J. HPT Tropika
Vol. 19, No. 1, March 2019
Pages: 42–51

ISSN: 1411-7525
E-ISSN: 2461-0399
DOI : 10.23960/j.hptt. 11943-52

THE EFFECTIVENESS COMBINATION OF RESISTANT VARIETIES AND METALAXYL FUNGICIDE IN CONTROLLING DOWNY MILDEW DISEASE (*Peronosclerospora maydis)* IN MAIZE PLANT

Syahrir Pakki & Nurasia Jainuddin

Cereals Plant Research Institute, Maros
Jl. Dr. Ratulangi No. 274 Maros 90514
Email: pakki_syahrir@yahoo.com

ABSTRACT

The effectiveness combination of resistant varieties and metalaxyl fungicide in controlling downy mildew disease* (Peronosclerospora maydis) *in maize plant. Downy mildew caused by *Peronosclerospora maydis* is an important disease in the centers of corn cultivation in Java. The aim of this study was to determine the effectiveness of a combination of metalaxyl fungicide and varieties that have a high sustainability of downy mildew caused by *P. maydis*. The study was conducted in Kediri, East Java, which is an endemic area of downy mildew caused by *P. maydis*. The Split Plot Design with 3 replications was used in this study. The main plots were 5 corn varieties (1) Bima-3 Bantimurung, (2) Bima-20 URI, (3) Lagaligo, (4) Bima-15 Sayang, and (5) Anoman as a susceptible check. The subplots were 5 levels of seed treatment dose with metalaxyl fungicide (0 g/kg, 2 g/kg, 3 g/kg, 5 g/kg, and 7 g/kg seeds). The combination of resistant varieties with metalaxyl at a dose level of 5 g and 7 g/kg of corn seeds was effective in controlling downy mildew caused by *P. maydis*. In Bima-3 varieties Bantimurung and Lagaligo showed low infection reactions of 7.7-8.1%, and 10.4–11.2% respectively. In a combination of treatment conditions of susceptible varieties (Anoman) with 2, 3, 5 and 7 g/kg seeds, disease incidence reach 100% or most of the plants die. The lower incidence was also followed by yield, ear length and weight of a 1000 seeds that higher than other treatments. The combination of the use of susceptible variety with 2 g to 7 g/kg of metalaxyl doses was not effective in controlling downy mildew caused by *P. maydis*.

Key words: downy mildew, metalaxyl, resistant varieties

INTRODUCTION

Maize is a plant functioning as the main source of protein in fulfilling people's food sufficiency, especially in developing countries. The productivity potential of superior maize cultivars ranges from 7-13 ton/ha but the average productivity at the farm level is still around 5-6 ton/ha. Downy mildew is one of the main factors causing yield loss in maize. The disease can cause yield loss up to 90-100%. The earlier the plants are infected, the higher the rate of yield loss (Wakman & Burhanuddin, 2007; Pakki & Burhanuddin, 2013; Burhanuddin *et al.*, 2015).

The previous research showed that downy mildew in Indonesia was caused by three species, namely *Peronosclerospora maydis* in Java and Kalimantan, *P. philippinensis* in Sulawesi and *P. sorghi* in Sumatra, some in West Java, Jakarta and Kendari (Wakman *et al.*, 2006; Pakki & Muis 2007; Soenartiningsih & Talanca, 2010).

Control of downy mildew can be done by planting resistant cultivars, implementing an escape strategy by imposing a period without planting maize, eradicating infected plants from the rest of the previous crop and using fungicides with active ingredients called metalaxyl and demotroph (Wakman *et al.*, 2006; Pakki, 2017a). The maize seeds planted without treated with metalaxyl fungicides, have a high chance of developing downy mildew (Talanca *et al.*, 2012). The use of fungicides made from active metalaxyl in the Bengkayang area, West Kalimantan is no longer effective because it is suspected that *P. maydis* have been resistant to the fungicide (Burhanuddin, 2011). Burhanuddin *et al.* (2015) reported that *P. maydis* was more virulent than *P. philippinensis*. The difference is thought to be the result of the emergence of new races, in one species which later become dominant and cause a higher virulence level compared to other species. The difference in virulence levels allows for variations in the damage caused, so an effective study of the functional dose of each species causing downy mildew is necessary.

This research aimed to determine the effectiveness of combination of the dose of fungicide containing metalaxyl active ingredient and maize cultivars resistant to downy mildew caused by *P. maydis*.

MATERIALS AND METHODS

Research Site. This research was conducted from April to October 2016 in endemic area of downy mildew caused by *P. maydis* in Kediri East Jave. The experiment was arranged in Split Plot Design with 3 replications. The main plot was 5 maize cultivars obtained from the endurance test of downy mildew caused by *P. maydis* in 2015. The cultivars were: (1) Bima-3 Bantimurung, (2) Bima-20 URI, (3) Lagaligo, (4) Bima-15 Sayang, and (5) Anoman. Cultivar Anoman was used as a susceptibil comparator. Meanwhile, the subplots were 5 doses of seed doses using fungicides containing metalaxyl, i.e. 0 g/kg (control), 2 g/kg, 3 g/kg, 5 g/kg and 7 g/kg seeds.

Each plot was 4 m x 3 m with planting space of 75 cm x 20 cm in which 80 plants were planted per plot. Each planting hole was given one corn seed along with some 3G Carbofuran granules to prevent ants or pests at the beginning of the plant growth. At 10 days after planting (DAP), each experimental plot was given basic fertilizer at a rate of 100 kg/ha urea, 100 kg/ha ZA, 100 kg/ha SP-36 and 100 kg/ha KCl. Fertilization II and III were given consecutively at 30 and 45 dap at a dose of 100 kg/ha urea.

As inoculum source of downy mildew, cultivar Anoman, a susceptible cultivar, was planted 3 weeks before planting the treated cultivars. Cultivar Anoman was planted as many as two rows around the replication plot and between each replication. The inoculum source was infected naturally and also inoculated with conidia suspension of *P. maydis* obtained from around the research site. The downy mildew disease is expected to cause natural infections in treatment plots within each replication.

Data variables observed include:

(a) Observation of climate (temperature) with daily measurement using Mercury Thermometer store in the surrounding of the research location which was read in the morning and afternoon. Rainy days and precipitation intensity (heavy, medium and light) were recorded based on the intensity on rainy days.

(b) Disease intensity of downy mildew at 30 and 45 DAP

(c) Plant height observed in 25 dap of 10 sample clusters taken randomly in each plot, based on the proportion of plants infected with downy mildew

(d) Harvesting done when there were black layers on the seeds, estimation of production/yield loss calculated from harvesting samples obtained randomly in accordance with the proportion of plants infected with downy mildew at 45 DAP. Data obtained from the crop components then were converted to tons per ha by using the following formulas (Yasin *et al.,* 2014):

$$Y = \frac{\left(\frac{10,000}{\text{Lp}}\right)(100 - \text{ka})}{85} \times \text{BP} \times \text{R}(0.8)$$

Remarks:
Y = seed yield (ton/ha);
LP = plot area at harvest (m²);
ka = moisture content at harvest (%);
BP = fresh cob weight harvested (kg);
R = average yield (shelling percentage)
(0.8% for CYMMIT constant)

(e) Weight per 1000 seeds

(f) Cob length of 20 cob samples obtained randomly in proportion to the percentage of plants infected with downy mildew at 45 DAP.

RESULTS AND DISCUSSION

During the research activities, the daily temperature every week was around 27ºC to 33ºC with 1-2 days of rainfall (Table 1). The condition of the temperature and intensity of rainy days 1-2 days a week is very suitable for conidia development of downy mildew disease. Wakman & Burhanuddin (2007) reported that normal temperature, around 30ºC, and no rainy days every day allow the production of conidia of downy mildew leading to optimal infection process in the field. At the planting time of treated plants, 100% of the inoculum source plants had been infected with downy mildew. The high infection rate is caused natural infections in the treated plants which were also high, so there was no escape from downy mildew infection in the field.

Based on observations at 30 DAP (Table 2), disease intensity of downy mildew caused by *P. maydis* in the control plots reached 89.2 - 100%. Typical symptoms of downy mildew observed in the research site were chlorotic color, whitish yellow color extending parallel to the leaf bone, leaves stiffening, dwarfed, and in the control plot, some plants were dry and dead. When carefully observed, white flour-like patches could be seen at the bottom of the leaf. The symptoms of downy mildew observed in the research site is in accordance with what was stated by Jatnika *et al.* (2013); Lukman *et al.* (2013); Pakki (2014); & Pakki (2017b).

The treatment combination of resistant cultivar Bima-3 Bantimurung and seed treatment using active metalaxyl 7 g/kg and 5 g/kg showed significantly lower disease intensity of downy mildew reaching 5.8% and 5.0%, respectively, compared to seed treatment using active metalaxyl 3 g/kg, 2 g/kg and without active metalaxyl (control) which were 12.9-15% (Table 2). The same thing was also observed in cultivar Lagaligo which was only infected with disease intensity of 8.6 -10.7%, significantly lower than disease intensity observed in control which was 30.6%. This result is in line with the results of the research of Talanca & Tenrirawe (2015); Pakki & Burhanuddin (2013) mentioning that cultivar Bima-3 Bantimurung and Lagaligo had higher resistance than other cultivars.

At 30 DAP, the treatment combination of cultivar Bima 20 URI and Bima-15 and seed treatment using 5 and 7 g/kg of metalaxyl active ingredients showed significantly lower disease intensity compared to control, although the disease intensity was still high reaching 13.4 - 28.3%, significantly higher than cultivar Bima-3 Bantimurung and Lagaligo (5.8% and 6.8%). The high intensity indicates that cultivar Bima 20 URI and Bima 15 Sayang which are resistant and supported by the administration of active metalaxyl 7 and 5 g/kg have lower genetic ability in limiting *P. maydis* conidia invasion.

Table 1. Climate conditions (temperature and rainy days) during planting, Kediri 2016

Plant age (WAP)	Temperature (°C)	Rainy days (RD)	Rainfall
1	28 – 32	1	Medium
2	28 – 31	2	Low
3	27 – 31	1	High
4	28 – 33	1	Medium
5	28 – 32	2	Medium
6	29 – 33	1	High
7	28 – 32	2	Medium
8	29 – 33	2	High
9	28 – 33	1	Medium
10	27 – 31	2	Medium
11	28 – 32	1	Low
12	28 – 33	1	Medium
13	27 – 33	1	Medium
14	27 – 34	2	Medium
15	25 – 36	1	Medium

WAP = Week After Planting. Temperature, Rainy Days (RD) and Rainfall (High, medium and low): In accordance with direct observation in each day, specifically the temperature using a Mercury Thermometer.

Table 2. Effect of the combination of varieties treatment and dose of metalaxyl active ingredients on the incidence of *P. maydis* downy mildew at 30 DAP. Kediri, 2016

Main Plot (Variety)	Disease incidence (%) at the metalaxyl dose level				
	7 g	5 g	3 g	2 g	0 g
A (Bima-3 Bantimurung)	5,8 bz	5,0 bz	12,9 ayz	12,9 az	15,2 az
B (Bima-20 URI)	13,4 by	14,9 by	15,6 by	39,9 ax	42,3 ax
C (Lagaligo)	8,6 cz	10,7 az	9,2 cz	23,7 bz	30,6 by
D(Susceptible check, Anoman)	89,2 bw	96,2 aw	96,6 aw	98,6 aw	100,0 aw
E(Bima-15 Sayang)	27,4 cx	28,3 bcx	28,8 bcx	31,7 by	37,1 by

Numbers followed by the same letter in the same column and/or on the same line are not significantly different at the 5% level of the DMRT test. Mainplot CV (Varieties 4.83%, CV, Subplot fungicide dosage 6.93%.
a-d = Distinguishing symbols between columns, w-z = Distinguishing symbols between lines.

Cultivar Bima-3 Bantimurung was obtained from a single cross between Nei 9008 and Mr-14 strain (Syuryawati *et al.*, 2007). Nei 9008 has genetic properties that are resistant to downy mildew (personal communication with a breeder, Dr. A.Takdir). Likewise, composite maize, Lagaligo, was obtained from the recombinations of 20 strains of S4, and the selection of its durability produced a resistant reaction towards downy mildew (Syuryawati *et al.,* 2007). Thus, the combination of the performance of the resistant cultivars and the active ingredients of metalaxyl at doses of 5 and 7 g/kg was more effective in controlling downy mildew caused by *P. maydis*.

The absence of resistant genes in plant cell tissue in susceptible conparator (cv. Anoman) caused the treatment of metalaxyl active ingredients to work alone to limit pathogenic invasion of *P. maydis*. Such conditions in the vegetative phase at 30 dap caused the disease intensity of downy mildew (*P. maydis*) to reach around 98.6%. About 98.6% of downy mildew (*P. maydis*) attacks indicate that the combination of cultivars which do not have resistant genes and active ingredients of metalaxyl at doses of 2, 3, 5 and 7 g/kg is not effective in controlling downy mildew disease from *P. maydis*.

At 45 DAP (Table 3), the optimal indication of downy mildew attack was reflected in the condition of all plots planted with susceptible comparator (cv. Anoman), reaching 100% or some clumps of dead plants. In each plot of treatment, pathogenic intensity of *P. maydis* continued to develop (Table 3). Cultivar Bima-3 Bantimurung and Lagaligo combined with active ingredients of metalaxyl at 5 and 7 g/kg still showed low infection reaction of 7.7 - 8.1% and 10.4 -11.2%, consecutively. Those infection reaction rates were also significantly lower than cultivar Bima-20 URI and Bima-15 Sayang reaching 17.7 -22.9% and 30.3 -34.9%, respectively. Bima-3 Bantimurung and Lagaligo are maize cultivars classified as having high resistance to downy mildew caused by *P. maydis* (Pakki, 2017a). The low disease intensity of downy mildew is a reflection of the double performance of resistant genes and metalaxyl active ingredient, which causes *P. maydis* to be unable to infect optimally.

The lower infection rate on cultivar Bima-3 Bantimurung and Lagaligo is presumably because at initial penetration, conidia successfully attaches to the leaves but is unable to invade cells of the epidermis or conidia infects tissue cells but cannot develop due to combination performance of resistant genes and metalaxyl active ingredients. Singh (1980) stated that one of the causes of low pathogenic infections caused by fungi is that plants contain enzymes, released by the leaf cell wall, able to reduce the aggressiveness of the pathogenic fungus, conidia. From the data of each description of a new superior maize cultivar released, the resistance to downy mildew is the main requirement that must be possessed. According to Sujiptrihati *et al.* (2012); Hoerussalam *et al.* (2013), efforts to assemble maize plants that are resistant to downy mildew through screening of germplasm and crosses, were faced with limited constraints on genetic resources and the length of the assembly process. Some of the results of research on maize germplasm screening for downy mildew disease, there were only about 1 - 3% of accessions that are resistant to downy mildew which were obtained (Pakki *et al.*, 2012; Pakki *et al.*, 2013; Pakki & Pabbage, 2015). The indications for this data encourage the need for continuous systematic efforts to find resistant genes. On the other hand, the findings of technological control innovation based on the level

Table 3. Effect of combination treatment of varieties and metalaxyl doses on *P. maydis* downy mildew disease at 45 DAP. Kediri, 2016

MainPlot (Variety)	Disease incidence (%) at the metalaxyl dose level				
	7 g	5 g	3 g	2 g	0 g
A (Bima-3Bantimurung)	8,1 dz	7,7 dz	18,1 cz	21,2 bz	23,2 az
B (Bima -20 URI)	17,7 ey	22,9 dy	25,1 cy	56,9 ax	49,5 bx
C (Lagaligo)	10,4 dz	11,2 dz	15,6 cz	28,2 bz	37,4 az
D (Susceptible check, Anoman)	100,0 aw	100,0 aw	100,0 aw	100,0 aw	100,0 aw
E (Bima-15 Sayang)	30,3 cx	34,9 bx	34,7 bx	35,6 by	42,4 ay

Numbers followed by the same letter in the same column and/or on the same line are not significantly different at the 5% level of the DMRT test. Mainplot CV (Varieties 21.20%, CV, Subplot fungicide dosage 24.53%. a-d = Distinguishing symbols between columns, w-z = Distinguishing symbols between lines.

of virulence of species causing downy mildew are expected to enrich control alternatives so as to reduce the loss of maize yield at the farm level.

Cultivar Bima-3 Bantimurung and Lagaligo combined with metalaxyl active ingredients at 3 g/ kg-2 g/kg showed disease intensity of 18.1 -21.2% and 15.6 -28.2%, respectively. The higher intensity of downy mildew has signaled that the use of resistant cultivars combined with doses of metalaxyl active ingredients at 2 and 3 g/kg of seeds cannot be used in the endemic areas of *P. maydis*. The same thing was also seen on cultivar Bima-20 URI and Bima-15. Unfortunately, with the highest dose of metalaxyl active ingredients which is 7g / kg, the disease intensity (*P. maydis*) still reached 17.7% and 30.3%.

The data above indicate that the level of damage caused by *P. maydis* causing downy mildew in endemic areas of maize plantations in Java this is classified as high and is able to cause greater yield loss in maize plantations in the western part of Indonesia. Burhanuddin & Tandiabang (2011) reported that the level of virulence or severity caused by downy mildew from *P. maydis* was higher, by around 25-30%, compared to the diseases caused by *P. philippinensis*. Hikmawati *et al.* (2011) stated that there was a difference in response to downy mildew, including the resistant cultivars developed at this time that were thought to cause a change in the pathogen phenotype. Likewise, Talanca *et al.* (2012) reported that in several locations, the use of saromyl fungicide (metalaxyl active ingredient), tended to be ineffective in controlling downy mildew disease, and this was thought to be due to the resistance of the pathogen.

The use of Ridomil made from metalaxyl at a dose of 2 g/kg of seeds, both in resistant and susceptible cultivars, was still effective in controlling downy mildew caused by *P. philippinensis* (Wakman & Burhanuddin, 2007; Burhanuddin *et al.*, 2015). The data reinforce the suspicion that the two species causing downy mildew differ in their level of virulence and the severity of the disease caused. The implications of differences in the level of virulence and severity encourage the need to find cultivars resistant to downy mildew based on the pathigen species.

Plant growth is one of indicators to measure the response rate of the cultivars due to the infection of downy mildew. Fahmi & Sujitno (2015) stated that plant height measurements were used as indicators of severity as a result of systemic pathogenic infections. *P. maydis* are systemic in nature to infect all plant tissues, causing dwarf plants or death in susceptible maize cultivars (Wakman e*t al.*, 2007; Pakki 2017b).

The plant height of cultivars infected with downy mildew with a higher intensity (Table 3) was significantly higher than that of controls (Table 4). Observation of the physiological condition of plant tested showed that, if the plant was infected with *P. maydis* earlier, the plant growth was more dwarfed compared to plants that were infected later or healthy plants. Through the results of photosynthesis, pathogens will interfere with the flow of nutrients from leaf cells into phloem as well as translocation from phloem into the cells of the host plant tissue. Vascular tissues of infected plant can also be filled with the invasion of pathogenic masses, causing blockage of plant vascular tissues, so that plants become more stunted than normal plants.

The systemic effect of the pathogen was also seen in production, cob length and weight of 1000 seeds. *P. maydis* uses nutrients for its development so that plant growth is not normal. The severe infection in each individual plant occurs due to a positive response between the host and pathogens, causing blockage of the plant tissue so that the host plant cannot grow normally, thus the yield loss is greater than that of healthy plants (Singh, 1980).

The interaction effects between cultivar Bima-3 Bantimurung and metalaxyl active materials at a dose of 7 g/kg and 5 g/kg produced a production rate of 6.3 ton/ha (Table 5). Meanwhile, cultivar Lagaligo had production rate of 4.1-4.2 ton/ha, significantly higher than if combined with the use of metalaxyl at 3 g/kg, 2 g/kg and control. Hoerussalam *et al.* (2013) stated that the resistance of a cultivar to disease is one of the important characteristics in plant breeding because it affects the quality and level of crop production.

The same thing was also seen in the variable of weight of 1000 seeds (Table 6). The weight of 1000 seeds of cultivar Bima-3 Bantimurung treated with metalaxyl at 7 and 5 g/kg of seed was significantly higher than that of control and metalaxyl treatment of 2 g/kg and 3 g/kg of seeds. These data indicate that the combination of resistant cultivars and metalaxyl at doses of 7 g/kg and 5 g/kg is more effective in controlling downy mildew caused by *P. maydis*.

According to Nene & Thapliyal (1971), the active ingredients of several fungicides serve to activate the disease defense system, by changing host relationships with the pathogens to beneficial symbioses without affecting the potential yield of a cultivar. The action mechanism of active ingredients does not interfere with the metabolism of plant growth. The active ingredients generally act only to activate plant enzymes, which then become a barrier to the work processes that cause disease in invading plant tissue cells. In the future, the breeding program to find cultivars to downy mildew should be adapted to the pattern of the spread of pathogens causing downy mildew from the class of *Peronosclerospora* spp. In the recent five years, the surveys in Indonesia based on the conidia morphology found that the species causing downy mildew were *P. maydis*, *P. philippinensis* and *P. sorghi*. *P. maydis* predominantly causes infection in Java, *P. philippinensis* in the Sulawesi region, and *P. sorghi* in Southeast Sulawesi, West Nusa Tenggara and partly in South Sulawesi (Muis *et al*., 2013; Muis *et al.*, 2016; & Muis & Nonci, 2017). Rustiani *et al.*, (2015), also found that identification based on the morphological characteristics of conidia in 5 provinces in Java showed that about 68% of the species causing downy mildew were classified as *P. maydis*. Likewise, the results of the study by Lukman *et al.* (2013) showed that in the distribution of downy mildew-causing species there was a close relationship between geographical location and genetic similarity between each isolate.

Utomo *et al.* (2010) reported that besides applied through seed treatment, metalaxyl fungicide sprayed through leaves could increase the cob weight and dry seed weight. The continuous use of metalaxyl was suspected to have caused resistance to *P. maydis* (Burhanuddin & Tandiabang, 2011). This situation encourages the invention of other active fungicides, in an effort to control downy mildew. According to Asputri *et al.* (2013), it was found that the application of fungicides with active ingredients of pyraclostrobin could suppress the development of downy mildew in cultivar P21, BISI 2, BISI 22, Pertiwi 3 and NK 33. Downy mildew can also be reduced by seed treatment using biological agents of *Trichoderma viridae*, *T. harzianum*, *Gliocladium virens*, *Aspergillus* spp., *Beauveria* spp. and *Bacillus subtilis* (Sadoma *et al*., 2011; Amin *et al.*, 2013; Sekarsari *et al.*, 2013; Zainudin *et al*., 2014).

The observation on cob length (Table 6) showed that the combination of resistant cultivars and metalaxyl

Table 4. Effect of combination treatment of varieties and metalaxyl doses on the height of corn plants at 25 DAP. Kediri, 2016

MainPlot (Variety)	Plant height (cm) at the level of the metalaxyl dose				
	7 g	5 g	3 g	2 g	0 g
A (Bima-3 Bantimurung)	64,0 ax	64,0 ay	68,0 aw	55,6 bw	53,6 bwx
B (Bima- 20 URI)	75,0 aw	72,6 abx	69,3 bw	56,0 cw	57,6 cw
C (Lagaligo)	78,0 aw	79,6 aw	72,0 bw	55,0 cw	54,0 cwx
D (Susceptible check, Anoman)	58,0 ax	46,3 bcy	45,6 bcx	50,6 bw	42,3 cy
E (Bima-15 Sayang)	63,0 ax	56,6 by	56,0 by	54,3 bcw	50,9 cx

Numbers followed by the same letter in the same column and/or on the same line are not significantly different at the 5% level of the DMRT test. Mainplot CV (Varieties 5.39%, CV, Subplot fungicide dosage 5.65%.
a-d = Distinguishing symbols between columns, w-z = Distinguishing symbols between lines.

Table 5. Effect of combination treatment of varieties and metalaxyl doses on corn crop production. Kediri, 2016

MainPlot (Variety)	Yield (t/ha) at the metalaxyl dose level				
	7 g	5 g	3 g	2 g	0 g
A (Bima-3 Bantimurung)	6,3 aw	6,3 aw	4,8 bw	4,7 bw	4,1 bw
B (Bima -20 URI)	5,7 ax	5,0 bx	4,8 bw	4,7 cw	3,8 cw
C (Lagaligo)	4,1 ay	4,2 ay	3,0 by	2,9 by	2,8 bx
D (Susceptible check, Anoman)	0,2 az	0,1 az	0,2 az	0,1 az	0,1 ay
E (Bima-15 Sayang)	5,3 ax	4,0 by	3,8 bx	3,6 bcx	3,0 cx

Numbers followed by the same letter in the same column and/or on the same line are not significantly different at the 5% level of the DMRT test. Mainplot CV (Varieties 15.36%, CV, Subplot fungicide dosage 10.85%. a-d = Distinguishing symbols between columns, w-z = Distinguishing symbols between lines.

Table 6. Effect of combination of varieties and metalaxyl doses on the length of corn extract. Kediri, 2016

MainPlot (Variety)	Cob length (cm) at the level of the metalaxyl dose				
	7 g	5 g	3 g	2 g	0 g
A (Bima-3 Bantimurung)	18,1 axy	17,8 aw	18,1 awx	15,8 aw	14,8 aw
B (Bima -20 URI)	21,1 awx	20,0 aw	14,1 by	15,0 bw	14,0 bw
C (Lagaligo)	18,8 axy	19,0 aw	19,7 aw	17,8 abw	15,4 bw
D (Susceptible check, Anoman)	8,6 az	7,0 ax	9,3 az	9,3 ax	9,3 ax
E (Bima-15 Sayang)	22,2 aw	20,3 aw	16,3 bxy	16,3 bw	13,7 bw

Numbers followed by the same letter in the same column and/or on the same line are not significantly different at the 5% level of the DMRT test. Mainplot CV (Varieties 8.97%, CV, Subplot fungicide dosage 13.30%.
a-d = Distinguishing symbols between columns, w-z = Distinguishing symbols between lines.

Table 7. Effect of combination of varieties treatment and metalaxyl dose on the weight of 1000 corn seeds. Kediri, 2016

MainPlot (Variety)	Weight of 500 seeds (g) *) at the level of the metalaxyl dose				
	7 g	5 g	3 g	2 g	0 g
A (Bima-3 Bantimurung)	446,8 aw	402,1 cx	422,3 bw	364,1 dw	342,7 ex
B (Bima-20 URI)	413,8 ax	404,1 awx	404,4 aw	283,5 bx	272,9 by
C (Lagaligo)	422,5 ax	424,0 aw	415,0 aw	302,0 cx	323,8 bx
D (Susceptible check, Anoman)	42,2 ay	48,5 ay	42,1 ax	42,6 ay	41,0 ay
E (Bima-15 Sayang)	424,4 ax	400,9 bx	404,3 bw	374,9 cw	376,0 ew

Numbers followed by the same letter in the same column and/or on the same line are not significantly different at the 5% level of the DMRT test. Mainplot CV (Varieties 4.21%, CV, Subplot fungicide dosage 3.82%.
*) Water content around 19-21%.
a-d = Distinguishing symbols between columns, w-z = Distinguishing symbols between lines.

at 2, 3, 5 and 7 g/kg seeds produced cobs which were longer than the control. In the susceptible comparator, plants infected with downy mildew (*P. maydis*) produced small seeds with smaller cobs. Some individual plants surviving produced several cobs with a length of about 7.0 cm to 9.3 cm with low weight of 1000 seeds reaching 42.1 - 48.5g (Table 7). This result was very low compared to the condition of healthy seeds. The potential weight of 1000 seeds of cv. Anoman with healthy seeds is 360 g (Aqil & Arvan, 2007).

CONCLUSION

The combination of resistant cultivars and metalaxyl at the dose of 5 g and 7 g/kg of seeds was effective in controlling downy mildew caused by *Peronosclerospora maydis*. Cultivar Bima-3 Bantimurung and Lagaligo showed a low infection rate reaching 7.7-8.1%, and 10.4–11.2%, respectively. The combination of susceptible cultivar (Anoman) and metalaxyl at the dose of 0, 2, 3, 5 and 7 g/kg of seeds showed high infection rate reaching 100% meaning that most plants were dead. The lower intensity was also followed by higher production, longer cobs and higher weight of 1000 seeds compared to other treatments. The combination of susceptible cultivar and metalaxyl at the doses of 2-7 g/kg of seeds was not effective in controlling downy mildew caused by *Peronosclerospora maydis*.

ACKNOWLEDGMENTS

We thank to Mr. Hasbi and Mrs. Amina for technical assistance in the laboratory and field.

REFERENCES

Amin N, Daha L, Nasruddin A, Junaed M, & Iqbal A. 2013. The use of endophytic fungi as biopesticide against downy mildew *Peronosclerospora* spp. on maize. *Natural A. Sci..* 4(4): 153–159.

Aqil M & Arvan RY. 2007. *Deskripsi varietas unggul jagung*. Balai Penelitian Tanaman Serealia, Maros.

Asputri NU, Aini LQ, & Abadi LA. 2013. Pengaruh aplikasi *Pyraclostrobin* terhadap serangan penyebab penyakit bulai pada lima varietas jagung (*Zea mays*). *JHPT Tropika.* 1(3):77–84.

Burhanuddin. 2011. Fungisida metalaksil tidak efektif menekan penyakit bulai (*Peronosclerospora maydis*) di Kalimantan Barat dan alternatif pengendaliannya. In: Makarim K, Zubachtirodin, Yasin HG, Soenartiningsih, Dahlan HA, Tandiabang J, Arief R, Suarni, Syafruddin, Hermanto, & Aqil M (Eds.). *Prosiding Seminar Nasional Serealia*. pp. 395-399. Inovasi Teknologi Mendukung Swasembada Jagung dan Diversifikasi Pangan. Maros. 27–28 Juli 2010.

Burhanuddin & Tandiabang J. 2011. Penyakit bulai di pulau Madura, Jawa Timur. *Prosiding Pekan Serealia Nasional.* pp.358-362. In: Makarim K, Zubachtirodin, Yasin HG, Soenartiningsih, Dahlan HA, Tandiabang J, Arief R, Suarni, Syafruddin, Hermanto, & Aqil M (Eds.). Inovasi Teknologi Mendukung Swasembada Jagung dan Diversifikasi Pangan. Balai Penelitian Tanaman Serealia. Pusat Penelitian dan Pengembangan Tanaman Pangan. Maros. 27–28 Juli 2010.

Burhanuddin, Talanca H, & Pakki S. 2015. Variasi virulensi penyakit bulai yang disebabkan oleh spesies *Peronosclerospora maydis* dan *P. philippinensis*. *Prosiding Seminar Nasional Taman Tekhnologi Pertanian dan Kedaulatan Pangan di Kawasan Indonesia Timur*. pp. 395–408. In: Suharsono, Munir FF, Basri Z, Heluti F, Sukisman, Amin M, Syafruddin & Saidah (Eds.). Balai Pengkajian Teknologi Pertanian. Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian, Palu. 25 April 2015.

Fahmi T & Sujitno E. 2015. Keragaan produktivitas varietas jagung pada musim hujan di lahan kering dataran tinggi Kabupaten Bandung, Jawa Barat. *Pros. Sem. Masy. Biodiv. Indon.* 1(7): 1674–1677. 16 Februari 2018.

Hikmawati H, Kuswinanti T, Melina , & Pabendon MB. 2011. Karakterisasi morfologi *Peronosclerospora* spp., penyebab penyakit bulai pada tanaman jagung dari beberapa daerah di Indonesia. *J. Fitomedika*. 7(3): 159–161.

Hoerussalam, Purwantoro A, & Khaeruni A. 2013. Induksi ketahanan tanaman jagung (*Zea mays* L.) terhadap penyakit bulai melalui seed treatment serta pewarisannya pada generasi S1. *Ilmu Pertanian*. 16(2): 42–59.

Jatnika W, Abadi AL, & Aini LQ. 2013. Pengaruh aplikasi *Bacillus* sp. dan *Pseudomonas* sp. terhadap perkembangan penyakit bulai yang disebabkan oleh jamur patogen *Peronosclerospora maydis* pada tanaman jagung. *J. HPT*. 1(4):19–29.

Lukman R, Afifuddin A, & Lubberstedt T. 2013. Unraveling the genetic diversity of maize downy mildew in Indonesia. *J. Plant Pathol. Microb.* 4(2): 162.

Muis A, Pabendon MB, Nonci N, & Waskito WPS. 2013. Keragaman genetik *Peronosclerospora maydis* penyebab bulai pada jagung berdasarkan analisis marka SSR. *Penelitian Pertanian Tanaman Pangan.* 32(3): 139–147.

Muis A, Nonci N, & Pabendon MB. 2016. Geographical distribution of *Peronosclerospora* spp., the causal organism of maize downy mildew, in Indonesia. *AAB Bioflux.* 8(3): 143–155.

Muis A & Nonci N. 2017. Pemetaan spesies penyebab penyakit bulai di Indonesia. Teknologi Pengendalian Penyakit Utama Jagung. Laporan Tahunan Hasil Penelitian Balai Penelitian Tanaman Serealia (Belum dipublikasi).

Nene YL & Thapliyal PN. 1971. Fungicides in plant disease control, *Second edition. Oxpord & IBH Publishing co. PVT. LTD.* Calcutta.

Pakki S. 2014. Epidemiologi dan strategi pengendalian penyakit bulai (*Peronosclerospora* sp.) pada tanaman jagung. *J. Penelitian dan Pengembangan Tanaman Pangan.* 33(2): 47–52.

Pakki S. 2017a. Kelestarian ketahanan varietas unggul jagung terhadap penyakit bulai dari spesies *Peronosclerospora maydis*. *Penelitian Pertanian Tanaman Pangan.* 1(1): 12–19.

Pakki S. 2017b. Penyakit-penyakit utama pra dan pasca panen pada tanaman jagung. *Mujahid Press.* Bandung. P. 129.

Pakki S & Burhanuddin. 2013. Peranan varietas dan fungisida dalam dinamika penularan Parasit obligat Parasite dan saprofit pada tanaman jagung. In: Muis A, Pabbage MS, Yasin MHG, Aqil M, Hermanto, & Pakki S (Eds.). pp. 479–488. *Prosiding Seminar Nasional Serealia.* Peningkatan Peran Penelitian Serealia Menuju Pertanian Bioindustri. Balai Penelitian Tanaman Serealia. Pusat Penelitian dan Pengembangan Tanaman Pangan. Maros. 28 Juni 2019.

Pakki S & Muis A. 2007. Patogen utama pada tanaman jagung setelah padi rendengan di lahan sawah tadah hujan. *Penelitian Pertanian Tanaman Pangan.* 26(1): 55–61.

Pakki S, Pabbage MS, & Azrai M. 2013. Skrining ketahanan plasma nutfah jagung terhadap penyakit bulai (*Peronosclerospora* sp.) *Prosiding Seminar Nasional Serealia.* In: Muis A, Pabbage MS, Yasin HG, Aqil M, Hermanto, & Pakki S (Eds.). Maros. 18 Juni 2013.

Pakki S, Pabbage MS, & Takdir A. 2012. Skrining plasma nutfah Jagung terhadap penyakit bulai. *Laporan Tahunan Kelompok Peneliti Hama dan Penyakit Tanaman*. Balai Penelitian Tanaman Serealia. Maros.

Pakki S & Pabbage MS. 2015. Penampilan penyakit Bulai (*Peronosclerospora philippinensis*) pada tujuh puluh plasma nutfah jagung. In: Muis A, Syafruddin, Bahtiar, & Aqil M (Eds.). *Prosiding Seminar Nasional Serealia*. Maros.

Rustiani US, Sinaga MS, Hidayat SH, & Wiyono S. 2015. Tiga spesies *Peronosclerospora* sp. Penyebab penyakit bulai jagung di Indonesia. *Berita Biologi.* 14(1): 29–37.

Sadoma MT, El-Sayed ABB, & El-Moghazy SM. 2011. Biological control of downy mildew disease of maize caused by *Peronosclerospora sorghi* using certain biocontrol agents alone or in combination. *J. Agric. Res*. 37(1): 1–11.

Sekarsari RA, Prasetyo J, & Maryono T. 2013. Pengaruh beberapa fungisida nabati terhadap keterjadian penyakit bulai pada jagung manis (*Zea mays saccharata*). *J. Agrotek Tropika.* 1(1): 98–101.

Singh RS. 1980. Introduction to Principles of Plant Pathology. Third edition. New Delhi: *Oxford & IBH Publishing Co*, New Delhi India.

Soenartiningsih & Talanca A. 2010. Penyebaran penyakit bulai (*Peronosclerospora maydis*) pada jagung di Kabupaten Kediri. In: Saenong S, Baharuddin, Kuswinanti T, Daud ID, Agus N, Yasin M, Soenartiningsih, Hasan F, Rugaya A, Nurwahida U, Dahyar, & Talanca AH. *Prosiding Seminar Ilmiah dan Pertemuan Tahunan XX PEI-PFI Komda Sulsel.* Maros.

Sujiprihati, Syukur SM, Makkulawu AT, & Iriang RN. 2012. Perakitan varietas bibrida jagung manis berdaya hasil tinggi dan tahan terhadap penyakit bulai. *JIPI*. 17(3): 159–165.

Syuryawati, Constance R, & Zubachtirodin. 2007. Deskripsi varietas unggul jagung. *Balai Penelitian Tanaman Serealia*, Puslitbangtan. Badan Penelitian dan Pengembangan Pertanian, Maros.

Talanca AH, Burhanuddin, & Tenrirawe A. 2012. Uji resistensi cendawan (*Peronosclerospora maydis*) terhadap fungisida Saromyl 35 SD. In: Saenong MS, Saenong S, Daud ID, Agus N, Kuswinanti T, Soenartiningsih, Tjajo A, Jahuddin R, Talanca AH, Masmawati, Hasmah, & Laila MSI (Eds.). *Prosiding Seminar dan Pertemuan Tahunan PEI-PFI XXI Komda Sul-Sel*. Makassar.

Talanca AH & Tenrirawe A. 2015. Respon beberapa varietas terhadap penyakit utama jagung di Kabupaten Kediri Jawa Timur. *J. Agrotan.* 1(1): 67–78.

Utomo SD, Islamika N, Ratih S, & Ginting C. 2010. Pengaruh fungisida metalaksil terhadap keterjadian penyakit bulai dan produksi populasi jagung Lagaligo x tom thumb. *Jurnal. Agrotropika.* 15(2): 56–59.

Wakman W, Asikin S, Bustan A, & Thamrin M. 2006. Identifikasi spesies cendawan penyebab penyakit bulai pada tanaman jagung di Kabupaten Tanah Laut Provinsi Kalimantan Selatan. *Seminar Mingguan*, Balitsereal. Maros.

Wakman W & Burhanuddin. 2007. Pengelolaan penyakit prapanen jagung. *Dalam* Buku *Jagung*. Teknik produksi dan pengembangan. *Balai Penelitian*

Tanaman Serealia. Pusat Penelitian Tanaman Pangan. Bogor.

Wakman W, Pakki S, & Kontong S. 2007. Evaluasi ketahanan varietas/galur jagung terhadap penyakit bulai. *Laporan Tahunan Kelompok Peneliti Hama dan Penyakit.* Balitsereal, Maros.

Yasin HG, Sumarno, & Nur A. 2014. Perakitan varietas jagung fungsional. *IAARD Press*. Badan Litbang Pertanian .

Zainudin, Abadi AL, & Aini LQ. 2014. Pengaruh pemberian Plant Growth Promoting *Rhizobacteria* (*Bacillus subtilis* dan *Pseudomonas fluorescens*) terhadap penyakit bulai pada tanaman jagung (*Zea mays* L.). *JHPT.* 2(1): 11–18.