The Synergistic Effect of Benalaxyl 8% and Mancozeb 65% Wp in Combating Downy Mildew of Cucumber

SUJOY SAHA, N. D. ASHTEKAR, A.B. RAI, B. K. SHARMA AND ANANDA KRISHNAN BALARAMAN

J. Mycopathol, Res, 55(3) : 227-230, 2017;
ISSN 0971-3719
© Indian Mycological Society,
Department of Botany,
University of Calcutta,
Kolkata 700 019, India

This article is protected by copyright and all other rights under the jurisdiction of the Indian Mycological Society. The copy is provided to the author(s) for internal non-commercial research and educational purposes.

J. Mycopathol. Res. ***55(3)*** *: 227-230, 2017;* (ISSN 0971-3719)
© Indian Mycological Society, Department of Botany,
University of Calcutta, Kolkata 700 019, India

Synergistic effect of Benalaxyl 8% and Mancozeb 65% WP in combating Downy mildew of Cucumber

SUJOY SAHA*[1], N. D. ASHTEKAR[2], A.B. RAI[1], B. K. SHARMA[1] AND ANANDA KRISHNAN BALARAMAN[3]
[1]Division of Plant Pathology, ICAR- Indian Institute of Vegetable Research, Varanasi 221305, Uttar Pradesh
[2]Division of Plant Pathology, ICAR- National Research Centre for Grapes, Pune 412307, Maharashtra
[3]FMC India Private Limited, Bangaluru 560052, Karnataka

Received : 08.05.2017 Accepted : 07.06.2017 Published : 30.10.2017

The widely distributed and devastating oomycete, *Pseudoperonospora cubensis* (Berkeley & Curtis) Rostovtsev is the causal agent of cucurbit downy mildew, infecting over 40 host species. The present study was undertaken to evaluate the synergism of Benalaxyl and Mancozeb against downy mildew of cucumber. Five different treatments comprising of solo and combination doses of these fungicides were evaluated for the control of this disease in two consecutive seasons. The pooled data indicates that combination dose of Benalaxyl 8% +Mancozeb 65% WP @ 3000 g/ha provided the best disease control (84.6% and 86.3%) amongst all the treatments along with increasing the yield by 30.5% and 29.6% for two seasons respectively. The combination was not phytotoxic on cucumber upto the dose of 5000 g/ha.

Key words: Benalaxyl, cucumber, downy mildew, mancozeb, synergism

INTRODUCTION

Cucumber (*Cucumis sativus*) is the fourth most widely cultivated vegetable crop in the world and is known for its several uses. Besides being an excellent source of vitamin K and Molybdenum, cucumbers are rich in pantothenic acid, minerals and vitamin C. It helps to fight inflammation, stress and obesity as well as supports digestive and heart health (Kumar *et al.* 2010). In India cucumber has a production of 16 X 10^3 tons with an acreage of 25 X 10^3 Ha (Vanita *et al.* 2013). The most widespread and serious pathogen hampering the yield of cucumber is *Pseudoperonospora cubensis* (Berkeley & Curtis) Rostovtsev. (Palti, 1974), first described by Berkeley in 1868 from Cuba.

The exceptional ability of the spores of *P. cubensis* to survive uncongenial conditions coupled with the difficulty of covering the underside of the foliage near the ground with fungicides restricted the efficacy of fungicidal control of downy mildew in the 1970's. This brought to the fore the need towards breeding for resistance as a potential alternative. Cucumber yield losses from downy mildew remained minimal compared to other diseases till 2004, when a more virulent race of *P. cubensis* caused more than 40% loss for cucumber growers (Colucci *et al.* 2006).The host resistance was thus no longer effective due to which the control of downy mildew demanded an intensive fungicide program as the first line of defense (Savory *et al.* 2011).

The chemical control of downy mildews, including that of the cucurbits, got a major break-through with the discovery of the systemic action of the acylalanine group on these diseases (Palti and Cohen, 1980). In the recent past, new fungicides, mostly systemic, have been developed against the disease *viz*. dimethomorph, cyazofamid, zoxamide, mandipropamid and fluopicolide. However, most systemic fungicides have a specific, single-site mode of action, (Gisi, 2008; Urban and Lebeda, 2006), thereby, raising the risk of resistance development in the pathogen against such

*Corresponding author : sujoyta@gmail.com

fungicides. *P. cubensis* is considered by FRAC as one of the ten plant pathogens accepted as showing a high risk of resistance development to fungicides (Pathogen risk list 2005, http://FRAC.info) with a high evolutionary potential (Lebeda and Urban, 2004). To overcome this issue, the usage of fungicides exhibiting a good synergistic combination of fungicides is an effective strategy for the management of downy mildew pathogens. Thus, it is best to use preventative multisite inhibitors, mixed with systemic fungicides to reduce the risk of resistance (Skylakakis, 1981). Considering this, a field trial was envisaged to evaluate the efficacy of the synergistic combination of Benalaxyl and Mancozeb against downy mildew of cucumbers. Benalaxyl, a Phenly Amide / Acylanilide fungicide is highly active against a wide range of plant pathogenic oomycetes (Gisi, 2002) and functions by arresting the nucleic acid synthesis of the pathogens. Mancozeb is a widely used dithiocarbamate fungicide having a multisite contact activity. Thus, the combination of Benalaxyl 8%+ Mancozeb 65% WP (B+M) was evaluated for its efficacy against downy mildew of cucumber.

MATERIALS AND METHODS

The trial was conducted at the research farm of ICAR -Indian Institute of Vegetable Research at Varanasi, Uttar Pradesh, India for two consecutive Rabi seasons (2010-11, 2011-12). Twenty eight days old seedlings of cucumber var. Swarna Sheetal were transplanted in plots of area 5m×5m. Standard package of practices were followed to raise the crop. Seven different treatments comprising of 3 combination doses of B+M @ 2000, 2500 and 3000 g/ha, 2 solo doses of Benalaxyl 8% SC @ 2500 ml/ha and Mancozeb 75% WP@ 2000 g/ha, a standard check fungicide Metalaxyl 8% + Mancozeb 64% @ 2500 g/ha and an untreated control were laid down in the randomized block design (RBD) with three replications. Fungicide application began with the visibility of initial disease symptoms i.e. 35 days after planting for downy mildew (10-12 leaf stage) and repeated once after 15 days. Ten plants from each replication excluding the border rows were taken at the beginning of each spray and scored for disease using 0-4 rating scale (0- healthy or no disease, 1- 1-10%, 2– 11-25% ,3 –26-50%, 4 –51% and above area infected) of Thind *et al.* 1991. The Percent Disease Index (PDI) was calculated based on the observation using the formula of Wheeler (1969) where,

$$\frac{\text{Sum of numerical values}}{\text{(Number of leaves counted} \times \text{maximum disease rating)}}$$

The harvesting was done after fruit maturity and fruit yield was calculated in quintals per hectare. All the data obtained was statistically analyzed.For phytotoxicity observations, the cucumber plants were treated with the combination dose of B+M @ 2500 and 5000 g/ha doses. Observations on leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty were recorded on ten randomly selected cucumber plants from each plot at 0, 1, 3, 7 and 10 days after application (DAA). The level of phytotoxicity was estimated by visual assessment mentioned in scale of 0-10 (Table 1).

RESULTS AND DISCUSSION

The analyzed data presented in Table 2 clearly indicates that the two doses of Benalaxyl 8%+ Mancozeb 65% WP @ 2500 g/ha and 3000 g/ha provided a significant disease control of downy mildew of cucumber with significant increase in the yield over its solo doses as well as the untreated control. The dose of B+M @ 2500g/ha manifested a disease control of 84.4% for downy mildew with an yield increase of 28.3%,while, the higher dose of B+M @ 3000 g/ha gave a disease control of 85.4% with a subsequent increase in yield by 30.0% as compared to untreated control. The disease control of downy mildew and the yield obtained from both these doses of B+M significantly surpassed the combination dose of Metalaxyl 8% + Mancozeb 64% WP @ 2500g/ha and the solo doses of Benalaxyl 8% SC @ 2500 g/ha and Mancozeb 75% WP @ 2000 g/ha.

No phytotoxicity symptoms were developed on leaves upto 15 days of spray in the two mentioned doses of the combination of B+M. This indicated that the two test combinations are not phytotoxic to cucumber upto the mentioned doses.

The results obtained help to elucidate the point that combination dose of B+M surpassed the solo doses of the same fungicides in controlling downy mildew of cucumber, thereby indicating that this combination possess synergistic effects. The major homologous component of this combination is the Phenyl Amide fungicide, Benalaxyl, which functions by arresting the nucleic acid synthesis by attacking the RNA polymerase 1 (FRAC code list 2016, http://FRAC.info). The N-C(C)-C conforma-

Table 1 : Phytotoxicity rating scale

Score	Phytotoxicity (%)	Score	Phytotoxicity (%)
0	No phytotoxicity	6	51 – 60
1	0 – 10	7	61 – 70
2	11 – 20	8	71 – 80
3	21 – 30	9	81 – 90
4	31 – 40	10	91 – 100
5	41– 50		

astating foliar disease of cucumber, many fungicides were targeted for its control. The results obtained from fungicide efficacy trials indicate that fungicides with active ingredients zoxamide, cymoxanil, famoxadone and cyazofamid are the most efficacious ones in managing the downy mildew on cucumber (Colucci, 2008). Interestingly, the multi-site fungicides including dithiocarbamates

Table 2 : Effect of Benalaxyl 8% +Mancozeb 65% WP on downy mildew of cucumber under field conditions

Treatments	Downy mildew PDI after application (DAA)					Yield (q/ha)			
	Dose (g/ha)	2010 -11	2011 -12	Mean PDI	Percent Disease Control	2010-11	2011-12	Mean	Percent yield increase
Benalaxyl 8%+ Mancozeb 65% WP	2000	12.00	10.83	11.42	77.98	274.57	276.00	275.29	19.10
Benalaxyl 8%+ Mancozeb 65% WP	2500	8.60	7.60	8.10	84.38	296.17	296.70	296.44	28.25
Benalaxyl 8%+ Mancozeb 65% WP	3000	8.03	7.10	7.57	85.41	299.67	301.10	300.39	29.95
Benalaxyl 8% SC	2500	17.30	16.27	16.79	67.63	245.70	246.30	246.00	6.42
Mancozeb 75% WP	2000	20.33	19.33	19.83	61.77	239.70	244.10	241.90	4.65
Metalaxyl 8% + Mancozeb 64% WP	2500	15.20	14.37	14.79	71.49	248.40	251.80	250.10	8.20
Control	--	52.0	51.70	51.87	0	229.70	232.60	231.15	0
CD (0.05)	--	11.96	12.16	-	-	7.95	7.97	-	-

Table 3 : Observations on phytotoxicity of Benalaxyl 8% +Mancozeb 65% WP on cucumber

Treatments	Dosage (g/ha)	Yellowing & Necrosis (Days after spray)					Vein Clearing (Days after spray)					Wilting & Leaf injury (Days after spray)					Epinasty and Hyponasty (Days after spray)					Stunting (Days after spray)				
		1	3	5	7	14	1	3	5	7	14	1	3	5	7	14	1	3	5	7	14	1	3	5	7	14
Untreated control	NIL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benalaxyl 8% + Mancozeb 65% WP	2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benalaxyl 8% + Mancozeb 65% WP	5000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Observations were recorded at 1, 3, 5, 7, 10 and 15 days after the spray of fungicides

tion of the acylanilide molecule, with its one asymmetric carbon atom, is important for its biological activity against Oomycetes (Davidse *et al*. 1984; Gozzo *et al*. 1985). The other protectant component, Mancozeb belongs to the group 'dithiocarbamates' which inhibits zoospore release and cysts germination of *Pseudoperonospora cubensis.*

Pseudoperonospora cubensis being a widely dev-

(e.g. mancozeb), phthalimides (folpet), chloronitriles (chlorothalonil) and copper formulations still account for about 50% of the downy mildew fungicide market. Among the single-site fungicides, four chemical classes the Quinone outside inhibitors (QoIs; 'strobilurins', mainly azoxystrobin, famoxadone, fenamidone), the phenylamides (PAs, mainly mefenoxam), the carboxylic acidamides (CAAs; mainly dimethomorph, iprovalicarb,

benthiavalicarb, mandipropamid) and the cyanoacetamid-oximes (cymoxanil) are the market leaders (Gisi *et al.* 2008) against downy mildew. Treatments involving these fungicides result in lower disease severity and higher yield than the non-treated control. In addition, a locally systemic + protectant fungicide program was compared to a protectant-only program with respect to delay of fungicide application. Results indicated that the locally systemic + protectant program was more effective than the protectant only program when applied before disease detection (Colucci, 2008). A synergistic fungicidal formulation *viz.* a combination of metalaxyl 4% and mancozeb 64% 68 WG have shown promising results for the control of downy mildew of cucumber (Gupta *et al.* 2014) and pointed gourd (Mondal *et al.* 2014). Thus the WP combination of Benalaxyl 8% and Mancozeb 65% was evaluated for its synergistic effects against downy mildew of cucumber.

Benalaxyl 8% +Mancozeb 65% WP @ 2500-3000 g/ha as a foliar spray manifested significantly higher percent disease control downy of cucumber over the solo doses, increased the yield and were devoid of any phytotoxic effects on cucumber. The combinations may be recommended for the management of downy mildew diseases and subsequently included in the Good Agricultural Practices (GAP) of cucumber

ACKNOWLEDGEMENTS

The authors are grateful to the Director, ICAR-IIVR, for his keen interest during the study and providing the facilities for research and FMC India Private Limited, Mumbai, for providing the financial assistance and samples required for the study.

REFERENCES

Colucci, S.J., Wehner, T.C., and Holmes, G.J. 2006. The downy mildew epidemic of 2004 and 2005 in the eastern United States. *Proc. Cucurbitaceae*. 2006:403–411.

Colucci, S. 2008. *Host range, fungicide resistance and management of Pseudoperonospora cubensis*, *causal agent of cucurbit downy mildew*. MS Thesis, North Carolina State University, Raleigh, USA

Davidse, L.C., Gerritsma, M., and Velthuis, M. 1984. A differential basis of antifungal activity of acylalanine fungicides and structurally related chloroacetanilide herbicides in *Phytophthora megasperma* f. sp. medicaginis. *Pest. Biochem. Physiol*. **21:** 301-308.

Gisi, U. 2002. *Chemical control of downy mildews*. Pages 119-159 in: Advances in Downy Mildew Research. P. T. N. Spencer-Phillips, U. Gisi, and A. Lebeda, eds. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Gisi, U., and Sierotzki, H. 2008. Fungicide modes of action and resistance in downy mildews. European *Journal of Plant Pathology*. **122:**157–167 DOI 10.1007/s10658-008-9290-5

Gozzo, F., Garlaschelli, L., Boschi, P.M. ,Zagni, A., Overeem, J. C., and deVries, L. 1985. Recent progress in the field of N-acylalanines as systemic fungicides. *Pestic. Sci*. **16:** 227-286

Gupta, S. K., and Jarial, K. 2014. Efficacy of some fungicides against downy mildew of cucumber. *International Journal of Farm Sciences* **4**:72-75

Kumar D, Kumar S, Singh J, Narender, R, Vashistha B, and Singh N. 2010. Free Radical Scavenging and Analgesic Activities of *Cucumis sativus* L. Fruit Extract. *Journal of Young Pharmacists*: JYP. 2010; **2:** 365-368. doi:10.4103/0975-1483.71627.

Lebeda A., and Urban J. 2004. Disease impact and pathogenicity variation in Czech populations of *Pseudoperonospora cubensis*. In Progress in Cucurbit Genetics and Breeding Research. *Proceedings of Cucurbitaceae 2004*, the 8th EUCARPIA Meeting on Cucurbit Genetics and Breeding, pp. 267–273. EdsA. Lebeda and H.S. Paris. Olomouc, Czech Republic:Palacky´ University in Olomouc.

Mondal, B., Das R., Saha, G., and Khatua, D.C. 2014. Downy Mildew of Pointed Gourd and its Management. Scholars Academic Journal of Biosciences (SAJB) 2014; **2**: 389-392

Palti, J. 1974. The significance of pronounced divergences in the distribution of *Pseudoperonospora cubensis* on its crop hosts. *Phytoparasitica* **2:**109–115. doi:10.1007/BF02980294

Palti, J., and Cohen. Y. 1980. Downy mildew of Cucurbits (*Pseudoperonospora cubensis*): The fungus and its hosts, distribution, distribution, epidemiology and control. *Phytoparasitica* **8:** 109-147.

Savory, E.A., Granke, L.L., Quesada-Ocampo, L.M., Varbanova, M., Hausbeck, M.K. and Day, B. 2011. The cucurbit downy mildew pathogen *Pseudoperonospora cubensis*. *Molecular Plant Pathology*, **12:** 217–226. doi:10.1111/j.1364-3703.2010.00670.x

Skylakakis, G. 1981. Effects of alternating and mixing pesticides on the buildup of fungal resistance. *Phytopathology* **71:** 1119-1121.

Thind, T.S., Singh, P.P., Sokhi, S.S., and Grewal, R.K. 1991. Application timing and choice of fungicides for control of downy mildew of musk melon. *Plant Disease Research* **6:** 49-53.

Urban, J. and Lebeda, A. 2006. Fungicide resistance in cucurbit downy mildew – methodological, biological and population aspects. *Annals of Applied Biology* **149:** 63–75

Vanitha, S.M., Chaurasia, S.N.S., Singh, P.M., and Naik, P.S. 2013. *Vegetable Statistics*. Technical Bulletin No. 51, IIVR, Varanasi, pp. 250.

Wheeler, B.E.J. 1969. *An Introduction to Plant Diseases*. 301p. John Wiley and Sons.Ltd. London