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Foreword

The growing demand for biofuel which is mainly driven by the increasing oil prices has created more challenges as well as opportunities on agricultural development. For developing countries like Indonesia, the challenges are mostly related to food security since maize, as an important source of modern biofuel, is a staple food for some of the population. In addition, maize is also an important source of feed and raw materials for many type of industries.

Since Indonesia has already determined to achieve and sustain food security, the effort to increase maize production mainly through increasing productivity has also challenged by two major sources of uncertainty, i.e. climate change and trade which require science and technolgy as well as market fairness and favorable policy.

In relation to our effort to enhance cooperation among some key stakeholders in food security issues and the need to spur up the regional coordination and networking, an International Maize Conference was held on 22-24 November 2012 in Gorontalo. The conference was organized by the Indonesian Ministry of Agriculture in collaboration with the Provincial Goverment of Gorontalo. The objectives of the conference were (i) to facilitate stakeholders in addressing the problems of the world maize production related to food security and alternative energy resources, and (ii) to share and exchange ideas/information of maize research results among scientists, researchers, policy makers, industries, and farmers from different countries in the world.

Attended by more than 400 participants from 10 countries, four main agenda of the conference were successfully organized. They were (i) International Seminar on Agribusiness of Maize, (ii) International Maize Expo, (iii) Governor Convention and Business Meeting, and (iv) Farm Field Day. The international seminar packed with exciting presentations and papers, all focussed on the theme of "Maize for Food, Feed, and Fuel". One keynote speaker from Indonesian Minister of Agriculture and some guest speakers from different countries came up with different perspectives of the theme.

I highly appreciate the participation and contribution of all participants and the organizer of the conference and my sincere gratitude to the Provincial Government of Gorontalo for all of the kind supports provided during the conference.

Jakarta, May 2013

Indonesian Agency for Agricultural
Research and Development
Director,

Dr. Haryono

ACKNOWLEDGEMENT

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Extended acknowledgement is also addressed to International Maize and Wheat Research Institute (CIMMYT) and all sponsoring partners: Syngenta, Monsanto, BISI International, and DuPont Pioneer for their kind support during the conference.

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MINISTRY OF AGRICULTURE
REPUBLIC OF INDONESIA

Keynote Speech
Minister of Agriculture
The Republic of Indonesia

At The Opening Ceremony of International Maize Conference
"Maize For Food, Feed and Fuel"
Gorontalo, 22-24 November 2012

Distinguished guests,

- **Dr. Prasanna Boddupalli, Director, Global Maize Program, CIMMYT, Nairobi, Kenya**
- **Governor of provinces in Sulawesi**
- **Participants, Ladies and Gentlemen.**

Assalamu'alaikum warahmatullaahi wabarakaatuh,

It is a great pleasure to be here and warmly welcome you all to this important gathering at the International Maize Conference, pertaining to the topic of **"Maize For Food, Feed And Fuel"**

The significance as well as the relevancy of this topic is particularly emphasized by the problem of the shifting balance between crops for food versus feed and fuel. Statistics show that for every 10 ears of corn that are grown in the United States today, only 2 are consumed directly by humans as food. The remaining 8 are used in almost equal shares for animal feed and for ethanol. This shift in balance between food and fuel may as well be the tipping point in world grain markets. China, once able to supply its internal corn demand, currently expects to import a few million tons of corn next year. This will likely place additional stress on maize market and industry.

I believe through this seminar, all participants will take the problems of this situation into account, coming up with new progressive ideas on the use of advanced technology and policies, to serve as an incentive in enhancing the maize production, in hopes of coping with future challenges.

Ladies and Gentlemen,

In 2050 the world's population will rise from 6 billion to 8 billion (33 percent) and half of them are in Asia. Consequently, the demand for food will increase by 50 percent, while the demand for water and energy will increase by 30 and 50 percent, respectively. Urbanization will continue at an accelerated pace, and about 70

Growth Characteristics of Three Cultivars Maize Plants in Symbiosis with Arbuscular Mycorrhiza Fungi

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ABSTRACT. This study aimed to investigate the growth characteristics of three cultivars maize plants in symbiosis with arbuskular mycorrhizal fungi. Greenhouse experiments are presented using a randomized block design factorial. The first factor is the cultivar of maize plant consists of three levels, namely: local maize cultivar Motoro (k1), hybrid corn cultivars Bisi-2 (k2), and composite maize cultivars Sukmaraga (k3). The second factor is the type of inoculant AMF (Arbuskular Mycorrhizal Fungi) consisting of two levels, namely: without inoculant AMF (m0) and inoculant AMF (m1) in the form of propagule consisting of spores, hyphae and roots infected with a dose of 7.5 g/plant. All combined treatment was repeated three times. The results showed that the growth characteristic of three cultivars of maize plants in symbiosis with arbuskular mycorrhizal fungi varies. Motoro maize cultivars had the highest rate of growth of plants compared cultivars Sukmaraga and Bisi-2. In contrast, leaf area index value of maize cultivars Bisi-2 higher than the cultivars Motoro and Sukmaraga. Motoro maize cultivars were more responsive to inoculation arbuskular mycorrhizal fungi compared with maize cultivars Sukmaraga and Bisi-2.

Key words: AMF, maize cultivars.

Introduction

For the development of agriculture in the province of Gorontalo, since 2001 the government has launched a program Agropolitan the commodity is maize. This option is very timely because of the availability of land suitable for planting maize in the Gorontalo quite extensive, reaching 158,000 ha and social conditions Gorontalo is already very familiar to the maize crop.

In the area of Gorontalo, the plant is widely cultivated maize composite Sukmaraga corn, corn Motoro (local varieties) and hybrid corn Bisi-2.

The problem is that the maize crop productivity is relatively low (about 4 t/ha) when compared with the potential result that around 10 t/ha (Mohammad 2006). To increase crop production has been attempted with both inorganic fertilizer single fertilizers such as Urea, SP-36 and KCl and compound fertilizer N, P, K on planting maize. However, the problem in acidic soils such as Ultisols and Inceptisols, most of the fertilizer is given will be left behind in the soil in a form that is not available to plants as fixed by ions of Al, Fe, and hydrous oxides of the metals. Furthermore, if the use of chemical fertilizers is done continuously with a large dose of concern may adversely affect a decrease in soil quality and the environment and energy waste.

Therefore, it is necessary to find the maize breeding efforts to save inorganic fertilizers, can improve soil quality and increase the productivity of crops on dry land.

These efforts can be done with rhizosphere microbial inoculated into the root zone. Microbial Inoculation aims to increase the effective useful microbial population. One of microbes that could potentially increase nutrient uptake and water resistance of maize to drought stress are arbuskular mycorrhizal fungi (Kandowangko 2004).

However, not all arbuskular mycorrhizal fungi have the potential to help even improve host plant growth. Because it relies on a combination of fungus and the host plant.

For that we need an alternative strived to improve the growth and yield of maize in marginal dry lands with inoculation arbuskular mycorrhizal fungi.

Materials and Methods

The design of experiments. Experiments have been prepared using randomized block desig factorial. The first factor is the cultivar of corn is composed of three levels, namely local maize cultivar Motoro (k1) of hybrid corn cultivars Bisi-2 (k2), and composite maize cultivars Sukmaraga (k3). The second factor is the type of inoculant AMF consisting of two levels, namely: without inoculant

AMF (m0) and inoculant AMF (m1) in the form of propagule consisting of spores, hyphae and roots infected with a dose of 7.5 g / plant. All combined treatment was repeated three times.

Implementation Trial. Seed maize is planted in accordance with a combination of treatment and maintained. The observations were made when corn plants aged 14-42 days after planting (DAP), the variables as follows: The rate of plant growth on average (RPG) a seven day is increase in plant dry weight per unit area of plant communities of land per unit time average of seven-day, calculated by formula Gardner *et al.* (1991):

$$RPG = \frac{1}{P} \times \frac{w_2 - w_1}{t_2 - t_1} \ (g\ m^2/day)$$

Leaf Area Index Average (LAI) seven day, the ratio of leaf area per unit ground area average seven-day period, calculated by formula Gardner *et al.* (1991)

$$LAI = \frac{LA_2 + LA_1}{2} \times \frac{1}{P} \ (cm^2/m)$$

Net assimilation rate average (NAR) seven day, the rate of addition of plant dry weight per unit leaf area per unit time average seven day period, calculated by formula Gardner *et al.* (1991)

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{In\ LA_2 + In\ LA_1}{LA_2 + LA_1} (g\ cm^2/day)$$

The symbolic meaning of letters in the formula (1), (2) and (3) are:

W = dry weight of plants (g)
LA = leaf area (cm^2)
t = time (days)
P = area of land (m^2)
Index 1 and 2 refer to the two-time sample sequence.

To measure leaf area used the gravimetric method is the measurement of leaf area was estimated by the weight ratio (Sitompul and Guritno 1995). The leaf area formula used is as follows:

$$Leaf\ Area = \frac{TWL}{WLS\ `} \times n \times \mu r^2$$

Notes: LA = Leaf area
TWL = Total weight leaves
WLS = Weight leaf samples
n = number of pieces of leaf
r = radius of pipe pit

Plant dry weight (dashed) and the roots, the plant was measured after the sample was dried in an oven at a temperature of 70ºC to a constant weight (approximately 48 hours).

Observations for characteristic grow RPG, LAI and NAR performed at 14, 21, 28, 35, 42 DAP, each at four plants destructive examples (Plants taken from two pits/ pots, each containing two crops planting hole).

Evaluation. Developmental characteristics of grew on average seven day period for four periods during the period of 14 to 42 DAP describe the dynamics of growth. Data obtained from five times the destruction plotted against the seven day period to form the curve characteristics grew by an average of seven-day as a function of the seven day period.

Result and Discussion

The Rate of Plant Growth (RPG)

The rate of plant growth on average (RPG) is increasing in plant dry weight per unit area of the plant community land per unit time averaged over a period of time. For this experiment, the rate of growth of plants used an average of seven daily for a period of 14-42 DAP.

The rate of plant growth on average for the three maize cultivars were inoculated either AMF or not, listed in Table 1 and Figure 1. From these data, it appeared that the rate of growth in average crop maize cultivars Sukmaraga and Motoro given inoculant AMF has increased rapidly when the plants are 21-35 DAP then subsequently decreased growth rate. In contrast to maize hybrids Bisi -2 inoculated AMF which had shown an increase in the rate of rapid plant growth when the plants are 35 DAP.

It was supposed to be influenced by genetic factors which age hybrid maize cultivars have a lifespan longer harvest is approximately 103 DAP when compared to maize cultivars with harvest Motoro 70-80 DAP. Furthermore, from the data in Table 1 and Figure 1, it seems that the three cultivars of maize plants inoculated AMF crop yield growth rate averages vary. Giving AMF inoculation on maize cultivars motoro who responded crop growth rate average of the highest when compared to maize cultivars Bisi-2 and Sukmaraga.

Leaf Area Index Average (LAI)

Leaf Area Index shows the average ratio between the active surface of green leaf photosynthesis by land area is covered by crops during the period.

Leaf area index of three maize cultivars appear listed in Table 2 and Figure 2. From these data it appears that the corn crop cultivars Sukmaraga given AMF inoculation had the highest LAI values compared with the other two maize cultivars.

Net Assimilation Rate Average (NAR)

Net assimilation rate shows the ratio between the area of the leaf lamina or tissues where photosynthesis takes place with total biomass. Net assimilation rate is a measure of the efficiency of leaf dry matter yield and is directly related to the ability of leaf photosynthetic activity. According to Gardner *et al.* (1991), the ability of plants produce dry matter can be studied through the NAR which is a measure of increase in plant dry weight per unit leaf area per unit time averaged over a period of time. From the data listed in Table 3 and Figure 3 turns NAR values of the three cultivars of maize is not static but varies lab value at every stage of corn growth. It was supposed to take part influenced by the role of AMF in helping plants absorb nutrients and water for plants and is also influenced by plant genetics and environmental conditions.

Table 1. The rate of plant growth on average of three cultivars of maize.

Cultivars of maize	AMF	Age of the plant (DAP)			
		14 – 21	21 – 28	28 – 35	35 – 42
Motoro	Without Inoculant (mo)	0.012	0.015	0.017	0.043
	Inoculant AMF (m_1)	0.006	0.005	0.064	0.035
Bisi – 2	Without Inoculant (mo)	0.007	0.008	0.024	0.036
	Inoculant AMF (m_1)	0.013	0.016	0.018	0.043
Sukmaraga	Without Inoculant (mo)	0.006	0.008	0.033	0.004
	Inoculant AMF (m_1)	0.011	0.013	0.037	0.008

Note: The rate of plant growth on average, with units g m^2 day^{-1}

Table 2. Leaf Area Index average of three cultivars of maize.

Cultivars of maize	AMF	Age of the plant (DAP)			
		14 – 21	21 – 28	28 – 35	35 – 42
Motoro	Without Inoculant (mo)	13.70	28.40	56.60	68.30
	Inoculant AMF (m_1)	10.60	23.30	69.10	93.10
Bisi – 2	Without Inoculant (mo)	9.83	17.92	21.33	40.37
	Inoculant AMF (m_1)	12.72	25.59	34.27	54.48
Sukmaraga	Without Inoculant (mo)	16.20	33.71	46.69	102.96
	Inoculant AMF (m_1)	15.04	38.45	61.75	119.49

Note: The rate of plant growth on average, with units g m^2 day^{-1}

Table 3. Net assimilation rate on average of three cultivars of maize.

Cultivars of maize	AMF	Age of the plant (DAP)			
		14 – 21	21 – 28	28 – 35	35 – 42
Motoro	Without Inoculant (mo)	0.004	0.004	0.002	0.004
	Inoculant AMF (m_1)	0.003	0.001	0.006	0.003
Bisi – 2	Without Inoculant (mo)	0.003	0.002	0.006	0.005
	Inoculant AMF (m_1)	0.005	0.004	0.003	0.005
Sukmaraga	Without Inoculant (mo)	0.002	0.002	0.005	0.003
	Inoculant AMF (m_1)	0.003	0.002	0.005	0.005

Note: The rate of plant growth on average, with units g m^2 day^{-1}

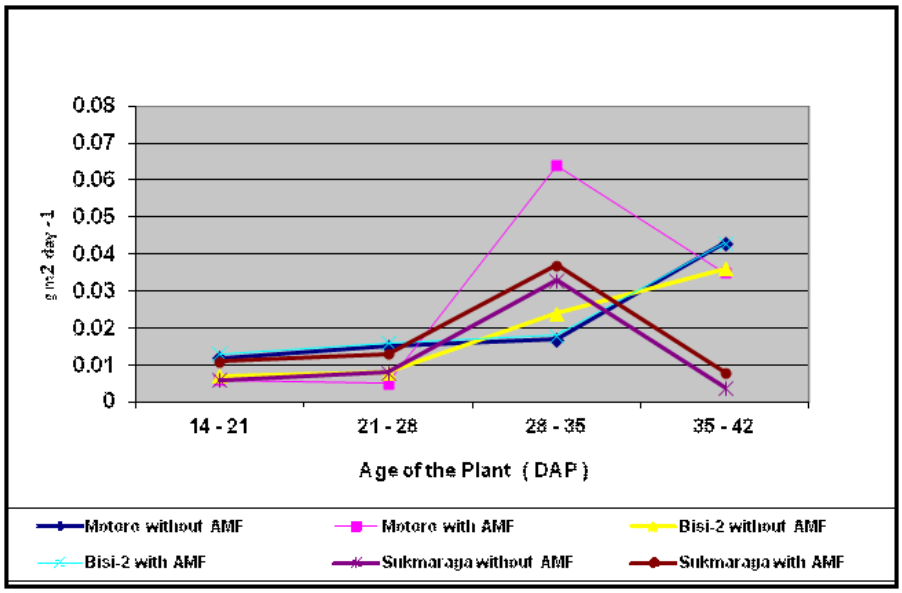

Figure 1. The rate of plant growth on average of three cultivars of maize.

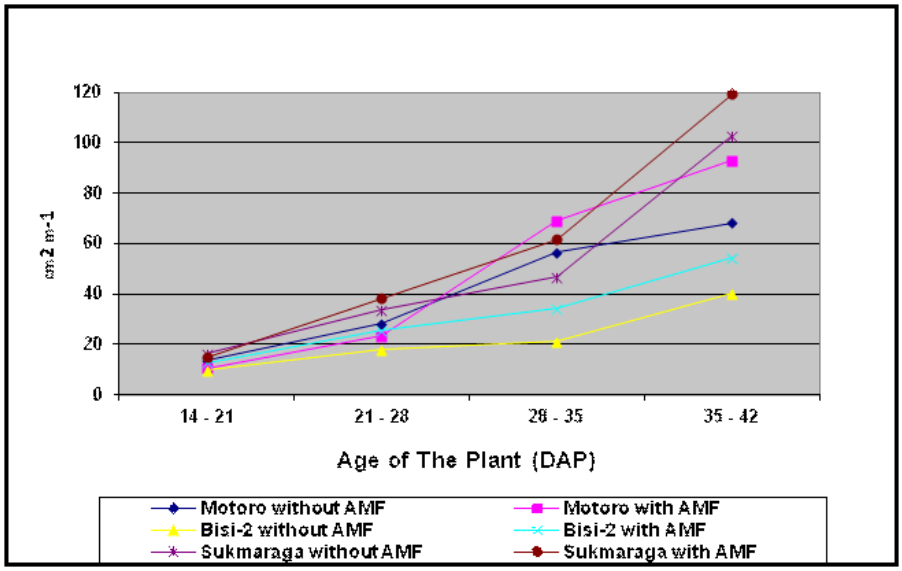

Figure 2. Leaf area index average of maize plants.

Dry Weight of Plants

Plant dry weight reflects the accumulation of organic compounds from the plant successfully synthesized organic compounds, and transported to the top of the plant (dashed) and the bottom of the plant (roots).

Based on the data listed in Table 4 and Figure 4, shows turns giving AMF inoculant on three maize cultivars that Motoro, Bisi-2 and Sukmaraga give a positive response. It appears from the dry weight of the plants were larger than plants that are not given inoculant AMF. However, of the three cultivars of maize cultivars apparently given Motoro AMF inoculants are more responsive to AMF inoculant delivery, when compared with the cultivar Bisi-2 and Sukmaraga. It appears on the dry weight of maize cultivars Motoro have a greater dry weight of 2.4 g/plant when compared with Sukmaraga cultivars differing only 1.8 g/plant and the Bisi-2 cultivars differing only 1.4 g/plant.

Table 4. Dry weight of three cultivars of maize plants in symbiosis with arbuscular mycorrhizal fungi.

AMF(g/polybag)	Cultivars of maize (g plant^{-1})		
	Motoro	Bisi 2	Sukmaraga
Without Inoculant (mo)	7.7	7.2	4.9
	9.8	5.2	8.3
	7.1	8.6	6.8
Average	**8.2**	**7.0**	**6.7**
Inoculant AMF (m_1)	10,4	8.2	10.0
	9.8	7.9	7.8
	10.9	9.0	7.8

Discussion

The dynamics of growth of three maize cultivars that vary in symbiosis with the AMF. It was due to the growth of a plant is influenced by the factors of the plant itself (genetic factors) and growth factors from the environment.

Maize plants in symbiosis with arbuscular mycorrhizal fungi will benefit. Because of the symbiosis, the host plant (maize) will acquire nutrients by arbuscular mycorrhizal fungi help, while fungi obtain photosynthate (of photosynthesis) from the host plant (Sieverding 1991).

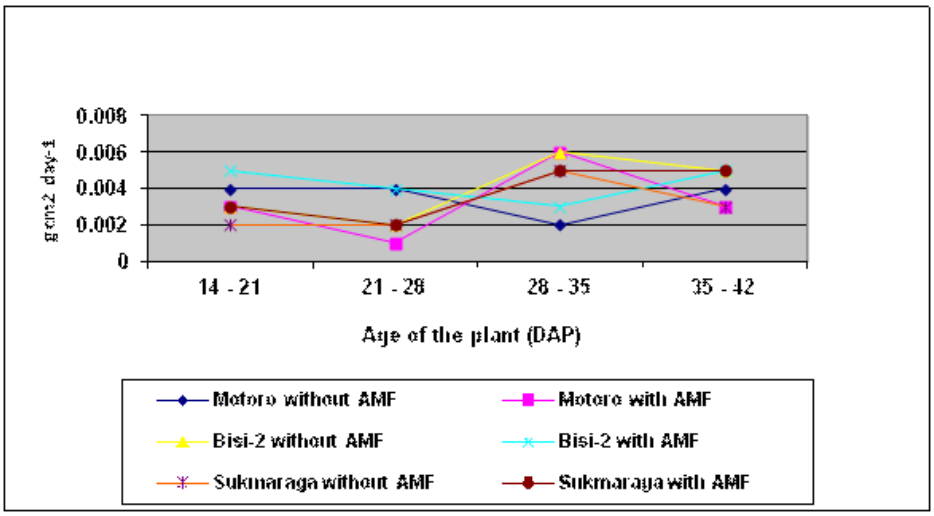

Figure 3. Net assimilation rate charts average of maize plants.

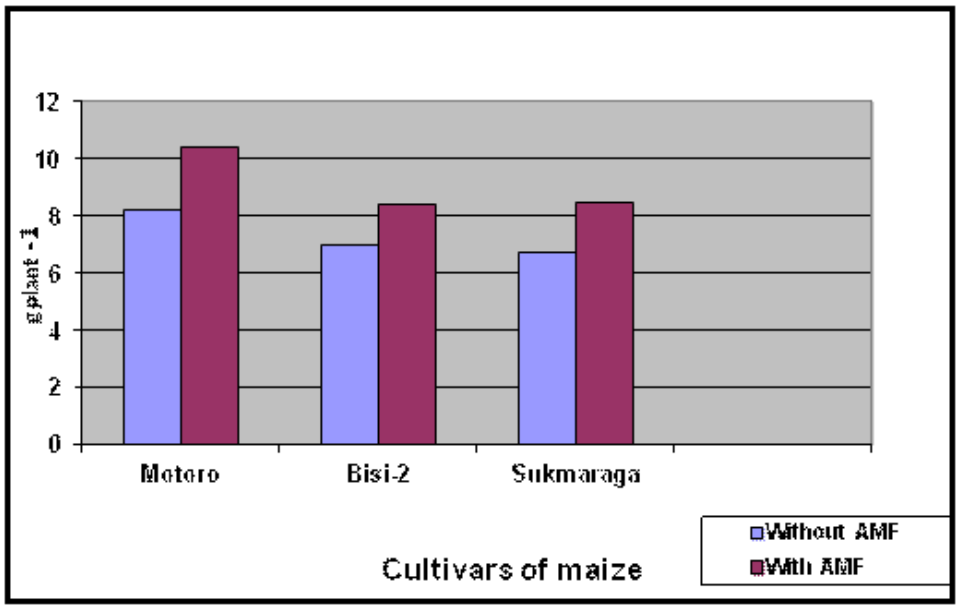

Figure 4. Dry Weight of three cultivars of maize plants when the plants are 42 DAP.

AMF inoculation on three maize cultivars role in the growth of corn plants. It appears on the variation of the rate of plant growth, leaf area index and net assimilation rate at each stage of plant growth.

The existence of AMF inoculation on maize cultivars third turned out to give a good response to the growth of maize. With the AMF the supply of nutrients to the growing need for photosynthesis so as to increase the area of the leaf as the main organ in the process of photosynthesis. Arbuscular mycorrhizal fungi can improve decision-phosphate, as proposed by Fitter and Hay (1992) that "advantages include decision mycorrhizal phosphate faster per unit root length than in plants not inoculated mycorrhizal".

In addition to phosphate, it arbuscular mycorrhizal fungi able to increase the absorption of nitrogen in plants (Kandowangko 2004). According to Tisdale et al. (1993) plants absorb nitrogen in the form of NO_3^- and NH_4^+. Nitrate (NO_3^-) is often the dominant source of N because it is generally present in higher concentrations compared to ammonium (NH_4^+) and NO_3^- ions are free to move to the roots via mass flow and diffusion. Marschner and Dell (1994), symbiosis with mycorrhizal plants helps the absorption of N from the soil only when N present in the form of ammonium (NH_4^+) ions as a form that is more difficult than the movement of nitrate (NO_3^-), ammonium uptake of the zone can be formed around the roots.

Furthermore Marschner (1995) suggested, in general, NH_4^+ absorbed merge into organic compounds in the roots, whereas NO_3^- are more cars on the xylem and also stored in the vacuole roots, canopy and storage organs. Accumulation of NO_3^- role in cation-anion balance and as osmoregulation. Gardner *et al.* (1991) states that the function of plant nitrogen is an essential ingredient constituent amino acids, amides, nucleotides, and nucleoprotein, and essential for cell division, cell enlargement, and it is important for growth. It causes plants inoculated arbuscular mycorrhizal fungi able to increase the value of RPG, LAI and NAR plants.

In plants that are not inoculated AMF, the supply of nutrient is limited so that the fulfillment is limited also. This condition causes the inhibition of vegetative growth of plants including photosynthesis organ growth affecting low value of RPG, NAR, LAI and dry weight of plants.

Conclusion

Based on the results of experiments that have been described, it was concluded that the growth characteristics of three cultivars of maize plants in symbiosis with arbuscular mycorrhizal fungi vary. Motoro maize cultivars had the highest rate of growth of plants compared cultivars Sukmaraga and Bisi-2. In contrast, maize cultivars Bisi-2 leaf area index value higher than the cultivars Motoro and Sukmaraga.

Motoro maize cultivars were more responsive to mycorrhizal fungi inoculation arbuskula giving compared with maize cultivars Sukmaraga and Bisi-2.

Based on the results of this study suggested that the trial is expected to continue in the trial court till generative growth of maize plants.

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bekerja sama dengan
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SERTIFIKAT

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Novri Youla Kandowangko

yang telah berpartisipasi sebagai:

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dalam

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Gorontalo, 22-24 November 2012

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