

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

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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

ABSTRAK

Efektivitas kombinasi varietas tahan dan fungisida metalaksil dalam pengendalian penyakit bulai (*Peronosclerospora maydis*) pada tanaman jagung. Penyakit bulai yang disebabkan oleh *Peronosclerospora maydis* merupakan penyakit penting pada sentra-sentra pertanaman jagung di Pulau Jawa. Penelitian bertujuan untuk mengetahui efektivitas kombinasi perlakuan fungisida berbahan aktif metalaksil dengan varietas yang mempunyai kelestarian ketahanan yang tinggi terhadap penyakit bulai yang disebabkan spesies *P. maydis*. Penelitian dilakukan di Kediri, Jawa Timur, yang merupakan daerah endemi penyakit bulai dari spesies *P. maydis*. Rancangan Percobaan menggunakan Petak Terpisah dengan 3 ulangan. Petak utama adalah 5 varietas jagung (1) Bima-3 Bantimurung, (2) Bima-20 URI, (3) Lagaligo, (4) Bima-15 Sayang, dan (5) Anoman sebagai varietas pembandingan yang rentan. Anak petak adalah 5 level dosis perlakuan benih dengan fungisida metalaksil (0 g/kg, 2 g/kg, 3 g/kg, 5 g/kg, dan 7 g/kg benih). Kombinasi varietas tahan dengan metalaksil pada taraf dosis 5 g dan 7 g/kg benih jagung, efektif mengendalikan penyakit bulai yang disebabkan oleh spesies *P. maydis*. Pada varietas Bima-3 Bantimurung dan Lagaligo berturut-turut memperlihatkan reaksi infeksi yang rendah, berturut-turut 7,7-8,1%, dan 10,4-11,2%. Dalam keadaan kombinasi perlakuan varietas rentan (Anoman) dengan 2, 3, 5 dan 7 g/kg benih, mencapai intensitas infeksi 100% atau sebagian besar tanaman mati. Intensitas yang lebih rendah tersebut juga diikuti produksi, panjang tongkol dan bobot seribu biji yang lebih tinggi dibanding perlakuan lainnya. Kombinasi penggunaan varietas yang rentan dengan dosis metalaksil 2 g sampai 7 g/kg benih, tidak efektif mengendalikan penyakit bulai yang disebabkan oleh spesies *P. maydis*.

Kata kunci: metalaksil, penyakit bulai, varietas tahan

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; Soenartiningasih & 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 Java.

Research Procedure. 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:

- 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.
- Disease intensity of downy mildew at 30 and 45 dap
- 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
- 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):

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

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 27°C to 33°C 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 30°C, 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*

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 HST. 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.

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.

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 comparator (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%,

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

Main plot (variety)	Disease incidence (%) at the metallaxyl dose level				
	7 g	5 g	3 g	2 g	0 g
A (Bima-3 Bantimurung)	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-15Sayang)	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.

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 Sujiprihati *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 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 & Tandiang (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 pathogen 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 *et 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*

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

Main plot (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

Main plot (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.

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 & Tandiang, 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 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 g-48.5 g (Table 7). This result was very low

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

Main plot (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

Main plot (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.

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*.

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ACCEPTED