WP with 3.0 ml a.i. L^{-1} resulted in the PDI (9.97%), PEDC (65.16%) and yield (23.54 t ha^{-1}) during 20 days after third drenching compared to control and provided greater yield and better economic return, which differed significantly from the other individual applications. However, individual application of Metalaxyl 35% WS with 0.91 ml a.i. L^{-1} with PDI (17.64%), PEDC (38.35%) and yield (20.53 t ha^{-1}) followed by Mancozeb 75% WP at 3.4 ml/ liter with PDI (19.34%), PEDC (32.40%) and yield (20.10 t ha^{-1}) (Fig. 1) found less effective as compared to combined applications of fungicides as well as control. Sharma *et al.,* (2017) the minimum incidence of soft rot was recorded in combination of Carbendazim + HWT (Hot water treatment) + *Trichoderma harzianum* (7.20%) and HWT + Mancozeb + *T. harzianum* (12.23%) after 30 days of storage as compared to control (39.30%). The similar results also obtained by Rai *et al.,* 2018.

Conclusion

From the above results, it may be mentioned that the combined use of Metalaxyl + Mancozeb at 4 ml a.i. L^{-1} as soil drenching treatments respectively was highly effective in controlling the disease as well as in increasing the rhizome yield followed by sole application of Metalaxyl and Mancozeb. The combined use of Metalaxyl + Mancozebat 4 ml a.i. L^{-1} may also be prescribed to the farmers for effective controlling rhizome rot of ginger. The findings of the study will be an encouraging one in the ginger production in our country. However, further studies are necessary for more confirmation of the above findings in different locations of India.

Acknowledgements

Authors are thankful to Directorate of Research under the Maharana Pratap University of Agriculture & Technology, Udaipur, Rajasthan (India) for providing opportunity and financial assistance during my research work.

References

Avinash, K. and Bijendra, Shivani. 2018. *In vitro* and glass house evaluation of fungicides against the pathogens associated with rhizome rot complex of ginger in Kumaon region of Uttarakhand. *Int. J. Chem. Stud.* **6**(5): 1364-1372.

Behera, S., Sial, P., Das, H. and Pradhan, K. 2020. *Pythium* soft rot management in Ginger (*Zingiber officinale* Roscoe) - A Review. *Curr. Appl. Sci. Technol.* **39**(35): 106-115.

Chester, K.S. 1959. How sick is the plant? In J.G. Horsfall and A.E. Diamond Eds., *Plant Pathology*. The Diseased Plant. Academic Press, New York, 1: 199-242.

Chowdhury, E.K., Hasan, M.M., Mustarin, K., Hasan, M.S. and Fancy, R. 2009. Efficacy of different fungicides in controlling rhizome rot of ginger. *J. Agrofor. Environ.* **3**(1): 179-181.

Dick, M.W., 1990. Phylum Oomycota. In: Margulis, L., Corliss, J.O., Melkonian, M., Chapman, D. (Eds.), Handbook of Protoctista. Jones & Bartlett, Boston, pp. 661.

Guji, M.J., Yetayew, H.T. and Kidanu, H.T. 2019. Yield loss of ginger *(Zingiber officinale)* due to bacterial wilt *(Ralstonia solanacearum)* in different wilt management systems in Ethiopia. Agric. & Food Secur. 8:5. https://doi.org/10.1186/s40066-018-0245-6

Goswami, D. and Syiem, M.B. 2021.Biocontrol of *Pythium aphanidermatum* causing soft rot in ginger with bio surfactant produced by a rhizospheric Bacillus species, *JOSAC*, **30**(1): 69-80. https://doi.org/10.25081/josac.2021.v30.i1.6586

Hosain, M.K., Hossain, S.M., Abedin, Z., Islam, M.M., Rahman, M.A., Rahman, M.S. and Zafor, M.A. 2018. Control of rhizome rot disease of ginger through application of fungicides. *Asian J. Agric. Res.* **5**: 1-9. DOI: 10.9734/ARJA/2018/40356

Kavitha, P.G. and Thomas, G., 2008. Population genetic structure of the clonal plant *Zingiber zerumbet* (L.) Smith (Zingiberaceae), a wild relative of cultivated ginger, and its response to *Pythium aphanidermatum*. Euphytica, **160**: 89-100.

Momina, A., Sentayehu, A., Girma, H.M. and Abush, T. 2011. Variability of ginger (*Zingiber officinale* Rosc) accessions for morphological and some quality traits in Ethiopia. *Int. J. Agr. Res.* **6**: 444-57.

Paret, M.L., Cabos, R., Kratky, B.A. and Alvarez, A.M. 2010. Effect of Plant Essential Oils on *Ralstonia solanacearum* Race 4 and Bacterial Wilt of Edible Ginger. *Plant Dis.* **94**: 521-527.

Rai, M., Ingle, A.P., Paralikar, P., Anasane, N., Gade, R. and Ingle, P. 2018 Effective management of soft rot of ginger caused by *Pythium* spp. and *Fusarium* spp.: emerging role of nanotechnology. *Appl Microbiol Biotechnol.* **102**(16): 6827-6839.

Sharma, B.R., Dutta, S., Roy, S., Debnath, A. and Roy, M.D. 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. *Plant Pathol. J.*, **26**: 198-202.

Sharma,S., Dohroo, N.P., Veerubommu, S., Phurailatpam, S., Thakur, N. and Yadav, A.N. 2017. Integrated Disease Management of Storage Rot of Ginger *(Zingiber officinale)* caused by *Fusarium* sp. in Himachal Pradesh, India. *Int. J. Curr. Microbiol. App. Sci.*, **6**(12): 3580-3592.

Stirling, G.R., Turaganivalu, U., Stirling, A.M., Lomavatu, M.F. and Smith, M.K. 2009. Rhizome rot of ginger *(Zingiber officinale)* caused by*Pythium myriotylumin* Fiji and Australia. *Australasian Plant Pathology*, **38**(5): 453-460.

Wheeler, B.E.J. 1969. An Introduction of Plant Disease. John Willey & Sons. Ltd., London, pp. 301.

Zadeh, J.B. and Kor, N.M. 2014. Physiological and pharmaceutical effects of Ginger (*Zingiber officinale* Roscoe) as a valuable medicinal plant. *Eur. J. Exp. Biol.*, **4**(1): 87-90.