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Evaluation of Various Commercially Available Biofertilizers on Grain Yield of Hybrid Maize under Field Conditions at South Sulawesi, Indonesia

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Abstract A field experiment was conducted on a farmer's field in Gowa, South Sulawesi, Indonesia from 6th April to 18th July 2013. Texturally, the soil was a silt loam with pH of 5.2, 1.07% organic matter, 0.12% total nitrogen, 41.60 mg kg^{-1} available phosphorus and 0.75 mg kg^{-1} available potassium. The experiment was aimed to evaluate the application of commercially available bio fertilizers on hybrid maize CV. Bima 19 URI grain yield in comparison with conventional fertilizers and control. The experiment included of 16 treatments i.e. no fertilizer as control; recommended dose (230 N+ 36 P_2O_5 + 60 K_20 kg ha^{-1}); 50% recommended dose(115 N+18P_2O_5 + 30 K_20 kg ha^{-1}); 50% recommended dose (115 N+18P_2O_5 + 30 K_20 kg ha^{-1}) + compost 2 t ha^{-1}; 70% recommendation dose (172.5 N+ 22.5 P_2O_5 + 60 K_20) kg ha^{-1};75% recommendation dose (172.5 N+ 22.5 P_2O_5 + 60 K_20 kg ha^{-1}) + compost 2 t ha^{-1}; compost 2 t ha^{-1}; plus 9 commercially bio fertilizers such as Beyonic; Bio-Padjar; Probio-New; Super Biost; Bion-UP; Bio-SRF; Agrofit; Biopim and Biocoat. The experiment was conducted in Randomized Complete Block Design arrangement with three replications. The result of the experiment showed that bio fertilizer significantly influenced leaf chlorophyll; NPK leaves levels, plant height, kernel row, ear length, 1000 grains yield and grain yield. The highest grain yield was obtained with Bio-Padjar 10.06 t ha^{-1} followed by Beyonic 10.04 t ha^{-1}, Biopim 9.96 t ha^{-1}, Bion-UP 9.82 t ha^{-1}, Super Biost 9.80 t ha^{-1}, Biocoat 9.77t ha^{-1}, Agrofit 9.76 t ha^{-1}, and Probio-New 9.73 t ha^{-1}. Contribution of biofertilizers increased grain yield vary in ranged from 5.83 – 8.52% and reduce 25 - 50% chemical fertilizer recommendation dose.

Keywords BioFertilizer, Chemical Fertilizer, Hybrid Maize, Yield

1. Introduction

Maize is one of the most important cereal crops in the world agricultural economy both as food for man and feed for animals. It has very high yield potential, there is no cereal on the earth which have so immerse potentiality and that is why it is called "King of Cereal" (Ali and Anjum 2017). Under the present trend of exploitive agriculture in Indonesia, inherent soil fertility can no longer be maintained on the sustainable basis. The nutrient supplying capacity of soil declines steadily under continuous and intensive cropping systems. The bio fertilizers are found positive contribution to soil fertility, resulting in an increase in crop yield without causing any environmental, water or soil pollution hazards. Bio fertilizers are the formulations of living organisms, which can fix atmospheric nitrogen in the soil and thereby, increasing the crop yield. In order to promote environmental friendly sustainable agriculture in Indonesia, government agency and university produce bio fertilizers when applied to the seed, plant or soil surfaces will encourage plant growth by increasing the supply of main nutrients, while reducing the environmental burden of excessive use of chemical fertilizers.

Chemical fertilizers pose a health hazard and affect the microbial population in soil by degrading the physical structure of the soil, leading to a lack of oxygen in the plants root zone, besides being quite expensive and making the cost of production high (Nagananda et al. 2010). Application of chemical fertilizer that is excessive and continuous can have negative impacts on the health of the soil and the environment, therefore to reduce these impacts; the use of organic fertilizer containing microbes can be used as an alternative to improve soil fertility. Increased productivity of maize on dry land can be done through a combination of the technology, especially the use of nutrient efficient varieties, rational fertilization practices and the expansion of planting area (Moelyohadiet al. 2012). However, a reduction in fertilizer subsidy in 1998 resulted in a scarcity of fertilizer in the field, increasing fertilizer prices, fertilizer supply and distribution is uneven between regions and the emergence of new types of fertilizers or

formula of unknown quality, effectiveness and efficiency levels. In addition, increasing use of chemical fertilizers is considered less effective and not efficient as well as leads to less favorable impact on the health of soil. Considered that, increasingly recognized the importance of using organic materials and bio fertilizers on the soil nutrient management (Munandar et al. 2009).

Bio fertilizers are the formulations of living organisms, which are able of fixing atmospheric nitrogen in the available form to plants, either by living freely in the soil or being and associated symbiotically with plant and thereby, increasing the crop yield (Chandrasekar et al. 2005). Bio fertilizer is usually contains microorganism having specific function such as Azospirillum to fix nitrogen and P solubizing bacteria to solubilize P from the soil and fertilizer to be available to the plants (Saraswati and Sumarno 2008). Bio fertilizer added to a soil to directly or indirectly make certain essential elements available to plants for their nutrition of bio fertilizers include nitrogen fixers, phytostimulators, phosphate solubilizing bacteria to solubilize P from the soil and fertilizer, plant growth promoting rhizobacteria (Shekh 2006). In order to promote environmental friendly sustainable agriculture some agency and university produce biofertilizers using beneficial microorganisms, which increase the yields of crops while reducing the environmental burden of excessive use of chemical fertilizer. Declining soil fertility due to the increased use of chemical fertilizer and continues to be a problem. An excessive chemical fertilizer efficiency is low so that the necessary efforts to improve fertilizer efficiency and the use of bio fertilizers that are environmentally friendly. Application of bio fertilizers became of great necessity to get a yield of high quality and to avoid the environmental pollution (Shevananda, 2008). For attaining highest grain yield in agriculture, addition both nitrogen and phosphate fertilizer is very important (Shaban 2013a, Shaban 2013b). The experiment aimed to evaluate various commercially available bio fertilizer on grain yield of hybrid maize under field conditions.

2. Materials and Methods

The experiment was conducted in a farmer's field in Gowa, South Sulawesi, Indonesia during the dry season from 6th April to 18th July, 2013. Variety used was hybrid maize of Bima 19 URI. The experiment included of 16 treatments i.e. no fertilizer as control; recommended dose (230 N+ 36 P_2O_5 + 60 K_20 kg ha^{-1}); 50% recommended dose(115 N+18P_2O_5 + 30 K_20 kg ha^{-1}); 50% recommended dose (115 N+18P_2O_5 + 30 K_20 kg ha^{-1}) + compost 2 t ha^{-1}; 70% recommendation dose (172.5 N+ 22.5 P_2O_5 + 60 K_20) kg ha^{-1};75% recommendation dose (172.5 N+ 22.5 P_2O_5 + 60 K_20 kg ha^{-1}) + compost 2 t ha^{-1}; compost 2 t ha^{-1}; plus 9 commercially biofertilizers such as Beyonic (Indonesian Institute of Sciences, LIPI), Bio-Padjar (Padjadjaran University, Unpad), Probio-New (Bogor Agricultural University, IPB), Super Biost (IPB), Bion-UP (Unpad), Bio-SRF (Technology Assessment and Application Agency, BPPT), Biopim (BPPT), Biocoat (BPPT), and Agrifit (Indonesian Agency for Agricultural Research and Development, IAARD). Planting distance was 75 cm x 20 cm, 1 plant hole^{-1} (population 66,666 plants ha^{-1}). The land was prepared with gramoxone herbicide sprayed a rate of 4 liters ha^{-1}. The size of the plot is 6 m x 4 m. Before sowing, seeds were mixed with saromil to prevent *downy mildew* disease a rate of 2.5 g kg^{-1} seed. Pests were controlled with furadan 3 G, which is applied at the planting time in the hole of the seeds and 15 days after planting (dap), applied in the tops of the leaves of plants at 5 kg ha^{-1}, respectively. Irrigation was given at 10 days interval during crop growth. Irrigation was stopped two weeks prior to harvest of the crop. The experiment involved in randomized complete block design with three replications. The all P, 50% N and 50% K fertilizers dose was applied at 10 dap. The rest of N and K were applied at 30 dap. Soil sample from location site was analyzed at ICERI laboratory, Maros. Soil sample for analysis was taken before starting the research to analysis of soil texture, pH, organic C, total of N content, available P, and available K. Data were collected includes: leaf chlorophyll and NPK leaves level (%) at 56 dap; plant height (cm) and ear height (cm) at 60 dap; kernels row, 1000 grain-weight (g) and grain yield (t ha^{-1}) at 15% moisture content.

3. Results and Discussion

3.1. Leaf Chlorophyll

The analysis of variance revealed that bio-fertilizer was significantly influenced on leaf chlorophyll content. Leaf chlorophyll content of bio fertilizer treatment ranged from 48.1 to 55.9 mg g^{-1} (Table 1).The chlorophyll molecules normally absorb light from the red and blue portions and reflect or transmit the green portion of the spectrum.

Chlorophyll is commonly recognized as giving plants their characteristic green color. High rates of photosynthesis are associated with plants that have a healthy, rich green color due to sound crop production practices such as fertilizer applications that encourage chlorophyll development. Chlorophyll is a pigment that has a clear impact on the spectral responses of plants, mainly in the visible spectrum portion. N is a key element in chlorophyll, therefore is usually a high correlation between them (Schlemmer et al. 2005). Chlorophyll content has been suggested as predict the community property most directly relevant to the portion of productivity (Dawson et al.2003). According to Effendi et al. (2012) the critical level of leaf chlorophyll on maize at V12 is $\leq$ 51 mg g^{-1}.

3.2. N, P and K Leaves

Analysis variance revealed that bio fertilizer was

significantly influenced N, P and K leaves level at 56 dap. The highest level of N leaves was Super Biost 2.76% N. The highest level of P leaves was Bio Padjar0.46% P. The highest level K leaves was Agrofit2.99% K (Table1).Bio fertilizer provides necessary nutrients to the plants by using the function of microbes. It can fix atmospheric nitrogen (N_2) and converts it to ammonia. Ammonium (NH_4^+) is oxidized to nitrate (NO_3^-) to make them available to plant. In this case, bio fertilizer creates and provides the nutrient to the plants directly, but most of microbes in bio fertilizer help and promote nutrient absorption of plants from the soil and applied fertilizers. In a case of Azospirillum, which is the nitrogen-fixing bacterium living at the rhizosphere; it is thought that plant growth promotion effect by bio fertilizer is come from its ability to produce phytohormone to stimulate root growth for their effective nutrient absorption in asoil and not because of its ability of nitrogen fixation. Therefore, it needs available nutrients in soil to activate this function. Also phosphrous-solubilizing microbes, which solubilizes phosphoric acid to help the absorption by the plants, only works when there is enough source of phosphoric acid in the soil (Machi 2014).

3.3. Plant Height

Analyses of variance showed that bio fertilizers significantly influenced on plant height at 60 dap. The highest plant height was Beyonic 191.3 cm (Table 2). Beyranvand et al. (2013) suggested that effect of nitrogen and phosphate bio fertilizers were evaluated positively, there were an increase in plant height.

3.4. Kernel Row and Ear Length

Analyses of variance revealed that bio fertilizer significantly influenced on kernel row. The highest kernel row was Beyonic 14.6 (Table 2).

Analyses of variance showed that bio fertilizer significantly influenced on ear length. The highest ear length was Super Biost 19.9 cm followed by Beyonic 19.4 cm and Bion- UP 19.3 cm (Table 2).

Table 1. The effects of different biofertilizer on leaf chlorophyll and N, P and K leaves of hybrid maize.Gowa, South Sulawesi, Indonesia. 2013

Treatments	Leaf Chlorophyll (mg g^{-1})	Leaves Level (%)		
		N	P	K
No fertilizer (control)	32.5 c	2.00 b	0.44 ab	2.70 ab
Recommendation dose (230 N + 30 P_2O_5 + 60 K_2Okg ha^{-1})	55.3 a	2.53 ab	0.43 abc	2.30 b
50% recommendation dose (115 N+ 15 P_2O_5+ 30 K_2Okg ha^{-1})	53.1 a	2.67 a	0.43 abc	2.64 ab
50% recommendation dose (115 N+ 15 P_2O_5+ 30 K_2Okgha^{-1})+ compost 2 t ha^{-1}	53.4 a	2.73 a	0.43 abc	2.89 a
70% recommendation dose (161 N+ 21 P_2O_5+ 42 K_2Okg ha^{-1})	53.1 a	2.42 ab	0.42 abc	2.94 a
75% recommendation dose (172.5 N+ 22.5 P_2O_5+ 45 K_2Okg ha^{-1}) +compost 2 t ha^{-1}	55.6 a	2.56 ab	0.43 abc	2.91 a
Compost 2 t ha^{-1}	32.8 c	2.42 ab	0.43 abc	2.97 a
Beyonic +compost 2 t ha^{-1}	53.4 a	2.36 ab	0.41 abc	2.82 ab
Bio-Padjar +compost 2 t ha^{-1}	54.3 a	2.71 a	0.46 a	2.64 ab
Probio-New	52.5 a	2.33 ab	0.42 abc	2.90 a
Super Biost	54.5 a	2.76 a	0.39 bc	2.81 ab
Bion-UP +compost 2 t ha^{-1}	52.0 a	2.73 a	0.38 c	2.50 ab
Bio-SRF	48.1 b	2.18 ab	0.45 ab	2.50 ab
Biocoat	54.6 a	2.64 ab	0.43 abc	2.70 ab
Biopim	55.9 a	2.47 ab	0.45 a	2.71 ab
Agrofit	52.0 a	2.63 ab	0.43 abc	2.99 a
CV (%)	4.4	13.5	6.8	10.9

Means within columns with the same letter are not significantly different at 5% level based on DMRT

Table 2. The effects of different biofertilizer on grain yield and yield componentsof hybrid maize.Gowa, South Sulawesi, Indonesia. 2013

Treatments	Plant height (cm)	Kernel row	Ear length (cm)	1000 grain weight (g)	Grain yield (t ha^{-1})
No fertilizer (control)	135.3 c	12.2 c	13.1 e	271 cd	5.54 f
Recommendation dose (230 N + 30 P_2O_5 + 60 K_2Okg ha^{-1})	175.3 ab	13.9 a	18.4 ab	315 a	9.27 bc
50% recommendation dose (115 N+ 15 P_2O_5+ 30 K_2Okg ha^{-1})	175.7 ab	13.5 abc	16.5 cd	302 ab	7.49 e
50% recommendation dose (115 N+ 15 P_2O_5+ 30 K_2Okgha^{-1})+ compost 2 t ha^{-1}	181.7 ab	13.1 abc	17.8bcd.	304 ab	7.81 de
70% recommendation dose (161 N+ 21 P_2O_5+ 42 K_2Okg ha^{-1})	179.3 ab	14.1 a	17.6 bcd	304 ab	9.23 c
75% recommendation dose (172.5 N+ 22.5 P_2O_5+ 45 K_2Okg ha^{-1}) +compost 2 t ha^{-1}	186.0 ab	14.5 a	17.7 bcd	279 cd	9.70 abc
Compost 2 t ha^{-1}	130.3 c	12.3 bc	11.5 f	295 abc	5,99 f
Beyonic +compost 2 t ha^{-1}	191.3 a	14.6 a	19.4 ab	298 abc	10.04 a
Bio-Padjar +compost 2 t ha^{-1}	189. ab	13.9 a	18.9 ab	308 ab	10.06 a
Probio-New	183.7 ab	13.7 ab	18.6 ab	297 abc	9.73 ab
Super Biost	180.7 ab	14.2 a	19.9 a	301 ab	9,80 a
Bion-UP +compost 2 t ha^{-1}	179.7 ab	13.1 ab	19.3 ab	310 ab	9,82 a
Bio-SRF	163.0 b	13.6 ab	16.4 d	281 bc	8,18 d
Biocoat	175.0 ab	14.4 a	19.1 ab	316 a	9,77 ab
Biopim	178.7 ab	14.0 a	18.0abcd	307 ab	9.96 a
Agrofit	174.3 ab	13.6 ab	18.3 abc	294 abc	9.76 a
CV (%)	7.6	5.5	5.5	5.3	8.2

Means within columns with the same letter are not significantly different at 5% level based on DMRT

3.5. Grain Yield and 1000 Grain-Weight

Analysis of variance showed that bio fertilizers significantly influenced grain yield. Data in Table 2 revealed that bio fertilizer produced grain yield ranged from 8.18 t $ha^{-1}$to 10.06 t ha^{-1}. Bio Padjar produced the highest grain yield 10.06 t ha^{-1} followed by Beyonic 10.04 t $ha^{-1}$and Biopim9.96 t ha^{-1}(Table 2).

Analysis of variance indicated that bio fertilizers significantly influenced 1000 grains weight. Biocoat produced the highest 1000 grains weight 316 g (Table 2).

Table 3. Grain yield increase of different bio fertilizers compare recommendation dose

Bio fertilizers	Grain Yield Increase (%)
Bio Padjar	8.52
Beyonic	8.31
Biopim	7.44
BionUP	7.01
Super Biost	6.80
Bio Coat	6.47
Agrofit	6.15
Probio- New	5.83

Contribution of bio fertilizers increased grain yield vary in ranged from 5.83 – 8.52% and reduce 25 - 50% chemical fertilizer recommendation dose (Table 3). Beyranvand (2013) stated that in long term studies showed a significant contribution of bio fertilizer for the yield increase of the field crops, which vary in range from 8 – 30% of control value depending on crop and soil fertility. Grain yield increase was reported with the bio fertilizer applications which account important benefit to the maize producers and maize production, causing decreasing in the inputs of production because of economizing much money to chemical fertilizers and increasing in grain yield (Azimi et al.2013). It is impact on the nutrient availability and growth, which positively influenced the maize photosynthesis and dry matter accumulation more actively that agree with Lin et al. 1983, Shevananda, 2008 and Beyranvand 2013.

4. Conclusions

Bio fertilizer significantly influenced leaf chlorophyll, NPK leaves levels, plant height, kernel row, ear length, 1000 grains yield and grain yield. The highest grain yield was obtained with Bio-Padjar 10.06 t ha^{-1} followed by Beyonic 10.04 t ha^{-1}, Biopim 9.96 t ha^{-1}, Bion-UP 9.82 t ha^{-1}, Super Biost 9.80 t ha^{-1}, Biocoat 9.77t ha^{-1}, Agrofit 9.76 t ha^{-1}, and Probio-New 9.73 t ha^{-1}. Contribution of bio fertilizers increased grain yield vary in ranged from 5.83 – 8.52% and reduce 25 - 50% chemical fertilizer recommendation dose.

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