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EFFECT OF BIO-INORGANIC FERTILIZER ON PRODUCTIVITY IMPROVEMENT OF WELL ADAPTED LOCAL MAIZE (*Zea mays ceratina* L.) VARIETY

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ABSTRACT

Exploitation of four inoculant formulas as biofertilizer purposes were mixed with chemical fertilizer (bio-inorganic fertilizer) application has been carried out. Chemical fertilizer used at gradual rate submission of a half, a quarter, and down to zero of doses stand to full fertilizer application in the quantity of 100 kg Urea and 300 kg NPK per ha. The study was performed in three replicates, and fourteen of treatments including the control with and without chemical fertilizer, were arranged in randomizes design by using two cultivar of adaptive local maize of *Zea mays ceratina* L. (*Batara Punu* or Waxy-corn and *Batara Kuasa* or Rice-corn) and compared to Faramita as hybrid one. Plant samples selected randomly from any field plot of treatments to calculate plant growth acceleration throughout plant biomass accumulation and its soil biological activity along with the vegetative growth. Afterwards, harvest fact monitored for yield quality within total plant biomass, grain number per ear, hundred seed weight, and harvest index were measured. Result of the conduct test informing that biofertilizer based on microbial application is an effort to minimize dependency on chemical fertilizer purposes having success. Microbial simbiont used within the plants intended to trim down chemical fertilizers supply even the possible' dose can be reduced to zero. In order to have maize yield, it could be a strategy for achieving sustainable agriculture through this fertilizer management plan for the local corn cultivation.

Keywords: *Zea mays ceratina* L., biofertilizer, inorganic fertilizer, mixed of bio-inorganic fertilizer.

INTRODUCTION

Biofertilizer utilization becomes urgent to substitute or mix it up to a single chemical fertilizer application. Single uses of chemical fertilization continuously caused to several negative impacts of the soil and water environment pollution and weaken the sustainable agriculture structure. Moreover, biofertilizer was recommended to use as due to growth prompting microorganism produce plant nutrient and replaced the chemical fertilizers function (Wu *et al*., 2005). The bacteria are helpful to plant growth support including *Azotobacter*, *Azospirillum*, *Pseudomonas* and *Rhizobium* (Zahir *et al*., 2004; Antonius *et al*., 2005; Turan *et al*., 2006; Banerjee *et al*., 2006; Antonius *et al*., 2007). Organic substance in soil would be mineralized by microbes through enzymatic processes turn into plant nutritive value as well as plant growth factor (Waldrop *et al*., 2000; Crecchio *et al*., 2006; Makoi and Ndakidemi, 2008; Rahmansyah *et al*., 2009).

In the other hand, Mehrvarz *et al.* (2008) in their study showed that maximum protein in barley (*Hordeum vulgare* L.) was obtained by pertaining phosphate solubilizing microorganisms. Biofertilizer combined with a half dose of chemical fertilizers (nitrogen, phosphorus and potassium) was led to increase in plant growth, plant height, branch number, fresh and dry weight of safflower (Asteraceae); in comparison to applying of chemical fertilizers alone, also utilization of *Azotobacter* biofertilizer, biophosphate fertilizer, organic fertilizers, and half rate of chemical fertilizer, which is all generate its grain yield balance (Ojaghloo *et al*., 2007). Maize yield improved by application of biological phosphate fertilizer, too; that it could be due to raise other nutrient absorption, and also to increase phosphate and micronutrient sorption in the alkaline soil. Utilization of biological phosphate fertilizers with chemical phosphate fertilizer in addition to enlarge maize yield could be a strategy to achieve sustainable agriculture (Yosefi *et al*., 2012).

Biofertilizer based on microbial application is an effort to minimize dependency on chemical fertilizer purposes. The use of microbial simbiont within the plants intended to trim down chemical fertilizers supply even the possible' dose can be reduced to zero. Through microbial enzymatic processes, organic substance could be mineralized and turn into inorganic substances to provide phosphate, nitrogen, potassium and other nutrient that can be absorbed by maize. Transformation processes of macro and micro elements can occur from soil to plants when it was determined by the existence of phosphate solubilizing bacteria and nitrogen-fixing bacteria as well as root exudates supporting which are lead the way to symbiotic progression (Bais *et al*., 2006). Therefore, exploitation of soil microbial through biofertilizer mixed with chemical fertilizer application might have a strong role for the plant nutrients supply to the local adaptive Waxy-corn and Rice-corn productivity; and so do the research conducted at this moment.

METHODOLOGY

The research was carried out in Bajeng Field Research Station (119°30'27.7" E and 05°18'35, 5" S), in South Sulawesi, Indonesia, during July to October growing season of 2012, which is a representative land at

39m above sea level. Soil chemical analysis and its biological properties provide in the Table-1.

Tabel-1. Soil chemical and biological properties

Soil chemical	Nitrogen (%)	Phosphorous (%)		Potasium (%)	Micronutrient (%)			Acidity (pH)	
		organic	[1]Inorganic		Calcium	Magnesium	[2]Iron	H_2O	KCl
	0.31±0.09	0.61±0.23	6.82±1.39	5.51±1.42	6.16±1.92	2.62±0, 57	11.92±2	5.14±0.15	4.91±0.19
and biological circumstance in previous to plant	[3]Soil respiration			[4]Acid phosphatase activity			[4]Urease activity		
	4.05±0.17			0.29±0.11			47.04±22		

[1]mg.kg^{-1}; [2]ppm; [3]mg CO_2.gram-soil^{-1}.hour^{-1}; [4]Unit.gram-soil^{-1}

The study was performed in plot experiment with three replicates; fourteen treatment of bio-inorganic fertilizer treatment (Table-2), arranged in randomizes complete design with using three cultivars of corn, consist of local maize (*Batara Punu* or Waxy-corn and *Batara Kuasa* or Rice-corn) and compared to Faramita as corn-hybrid cultivar. This experiment constitutes to form 126 plots; each plot's length was 10 m and 2.25 m width with four planting row at 75 cm distance between rows. Seeds were planted with 20 cm spacing between each other. Length between of main plots belongs to maize variety was 100 cm and range between subs plots following the treatment was 60 cm away. Chicken manure was amended with organic substance to amount of 8500 g per plot, for the entire plots before treatment.

In this experiment, biofertilizer (50 ml liquid inoculant per plant) bring into combination with inorganic fertilizer (Urea 100 kg/ha and NPK 300 kg/ha) and utilized as bio-inorganic fertilizer. The used of certain inoculant formulas contain microbial plant stimulator of *Aspergillus, Azotobacter, Azosprillum, Lactobacillus, Rhizobium* and *Pseudomonas*. Those inoculants were produced by institution (Indonesian Institute of Sciences) in sustaining to the organic farming program. The inoculant created into four combination formula of biofertilizer, separately and used as treatment (see Table-2). In the experiment, those inoculants assorted within a half, a quarter and down to zero of doses based on full fertilizer application in the quantity of 100 kg Urea and 300 kg NPK per ha.

Tabel-2. Inoculant exploited in soil and use with different fertilizer doses to make as "Bio-inorganic fertilizer" practice in the field treatment, including "Manure" and "Full dose of NPK" as the control treatment

Code	Name of inoculants used	Microbial constituent	Substance enrichment and its function	Treatment code for field inoculant practicing mixed with:		
				Zero NPK*	¼ NPK	½ NPK
A	Beyonic. Star Tmik	Phosphate solubilizing and nitrogen fixing bacteria, including biocontrol and bioremediation function	Microbial producing biocatalyst and plant growth hormone, and biocontrol for *Fusarium*	Iz-A	Iq-A	Ih-A
B	EM-121	*Aspergillus* sp.	Rhizomes extract (*Curcuma* sp, *Cymbopogon* sp, *Alpinia* sp and *Kaempferia* sp) augmented into inoculant for supporting plant microbes interaction	Iz-B	Iq-B	Ih-B
C	Bio-121	*Aspergillus* sp.	Eggs of *Pomacea caniculata* (Lamarck, 1819) as enrichment media to produces IAA	Iz-C	Iq-C	Ih-C
D	POC. Mega Rhizo	*Azotobacter, Azosprillum, Lactobacillus, Rhizobium, Pseudomonas* and *Aspergillus*	Microbial producing biocatalyst and plant growth hormone	Iz-D	Iq-D	Ih-D

*****NPK means mixed fertilizer of Urea and NPK at 100 and 300 kg ha^{-1}

Irrigation was performed once a week up to last stage of plant vegetative growth. Subsequent to tasseling stage, irrigation was made accordingly to evaporation levels, up to last stage of plant growth. After emergence

and establishment of plants in 10-15 cm as seedling height stage, thinning was done to maintain a stronger plant and keep in the desirable density. Vegetative plant growth calculated within the biomass weight of plant samples at three weeks after seed sawing, as well as biolgical property through soil sampling. On the harvesting time, five randomized selected plants samples in each plot were assessed its traits take within total plant biomass, grain number per ear, hundred seed weight, and harvest index were measured. Statistical calculations were doing by STATVIEW-SAS software and means comparison by Duncan's Multiple Range Test (Parker, 1979). The charts were performed by Window program.

RESULTS AND DISCUSSIONS

Plant growth effect

All seed maize cultivar were sprouting responsively to soil amended with organic chicken manure as basal fertilizer in the plots, and its improvement are exceed to all of the seedling growth in the soil treated with both fertilizer and biofertilizer during three weeks after seed sawing (Figure-1). The local varieties were not responsive in their growth at the beginning due to inorganic fertilizer (NPK) action. Afterward, Faramita cultivar takes an advantage as due to bio-inorganic fertilizer reaction evaluated to local cultivar growth improvement. Incorporation of smaller NPK doses with biofertilizer containing microbial inoculant in local maize cultivar had the potential to compare with full dose of NPK fertilizer. Jilani *et al*. (2007) informed through their study on the maize growth and its yield because of plant responsibility to biofertilizer application. Biological activity in soil samples gathered from 3 weeks cultivation period varied as due to treatment was revealed in Figure-2. Increasing in soil respiration showed highly activities because of EM-121 and POC. Mega Rhizo treatment in soil combined with a half dose of NPK fertilizer, as well as urease activity in soil sample deprived from Waxy-corn cultivation. A highest percentage activity of phosphatase enzymes (acid phosphomonoesterase) was also occurred in soil because of microbial performance which is derived from Beyonic. Stra Tmik and BIO-121.

Naserirad *et al*. (2011) was informing that effective treatment for maize cultivation become successful with *Azotobacter* and *Azospirillum* inoculation, separately. Double-inoculation of both inoculants was the most effective treatment in all maize cultivars. This is indicated that fertilizers used as double-inoculation caused to increasing maize yield through synergistic effects by improving growth prompting hormones. Application of biofertilizer has given the highest maize grain yield as El-Karmany (2001) revised. The result showed that incorporated chemical and biological fertilizer obtained highest kernel number per cob compared to sole application of them. Those combination in application was beneficial to the soil environment improvement because with decreasing the use of chemical fertilizer and use of organic inputs would increase the efficiency of water (Zarabi *et al*., 2011), and lastly, creating optimum photosynthetic processes and due to stimulate plant growth and development, too. *Trichoderma* isolates on plant growth and development have important economical implications such as shortening the plant growth period and time, as well as improving plant vigor to overcome biotic and/or abiotic stresses, resulting in increase plant productivity and yields. In addition, the reduction in lignifications which was induced by *T. harzianum* strain T22 has a beneficial effect in enhancing fresh state of *Zea mays* stalks (Akladious and Abbas, 2012).

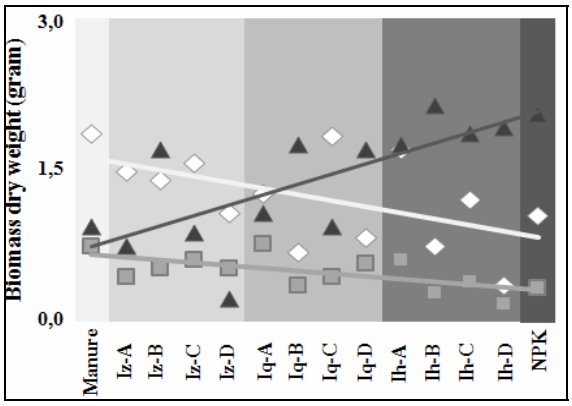

Figure-1. Three weeks plant biomass in response to treatment was proved by local Waxy (◊) and Rice-corn (■) compared to hybrid cultivar of Faramita (▲). Only hybrid cultivar gives positive reaction since the early growth to NPK and EM-121 (Iz/Iq/Ih-B) as bio-organic fertilizer management, respectively (absis notation is the same as in the Table-2).

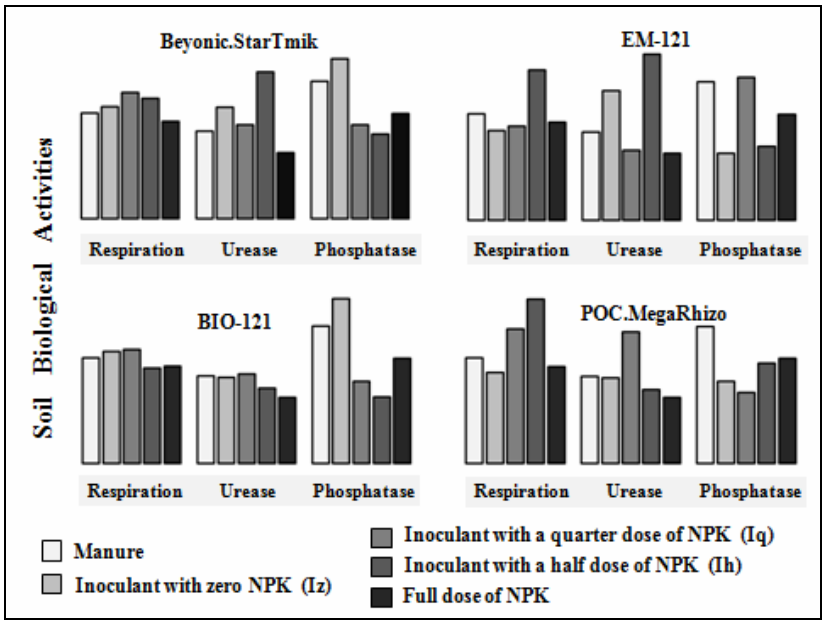

Figure-2. Representing the percentage microbial life activities and mineralization process in the soil samples collected from Waxy-corn cultivation area as due to treatment at the period of three weeks vegetative growth.

Upshot in soil biological competence which was sampled from Waxy-corn cultivation in the vegetative period was designated in Table-3. Soil respiration increase along with NPK fertilizer from a quarter to a half doses, afterward the activity turn down in full NPK doses adjustment. Phosphatase enzyme (acid phospho-monoesterase) activities were fluctuated under control level (manure and full NPK doses) because of bio-inorganic fertilizer purposes, and it was the same as urease activities as well.

Tabel-3. Soil biological property along with waxy-corn growth in three weeks period.

Soil biological circumstance at plant growth phase	[1]Manure	Inoculant with zero-[2]NPK				Inoculant plus a quarter-[2]NPK				Inoculant plus a half-[2]NPK				[3]NPK
		Iz-A	Iz-B	Iz-C	Iz-D	Iq-A	Iq-B	Iq-C	Iq-D	Ih-A	Ih-B	Ih-C	Ih-D	
- [4]Soil respiration	5.61	5.94	4.73	5.94	4.84	6.71	4.95	6.05	7.15	6.38	7.92	5.06	8.75	5.17
- [5]Acid phosphatase	0.60	0.70	0.29	0.72	0.36	0.41	0.62	0.36	0.31	0.37	0.32	0.29	0.44	0.46
- [5]Urease	34.75	44.40	51.07	34.16	34.01	37.27	27.48	35.49	52.41	58.35	65.47	29.86	29.41	26.29

[1]Chicken manure 0.4 kg. $(m^2)^{-1}$; [2]Same as Table-2; [3]NPK (100 kg Urea and 300 kg NPK.ha^{-1}); [4]mg CO_2.gram-$soil^{-1}$.$hour^{-1}$; [5]Unit.gram-$soil^{-1}$

Maize yield performance

Considerable adherence to evaluate the study of bio-inorganic fertilizer impact to the plant yield, the main parameter such as of harvest index, total-grain ear^{-1}, hundred kernel weight, and seed protein content were decided; while others' parameters were used to put up with that main data of the harvest facts. All of the information can be focused at the whole substance of the Table-4. Waxy-corn more responsive to EM-121 and BIO-121 evaluated through harvest index, and also accomplish to number of grain in ear parameter, too. Good produce of hundred kernel weight were performed by BIO-121 and POC. Mega Rhizo inoculation combined with NPK fertilizer purposes at a quarter (Iq) and half doses (Ih), respectively. Biological yield which is measured with the dry weight of Waxy-corn cob indicated that whole biofertilizer used as a single treatment and also be combined with a quarter of NPK doses in this work able to raise up the weight significantly compared to the control. Weight of rice corn cob was raised along with biofertilizer used. Bio-inorganic fertilizer from the lowest and turn to the full NPK dose, basically was increasing corn cob of Rice-corn and Faramita variety, as well. Hundred kernel weight of Rice-corn and Harvest index which is define within variety were not interfered by the treatment; although differences within cultivar of that parameters has fade of significance.

Tabel-4. Yield quality represent by parameters of harvest facts.

Define within treatment	[1]Manure	[2]Inoculant with zero-NPK				[2]Inoculant plus a quarter dose NPK				[2]Inoculant plus a half dose NPK				[3]Full dose of NPK
		Iz-A	Iz-B	Iz-C	Iz-D	Iq-A	Iq-B	Iq-C	Iq-D	Ih-A	Ih-B	Ih-C	Ih-D	
Waxy-corn:														
1. Grain in ear	[5]298 ab	342 a	327 ab	354 a	311 ab	334 ab	358 a	312 ab	310 ab	331 ab	341 a	267 b	290 ab	339 a
2. Hundred kernel weight (g)	26.1 a	25.3 ab	24.6 ab	25.1 ab	25.9 a	25.1 ab	23.7 b	28.8 a	27.4 a	26.8 a	26.5 a	25.3 ab	20.8 b	26.6 a
3. [4]Biological Yield (g) *(NS)*	97.1	102.5	102.9	105.8	98.7	97.5	109.9	106.0	100.9	108.2	111.6	98.8	91.5	107.7
4. Harvest index	0.28 ab	0.27 ab	0.30 a	0.29 ab	0.27 ab	0.27 ab	0.29 ab	0.25 b	0.27 ab	0.25 b	0.29 ab	0.29 ab	0.29 ab	0.29 ab
Rice-corn:														
1. Grain in ear	[5]261 b	335 ab	303 ab	328 ab	314 ab	349 ab	360 ab	344 ab	365 a	402 a	321 ab	375 a	327 ab	380 a
2. [4]100 kernel weight (g) *(NS)*	22.9	22.0	22.6	23.8	24.4	27.3	23.7	25.9	27.1	25.4	25.2	23.2	26.8	25.6
3. [4]Biological Yield (g) *(NS)*	96.4	111.2	101.9	102.6	101.3	123.4	118.3	128.2	126.4	142.4	108.7	116.3	128.3	135.6
4. Harvest index	0.25 ab	0.22 b	0.24 ab	0.22 b	0.22 b	0.26 ab	0.24 ab	0.28 a	0.26 ab	0.26 ab	0.23 b	0.24 ab	0.25 ab	0.27 a
Faramita-hybrid:														
1. Grain in ear	[5]222 c	202 c	211 c	210 c	208 c	288 b	293 b	323 b	303 b	351 a	353 a	380 a	365 a	353 a
2. Hundred kernel weight (g)	24.9 bc	23.9 c	24.2 c	23.1 c	21.6 c	23.1 c	25.8 c	28.8 ab	28.3 ab	32.1 a	31.8 a	29.7 a	32.9 a	33.4 a
3. Biological Yield (g)	64.7 e	60.1 e	63.9 e	58.9 ef	51.7 f	77.7 de	84.0 cd	104.9 bc	107.8 ab	135.1 a	137.5 a	139.0 a	142.1 a	141.9 a
4. Harvest index	0.40 ab	0.40 ab	0.37 b	0.38 b	0.40 ab	0.40 ab	0.39 ab	0.42 a	0.40 ab	0.40 ab	0.40 ab	0.40 ab	0.40 ab	0.39 ab
Define within variety														
1. Grain in ear	[5]258 b	290 ab	282 ab	301 ab	265 b	322 ab	338 ab	325 ab	326 ab	359 a	339 ab	342 ab	328 ab	359 a
2. Hundred kernel weight (g)	24.6 ab	23.7 b	23.8 b	24.0 ab	24.0 ab	25.2 ab	24.4 ab	27.8 ab	27.6 ab	28.1 ab	27.8 ab	26.1 ab	26.8 ab	28.5 a
3. Biological Yield (g)	86.1 bc	91.3 bc	89.6 bc	89.1 bc	83.9 c	99.5 abc	104.1 abc	113.0 abc	111.7 abc	128.6 a	119.3 ab	118.0 abc	120.6 ab	128.4 a
4. [4]Harvest index *(NS)*	0.31	0.30	0.30	0.30	0.30	0.31	0.31	0.32	0.31	0.30	0.31	0.31	0.31	0.32

[1]Chicken manure 0.4 kg. $(m^2)^{-1}$; [2]Same as Table-2; [3]NPK (100 kg Urea and 300 kg NPK.ha^{-1});
[4]*NS* = non significant; [5] means with the same phrases in each row does not significant (Fisher's PLSD 5%).

Tabel-5. Influential connection among parameters of the harvest fact.

Parameter	Correlation value (df.12; p 0.05= 0.532; p 0.01= 0.661)			Postulation
	Waxy	Rice	Faramita	
1. Total dry weight of plant biomass *vs*. biological yield	0.615*	0.839**	0.998**	It is ordinary phenomenon sustaining normal growth in the cultivar
2. Total dry weight of plant biomass *vs*. ear weight	0.830**	0.879**	0.997**	Normal growth appearance with an undersized difference in Waxy-corn cultivar as due to slight ear-peel variation among Ear Weight to Biological Yield (in the case 1)
3. Ear weight *vs*. biological yield	0.879**	0.988**	0.933**	Ear-peel distinction does not significant since of the strong correlation value in the cultivar
4. Ear weight *vs*. hundred kernel weight	0.590*	0.630*	0.966**	Significant value of seed quality differentiation among local to hybrid cultivar
5. Biological yield *vs*. number of grain in ear	0.555*	NS	0.947**	Rice-corn cultivar does not has significant correlation rate for the reason with the intention of inappropriate of the seed size
6. Harvest index *vs*. hundred kernel weight	- 0.584*	0.616*	NS	Through the parameter here, it has quietly different value among the local cultivar
7. Harvest index *vs*. biological yield	NS	0.720**	NS	Strong correlation only in Rice-corn cultivar
8. Hundred kernel weight *vs*. total dry weight of plant biomass	NS	NS	0.969**	The last three cases among its parameter (in cases of no. 8, 9 and 10) were present truthfully value in the cultivar
9. Total dry weight of plant biomass *vs*. grain in ear	NS	NS	0.938**	The last three cases among its parameter (in cases of no. 8, 9 and 10) were present truthfully value in the cultivar
10. Grain in ear *vs*. hundred kernel weight	NS	NS	0.920**	The last three cases among its parameter (in cases of no. 8, 9 and 10) were present truthfully value in the cultivar

NS = non significant different; * significant different; ** strongly significant different

The parameters which are representing the proximities element to put up the complementary value were evaluated all through their correlation (Tabel-5). The four numbers in the beginning of evaluation showed that all of the cultivar gives the same response as due to treatment. The last six numbers of appraised matters have differently response to be calculated among parameter between cultivar. Correlation between harvest-index to a hundred-kernel-weight is quietly different through the cultivars. Reviewing of the entire correlation in the analysis is implemented in the postulation column to reach understandable argument.

Variance analysis to total dry weight of biomass evaluated among and within cultivar, and the result showed in the Figure-3. Local maize (Waxy and Rice-corn) were fit and adapted to growth with biofertilizer practice, while Faramita hybrid was exceedingly dependable to NPK fertilizer. Local maize has highly green fodder production that has a real interest to livestock for the villager in Bajeng. Concerning to provide fertilizer purpose for local corn productivity, Beyonic Star Tmik inoculant mixed with half doses of NPK give rise to highest green fodder production of local cultivar along with the treatment in the study, while other inoculant have positive end result, too.

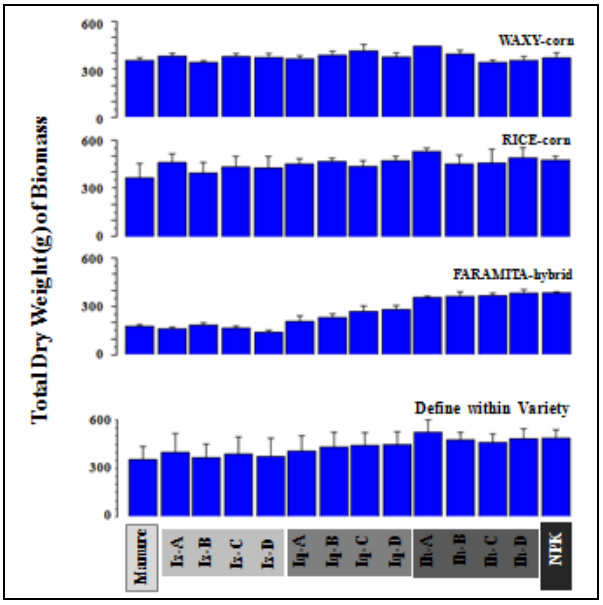

Figure-3. Biomass performance between cultivar and compared within variety (the lowest graph).

CONCLUTIONS

a) The present study indicates that local maize (Waxy and Rice-corn) has long adaptive to local environment and low response to fertilizer compared to hybrid Faramita cultivar.
b) That local cultivar was more amenable with the organic matter (chicken manure and biofertilizer) in the cultivation, particularly with microbial inoculant supplementary as its liability in the study.
c) The fertilizer management in the work here sent to a point for reducing chemical fertilizer utilization to the local Waxy-corn and Rice-corn, correspondingly.
d) Implication in biofertilizer usage over the indigenous local maize is necessary considered to drought tolerant performance for upcoming adaptation capability as due to climate anomaly consquences, and sustain to local food resources preservation.

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