A Proposal To Release Bio-Plant And Pro-Plant Fertilizers For Soil Fertility Improvement And Maize Grain Yield Production

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Abstract

Evaluation of Bio-Plant and Pro-Plant bio-fertilizers regarding their effects on soil fertility and maize grain yield production were evaluated at Bvumbwe and Bembeke for 3 years from 2009 to 2012. The pot experiments were carried out at Bvumbwe where sterilized and unsterilized soils were used with 5 Treatments replicated 3 times in a RCBD. 3 maize plants were planted in each 5L pot of soil. Field trials were conducted with plot sizes of 5m by 6 ridges spaced at 0.75m. One maize seed was planted per station spaced at 25cm. They were 3 replicates in RCBD. The results indicate that Bio-Plant and Pro-Plant fertilizers improved soil fertility and maize grain yields. Their performance was much better than the recommended fertilizer rate for maize at both sites. The combined use of 30% chemical fertilizer and 660cc of Pro-Plant gave the highest maize grain yields of 5514 kgs/ha at Bvumbwe and 4883 kgs/ha at Bembeke. In case of bio-organic farming, Treatment 6 gave the highest grain yields at Bvumbwe (3518kgs/ha) and Bembeke (3667 kgs/ha).The increase over the recommended fertilizer was over 10%-40% and over the zero fertilizer Treatment 1 was 60%-90% depending on the site and the Treatment of Bio-Plant and Pro-Plant fertilizers. For example at Bvumbwe during 2009-10 season (Table 5), there was a 28% increase in maize grain yield in Treatment 3 compared with Treatment 2 of the recommended chemical fertilizer rate.

1.0 Introduction

In Malawi most of the soils are highly weathered, infertile, and low in soil organic matter (OM) and soil nutrients. The main reason is because of the continuous cultivation of crops on the same piece of land with little inputs added leading to severe nutrient mining. Maida and Chilima (1976) reported that continuous cultivation without inorganic fertilizer and manure application resulted in a marked decrease in total organic matter, nitrogen (N) and exchangeable potassium (K), magnesium (Mg) and calcium (Ca). Soil fertility decline among smallholder farmers is the major factor responsible for the food insecurity in the country (Chilimba et al, 2007). Soil productivity can be improved and maintained through use of organic and inorganic fertilizers. In view of this, the use of chemical fertilizers has been advocated for many years to replace the depleted nutrients. However, most smallholder farmers are unable to access inorganic fertilizers due to the high cost. Carr (1997) reported that the use of fertilizer by farmers has declined to almost 40% due to increased fertilizer prices.

Other technologies have been developed, tested and promoted to the farmers in an effort to improve soil productivity and increase crop production. However, most of such technologies (eg compost manure) are limited in terms of their usage among most farmers. This is basically because the technologies are labour intensive, time consuming, and take longer time to mature. Most farmers prefer to burn crop residues during land preparation. As such soil fertility continues to decline and OM matters levels are becoming very low. Other cheap and less labour intensive technologies are required for use among farmers for improvement of soil fertility and crop yield production.

Bio-Plant and Pro-Plant are microbial bio-fertilizers manufactured by Artemis and Angel Co. Ltd. and have been introduced in Malawi by Agma Holding Ltd.. The bio-fertilizers are claimed to have many advantages and can significantly improve soil fertility and crop yield production. The bio-fertilizers are beneficial to the soil and plants. They are able to soften and aerate hard pan soils and make them crumble and increase nutrient availability to the plants. They are able to accelerate plant growth, strengthen plant immune system, greatly increase pest resistance and crops are protected from plant diseases. Bio-Plant is claimed to remove about 20% of harmful insects in the ground through breaking of the lifecycle (www.artemisthai.com). The 2 bio-fertilizers can be used in:

1. Bio-chemical farming:
    a. Farmers can reduce by 50% the amount of fertilizer and pesticide used in bio-chemical farming. Pesticides can be phased out quickly after the first season. The yield production could be increased by 30% when Bio-Plant is used in seed and soil preparation and Pro-Plant is sprayed on leaves.
2. 100% organic farming:
    a. The crop yield can increase in the range of 15%-30%-begin with compared to chemicals and the increase can go up much higher depending on the situation.
    b. The use of Bio-Plant and Pro-Plant has the capacity to restore soil fertility of poor soils, such as poor sandy soil. Use of bio-compost can quickly change the poor soil into fertile soil in a year.

The test results of bio-fertilizers by farmers and research institutes in different crops have shown to improve soil fertility and increase crop yields. The fertilizer has been tested with crops, such as rice, sugarcane, bananas, pineapple, rubber, cotton, maize, tobacco, tea, beans and various vegetables, such as carrots. The product have been tested and used in countries that include Thailand, Vietnam (2007-2009), Azerbaijan (2009), Bangladesh (2008), Benin (2009), China (2007-2008), Indonesia (2009), Kenya (2009), Mauritius (2008), Namibia (2009), Nigeria (2009), and Pakistan (2008 - 2009). In all the tested countries the crop yields increased from over 20%-50% depending on the crop and country. In Nigeria, the tests on *rice* at the I.I.T.A. Research Institute in Ibadan have shown that Bio-Plant and Pro-Plant produce a higher quality yield for a lower cost than Urea and NPK. The tests were part of the pre-selection process for tests to be carried out by the Bill Gates Foundation, which is choosing a microbial, 100% organic fertilizer for use by the Foundation around Africa. The Institute has indicated that it will recommend the bio-fertilizers to the Foundation. In Pakistan during 2008 - 2009, use of bio-fertilizer reduced the costs of cotton production by about 40% lower than the use of chemical fertilizers. In Benin, the costs of carrot production went down by 35% due to use of bio-fertilizers. The tobacco field tests in Yunnan province, China, showed that there was a 30%-40% increase in yield in 100% organic farming compared to chemical fertilizers with much lower costs. The leaves were larger, longer, and fresher-looking. Field tests on rice in Harbin, north China, showed a 50% increase in yield in 100% organic farming compared to chemical fertilizers with much lower costs. While in Mauritius (2008), the field tests on green beans indicated that there was a 30% increase in yield in 100% organic farming compared to chemical fertilizers with much lower costs (Artemis and Angel, 2009a).

Although literature review has demonstrated that bio-fertilizers are promising in improvement of soil productivity and crop production, their field evaluation has not been done in Malawi. At the same time farmers are using these bio-chemical fertilizers in maize production without adequate information such as optimal application rates and their effects on soil fertility. There is no scientific, Malawi field data about the Bio-Plant and Pro-Plant bio-fertilizers on their performance on soil fertility improvement and crop responses on yield production. Therefore, the purpose of this work is to evaluate the effects of Bio-Plant and Pro-Plant microbial bio-fertilizers on the improvement of soil fertility and maize crop yield production under Malawian field conditions. The generated information will be useful for the farmers in their agricultural production.

2.0 Objectives

- To evaluate the effect of Bio-Plant and Pro-Plant bio-fertilizers on soil fertility improvement.
- To evaluate the effect of Bio-Plant and Pro-Plant bio-fertilizers on maize grain yield production.
- To determine the optimum application rates for optimum maize grain yield production.

3.0 Materials and Methods

3.1 Nutrient composition of bio-fertilizer

Laboratory analysis results indicated that bio-fertilizer Bio-Plant and Pro-Plant contained molasses as substrate and beneficial fungi that include Aspergillus, Polyporus and Rhizopus, and other microorganisms that include Bacillus, Choromobactor, Streptomyces, Aerobactor, Nitrobactor, Nitrosomonas, Pseudomonas, and Clostridium. The total plate count is 1.5×10^6 CFU/ml. The analyzed microorganisms exist in the natural environment. The product contains many nutrients which are also higher as compared to other organic sources of fertilizer. The nutrient composition is given in Table 1 below as analysed by The Benin National Institute for Agricultural Research under the Ministry of Agriculture, Land, and Fisheries in the Republic of Benin in 2005. The product is claimed to have no specific associated hazards. More details on the safety of the product are given in appendix 1. No protective clothing is needed during handling of the product without any negative effect. The product has no environmental hazard as it contains no toxic chemicals (Artemis and Angel, 2009b).

Table 1: Nutrient composition of the bio-fertilizers

No	Element	Composition Fraction
1	pH	4.9
2	N	4.9-5.6%
3	P2O5	0.87%
4	K2O	1.01-1.14%
5	CaO	2.20-2.60%
6	MgO	0.45%
7	S	0.30%
8	Cl	11.1-11.3%
9	Zn	33.0-34.2 ppm
10	Fe	179.0-181.0 ppm
11	Cu	Trace
12	Mm	Trace

3.2 Preliminary Greenhouse Pot Experiment

Greenhouse experiments were conducted to get detailed data on the behaviour of the products in the soil. The pot experiments were carried out at the Bvumbwe Agricultural Research Station. There were 2 soil types (sterilized and unsterilized) and 5 different Treatments (Table 1) replicated 3 times in a randomised complete block design. 3 maize plants were planted in each 5L pot of soil. Maize plants were harvested after 6 weeks from the date of planting for biomass and soil data analysis.

3.3 Evaluation Field Trials of Bio-Plant and Pro-Plant

The evaluation field trials were conducted at Bvumbwe and Bembeke under controlled conditions for 3 years from 2009 to 2012. The two sites have soils differing in soil reaction with values less than pH 5.5 at Bembeke and pH 5.6-7.0 at Bvumbwe. Bio-Plant and Pro-Plant were used either alone or in combination with chemical fertilizer or organic fertilizer. Maize was grown on plot sizes of 5m by 6 ridges spaced at 0.75m. The ridges were 25cms high. The Treatments were laid as RCBD with 3 replicates. The Treatments are given below:

a) Organic farming:
   1. Zero fertilizer application
   2. 92 kgs N/ha Compost manure (5000kgs/ha)
   3. 50cc Bio-Plant plus 50cc Pro-Plant in 70L of water mixed with 500kgs organic material (dead leaves/plants, cow dung etc) per ha
   4. 150cc Bio-Plant plus 150cc Pro-Plant in 210L of water mixed with 1500kgs organic material (dead leaves/plants, cow dung etc) per ha
   5. 250cc Bio-Plant plus 250cc Pro-Plant in 350L of water mixed with 2500kgs organic material per ha
   6. 300cc Bio-Plant plus 300cc Pro-Plant in 420L of water mixed with 3000kgs organic material per ha
   7. 250cc Bio-Plant plus 250cc Pro-Plant in 350L of water alone per ha

b) Bio-chemical farming:
   1. Zero fertilizer application
   2. 92 Kg N/ha (200 kgs of 23:21:0+4S; 100 kgs of Urea) recommended fert. rate
   3. 330cc Bio-Plant plus 50 Kg (34 kgs 23:21:0+4S; 17 kgs Urea) fertilizer
   4. 660cc Bio-Plant plus 100 kgs (67 kgs 23:21:0+4S; 33 kgs Urea) fertilizer
   5. 990cc Bio-Plant plus 150 Kg (100 kgs 23:21:0+4S; 50kgs Urea) fertilizer
   6. 1320cc Bio-Plant plus 200 Kg (134 kgs 23:21:0+4S; 67kgs Urea) fertilizer
   7. 1320cc Bio-Plant alone per ha

3.4 Mixing of Bio-Plant with Chemical Fertilizer

50kgs of chemical fertilizer were placed on a plastic sheet of 1.5 x 1.5 m^2 spread out on the ground. Then Bio-Plant was spread on top and the two were evenly mixed. The bio-chemical fertilizer was applied the same day.

3.5 Mixing of Bio-Plant and Pro-Plant with organic material

70kgs of organic matter was spread on top of ridges. Then 5cc Bio-Plant and 5cc Pro-Plant were mixed in 7L of water. The bio-fertilizer was then sprayed on top of the organic material put on the soil. The soil was watered every 7 days and then the maize was planted after 14 days of bio-fertilizer Treatment to the soil.

3.6 Tracing of bio-fertilizer microbes in the inoculated soil and maize plants

Soil samples were collected before Bio-Plant and Pro-Plant application and soon after crop harvesting. Data on microbial populations were also collected. Xzapex Agar for soil and Potato Dextrose Agar for plants were used for culturing and for the identification of the microbial population in the inoculated soil and maize crops.

3.7 Data analysis

All crop yield data collected was subjected to statistical analysis at 95% level of confidence by scientific software called GENSTAT.

4.0 Results and Discussions

4.1 Green House Experiments

The biomass yield data is given in Table 2 and Table 3 below. The results in Table 1 and Table 2 clearly indicate that there were significant (P=<001) biomass yield differences among the Treatments and between the soil types. Harvested maize biomass significantly (P=<0.001) increased from 23%-84% over the control. The percentage biomass yield increase over the control was more in unsterilized compost and soil (35%-84%) than sterilized compost and soil (23%-43%). The results suggest that Bio-Plant and Pro-Plant bio-fertilizers enhance the release and availability of plant nutrients through mineralization of OM and fixation of N from the atmosphere. The results also imply that Bio-Plant and Pro-Plant are effective sources of fertilizer for maize production. The higher biomass yield in sterilized soil than in unsterilized soil was due to competition for nutrients by soil microorganisms and weeds, which was more in unsterilized soil.

Table 2: Effect of Bio-Plant and Pro-Plant on maize biomass yield (g/pot)

Treatment	Maize Dry Biomass (g/pot)		Mean
	Sterilized Soil	**Unsterilized Soil**	
Control	11.68	3.18	7.43
Bio/Pro-Plant	15.33	4.91	10.12
Bio/Pro-Plant + Chemical fertilizer	16.67	10.09	13.38
Bio/Pro-Plant + Compost manure	23.00	20.11	21.56
Compost Manure	20.67	20.17	20.42
Means	**17.47**	**11.69**	
% CV: 22.5			
LSD0.05 : Soil Type = 2.519 Treatment = 3.983			

Table 3: Effect of Bio-Plant & Pro-Plant on percentage maize biomass increase over control

Treatment	% Maize Dry Increase over Control		Mean
	Sterilized Soil	Unsterilized Soil	
Control	0	0	0
Bio/Pro-Plant	23.81	35.23	29.52
Bio/Pro-Plant + Chemical fertilizer	29.93	68.48	49.21
Bio/Pro-Plant + Compost manure	49.22	84.19	66.70
Compost Manure	43.49	84.23	63.86
Mean	**36.61**	**68.03**	

4.2 Field Evaluation Trials

4.2.1 Soil test results

The soil field test results of Bio-Plant and Pro-Plant at Bvumbwe are given in Table 4 and Table 5 during 2010-12 season. The results indicate that there were significant differences (P=0.5) between bio-organic and bio-chemical farming during 2010-11 and 2011-12. The mean of pH, OM, N were higher in bio-organic than in bio-chemical while for P it was higher in bio-chemical than bio-organic. Generally, the values were higher in Treatments treated with Bio-Plant and Pro-Plant than the control. For example, during 2011-12 (Table 5), under bio-organic farming P levels were 11.89ug/g higher than Treatment 1 and Treatment 2 where the values were 9.44ug/g and 9.0ug/g respectively, translating into over 30% increase in soil P. The results suggest that Bio-Plant and Pro-Plant enhanced the availability of nutrients to the maize plant.

Table 4: Effect of Bio-Plant and Pro-Plant soil parameters at Bvumbwe during 2010-11 season

Treatments	Soil pH		% Soil OM		% Soil N		Soil P (ug/g)	
	Bio-org	Bio-chem	Bio-org	Bio-chem	Bio-org	Bio-chem	Bio-org	Bio-chem
1	5.93	5.75	1.29	0.697	0.063	0.033	5.67	15.67
2	5.72	5.88	1.20	0.933	0.060	0.047	6.00	15.33
3	5.87	5.67	1.33	0.66	0.067	0.033	6.00	11.00
4	5.79	5.69	1.27	0.997	0.063	0.050	6.67	12.00
5	5.74	5.69	1.35	1.26	0.067	0.060	7.33	6.67
6	6.02	5.64	1.44	0.84	0.073	0.040	6.00	12.33
7	5.79	5.66	1.63	1.07	0.083	0.053	9.33	16.33
Means	**5.81**	**5.74**	**1.358**	**0.922**	**0.068**	**0.045**	**6.71**	**12.76**
%CV	**3.9**		**23.4**		**24.7**		**57.2**	
$LSD_{0.05\ Bio\text{-}type}$	**0.1447**		**0.1693**		**0.0088**		**3.534**	

Table 5: Effect of Bio-Plant and Pro-Plant soil parameters at Bvumbwe during the 2011-12 season

Treatments	Soil pH	% Soil OM		% Soil N		Soil P (ug/g)	
	Bio-chem	Bio-org	Bio-chem	Bio-org	Bio-chem	Bio-org	Bio-chem
1	4.910	1.49	1.58	0.074	0.079	9.44	8.33
2	4.463	1.34	1.57	0.067	0.078	9.00	9.33
3	4.693	1.43	1.49	0.071	0.073	8.11	7.33
4	4.469	1.51	1.45	0.074	0.073	11.89	8.33
5	4.609	1.44	1.42	0.072	0.079	12.67	10.44
6	4.581	1.51	1.57	0.078	0.077	11.00	10.43
7	4.821	1.52	1.54	0.076	0.076	9.11	9.89
Means	**4.650**	**1.46**	**1.52**	**0.073**	**0.076**	**10.17**	**9.16**
%CV	**4.8**	**19.2**		**17.8**		**27.2**	
$LSD_{0.05}$	0.2123	**NS**		**NS**		**Trt=1.735**	

4.2.2 Maize grain yields results
4.2.2.1 Climatic Conditions
The rainfall and temperature data are given in Appendix 2a and Appendix 2b. The information shows that the climatic conditions were favourable for maize crop production. This means the amount of annual rainfall and temperature range was adequate to get optimum maize grain yields and had no negative impact on maize grain yields.

4.2.2.3 Maize responses to Bio-Plant and Pro-Plant fertilizers
The results on the effect of bio-organic and bio-chemical farming on maize grain yields for the 3 years at Bvumbwe and Bembeke are presented from Tables 6 to Table 11. The visual maize crop performance results are shown in Plate 1. The results indicate that there were significant (P=0.05) yield differences among the Treatments and between the farming types at both Bvumbwe and Bembeke in all the 3 years of cropping season. The grain yields were higher in all the Treatments above the control at both sites Bembeke and Bvumbwe. For example, in 2011 the combined use of 30% chemical fertilizer and 660cc of Pro-Plant (Treatment 6) gave the highest maize grain yields of 5514 kgs/ha at Bvumbwe and 4883 kgs/ha at Bembeke. In case of bio-organic farming, Treatment 6 gave the highest grain yields at Bvumbwe (3518kgs/ha) and Bembeke (3667kgs/ha). However, in the 2011-12 growing season the grain yields (Table 10) were lower as compared to the other previous years. This could be attributed to soil factors compounded by rainfall problems. During the season there were intermittent prolonged droughts, which affected the growth and production of maize plants, including the grain yield. The droughts occurred at crucial stages of crop physiological development almost over 3 weeks soon after maize crops were at the 3 leaves stage. This compounded with low pH conditions it affected the production during the season.

The significant differences in grain yield were due to the effects of the Bio-Plant and Pro-Plant Treatments effects. At Bembeke the yields greatly improved due to the effect well mineralised crop residues by the Bio-Plant fertilizer applied to the plots that also had liming effect. This also means that Bio-Plant and Pro-Plant microbes mineralized and fixed more soil and air N respectively and made available to the crops for uptake. The bio-fertilizer further enhanced more availability of soil macro (such as P, K) and micro (such as Mg, Zn etc) nutrients, their uptake and use efficiency by the maize plants as compared with Treatment 2 where 300 kgs/ha of chemical fertilizer alone were applied and got slightly lower yields at

Bvumbwe. This suggests that Treatment 5 was more effective at producing the highest maize grain yields as compared to the rest of Treatments.

The results also show that the Bio-Plant and Pro-Plant bio-fertilizer Treatments performed much better than the current recommended chemical fertilizer rate for maize at both sites in Bembeke and Bvumbwe. The increase over the recommended fertilizer was over 10% to 40% and over the zero fertilizer Treatment 1 was 60% to 90% depending on the site and the Treatment of Bio-Plant and Pro-Plant fertilizers. For example, at Bvumbwe during the 2009-10 season (Table 5), there was a 28% increase in maize grain yield in Treatment 3 compared with Treatment 2 of the recommended chemical fertilizer rate. For the same Treatment there was 87% gain or increase in grain yield as compared with the zero fertilizer Treatment. Similar trends were observed in the following years and in the two sites.

Comparing the grain yields between the two sites, the yields were lower at Bembeke as compared with Bvumbwe. The difference in grain yield results between the 2 sites is ascribed mostly to soil fertility problems. Bembeke had strongly acid soil while Bvumbwe had moderately acid and this affected availability of nutrients to crops and also response of applied Bio-Plant and Pro-Plant microbes. These results suggest that soil conditions especially pH also affects the performance of Bio-Plant and Pro-Plant fertilizers in the initials times of application. However, plots treated with Bio-Plant positively improved soil fertility, crop nutrition and maize grain production as compared with the zero Treatment at both sites.

Plate 1: Visual effects of Bio-Plant and Pro-Plant bio-fertilizers on Maize crop at Bvumbwe during 2011-12 season

Table 6: Effects of Bio-Plant and Pro-Plant on Maize Grain Yields at Bvumbwe during the 2009-10 season

Treatment	Maize Grain Yield (Kgs/ha)		Mean
	Bio-chemical	Bio-organic	
1	1449	1641	1545
2	3499	3029	3264
3	**4473**	2376	3425
4	3476	2896	3186
5	4206	2997	3601
6	3827	**3792**	3809
7	2732	2458	2595
Mean	**3380**	**2741**	
CV (%)	**39.3**		
LSD $_{0.05}$	Bio-farming type: **762** Treatment: **1426** Biotype*Trt: **2017**		

Table 7: Effects of Bio-Plant and Pro-Plant on Maize Grain Yields at Bvumbwe during the 2010-11 season

Treatments	Bio-organic	Bio-chemical	Means
1	1786	2140	1963
2	2892	4978	3935
3	2487	4342	3415
4	2768	5436	4102
5	2691	5514	4102
6	3518	5345	4432
7	3534	2969	3251
Means	**2811**	**4389**	
%**CV :** 19.4 **LSD$_{0.05}$ Bio-type:** 443 **LSD$_{0.05}$ Trt:** 829 **LSD$_{0.05}$ Bio-type *Trt:** 1172			

Table 8: Effects of Bio-Plant and Pro-Plant on Maize grain yields at Bvumbwe during 2011-12 season

Treatments	Bio-organic	Bio-chemical	Means
1	3282	2365	2823
2	5570	5101	5335
3	3469	4731	4100
4	3666	5404	4535
5	3134	4444	3789
6	4598	5761	5180
7	3826	4061	3943
Means	**3935**	**4553**	
%**CV :** 29.7 **LSD Trt:** 1498.1;			

Table 9: Effects of Bio-Plant and Pro-Plant on Maize grain Yields at Bembeke during the 2009-10 season

Treatment	Maize Grain Yield (Kgs/ha)		Mean
	Bio-chemical farming	**Bio-organic farming**	
1	1947	1470	1708
2	2706	1062	1884
3	3064	1819	2442
4	2223	1977	2100
5	2352	3236	2794
6	2183	2914	2548
7	962	1617	1290
Mean	**2206**	**2013**	
CV (%)	**34.3**		
LSD $_{0.05}$	Bio-farming type: **459.3** Treatment: **859.2** Bio-farming type*Treatment: **1215.1**		

Table 10: Effects of Bio-Plant and Pro-Plant on Maize grain yields at Bembeke during the 2010-11 season

Treatments	Bio-organic	Bio-chemical	Means
1	783	917	850
2	4017	4000	4008
3	2650	3833	3242
4	2533	4017	3275
5	2833	4883	3858
6	3667	3500	3583
7	1300	2333	1817
Means	**2540**	**3355**	
%CV : 26.6 **LSD Bio-type:** 498.1; **LSD Trt:** 931.1			

Table 11: Effects of Bio-Plant and Pro-Plant on Maize grain yields at Bembeke during the 2011-12 season

Treatments	Bio-organic	Bio-chemical	Means
1	815	722	769
2	1130	1481	1306
3	2426	1574	2000
4	1778	1574	1676
5	1500	1500	1500
6	2481	2389	2435
7	778	1889	1333
Means	**1558**	**1590**	
%CV : 35.2 ; **LSD Trt:** 656.7			

5.0 Conclusion / Recommendations

- Bio-Plant and Pro-Plant bio-fertilizers significantly improved soil fertility and available soil nutrients, such as N, P, K, etc.
- Bio-Plant and Pro-Plant bio-fertilizers significantly increased maize grain yields and were equally effective as chemical fertilizer.
- The rate of 300cc Bio-Plant plus 300cc Pro-Plant in 420L of water mixed with 3000kgs organic material per ha in bio-farming and rate of 990cc Bio-Plant plus 150 Kg (100 kgs 23:21:0 + 4S; 50kgs Urea) fertilizer gave the optimum maize grain yield production at Bembeke.
- The rate of 660cc Bio-Plant plus 100 kgs (67 kgs 23:21:0 + 4S; 33 kgs Urea) fertilizer in bio-chemical farming and rate of 300cc Bio-Plant plus 300cc Pro-Plant in 420L of water mixed with 3000 kgs of organic material per hectare in bio-organic farming gave the optimum maize grain yield production at Bvumbwe.
- Therefore, we propose to the ATCC for consideration the release of the two bio-fertilizers. The proposed names are Bio-Plant and Pro-Plant bio-fertilizers.

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Appendix 1: Material Safety Data Sheets for the Bio-fertilizers

Material Safety Data Sheet 1
Bio-Plant Microbial Liquid 100% Organic Bio-fertilizer

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: Bio-Plant.

PRODUCT DESCRIPTION: Liquid, 100% organic bio-fertilizer made from fermented sugarcane molasses and cultured micro-organisms.

MANUFACTURER: Artemis & Angel Ltd.., 99/296 Sukhumvit 24, Klongtan, Klongtoey, Bangkok 10110, Thailand; Tel.: (President) +66-86-973-3813; (Sales): +66-82-727-9273
Fax: (Sales) +66-2-262-9010 Website: www.artemisthai.com
E-mail: peter_mcalpine@artemisthai.com

2. COMPOSITION / INFORMATION ON INGREDIENTS

INGREDIENT APPROX. % BY WT: This cannot be calculated as this is a liquid bio-fertilizer. The whole bio-fertilizer is beneficial to the soil and plants. No water or filler are added to increase the weight.

COMPONENTS: **Beneficial Fungi** (Aspergillus, Polyporus and Rhizopus); M**icroorganisms (**Bacillus, Achoromobactor, Streptomyces, Aerobactor, Nitrobactor, Nitrosomonas, Pseudomonas, Clostridium) TOTAL PLATE COUNT: 1.5 x 106 CFU/ml.

3. HAZARDS IDENTIFICATION

PHYSICAL APPEARANCE: Dark brown liquid.

IMMEDIATE CONCERNS: There are no specific hazards known to be associated with this product, although precautions should be taken to avoid unnecessary contact with eyes and mouth.

4. FIRST AID MEASURES

EYES: Irrigate thoroughly with water for at least 10 minutes. If any discomfort persists, obtain medical attention.

SKIN: No need for concern or medical attention. Just wash skin with water and soap.

INGESTION: Wash out mouth thoroughly with water. Obtain medical attention because the fungi would be in too high a concentration for the stomach.

INHALATION: No concern.

5. FIRE FIGHTING MEASURES

GENERAL HAZARD: No hazard.

EXTINGUISHING MEDIA: We do not know how you could set it alight as it does not contain any chemicals. It is just fermented molasses. If you manage to set it alight, use either water spray, foam, dry chemical, or carbon dioxide.

6. ACCIDENTAL RELEASE MEASURES

SMALL SPILL: No hazard. No need for appropriate protective clothing. Flush spillage down a drain or deposit it onto soil. There are no chemicals in it.

LARGE SPILL: No hazard. It can disposed of on the nearest soil or down a drain. If it enters a waterway, there is no need for concern. The micro-organisms will help to clean the water.

7. HANDLING AND STORAGE

HANDLING: No protective clothing is needed. You can handle it with your bare hands with no negative effect.

STORAGE: Store in a cool, shaded, dry place in original container. You can leave it exposed to the air without any concern.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

EYES AND FACE: No need for appropriate clothing and eye protection.

RESPIRATORY: No need for appropriate clothing and eye protection.

PROTECTIVE CLOTHING: No special clothing is needed.

WORK HYGIENIC PRACTICES: If it gets onto your hands or skin, wash your hands or skin in case your hands touch your eyes later on.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: Liquid, made from fermented molasses

ODOR: Molasses

APPEARANCE: Liquid

COLOR: Dark brown

pH: 3.6

BOILING POINT: About 100 degrees Celcius.

FREEZING POINT: About 0 degrees Celcius.

MELTING POINT: Not relevant

SOLUBILITY: Liquid

10. STABILITY AND REACTIVITY

STABLE: Yes

HAZARDOUS POLYMERIZATION: No

HAZARDOUS DECOMPOSITION PRODUCTS: None

11. TOXICOLOGICAL INFORMATION

TARGET ORGANS: There are no toxins or pathogens. No target organs.

CARCINOGENICITY: None.

IARC: None of the materials used in this product contain chemicals on the IARC list.

NTP: None of the materials used in this product contain chemicals on the NTP list as there are no chemicals in it.

GENERAL COMMENTS: The product has no carcinogenic properties or mutagenic or teratogenic effects. It is 100% bio-organic and chemical-free.

12. ECOLOGICAL INFORMATION

GENERAL COMMENTS: Bio-Plant is 100% organic. You can pour it onto the soil and it will make the plants grow well. If it enters a waterway, it will not cause any harm, and the micro-organisms will merely clean the water. There is no concern for the environment.

13. DISPOSAL CONSIDERATIONS

DISPOSAL METHOD: Throw it onto soil so that the soil and plants benefit. There are no chemical residues. Indeed, it will remove the NPK chemical residues in the soil and make them available for the plants while improving the soil's micro-biology.

14. TRANSPORTATION INFORMATION

SPECIAL SHIPPING NOTES: This product is not regulated under national or international transport regulations.

15. REGULATORY INFORMATION

GENERAL COMMENTS: This product is not regulated by any known government agency as hazardous.

16. OTHER INFORMATION

MANUFACTURE DISCLAIMER: The information supplied on this sheet is to the best of our knowledge accurate at the time of preparation. It does not relieve the user of this product of any responsibility to comply with local, national, or international laws relating to the handling or use of this product. The supplier does not accept responsibility for any claims resulting from the misuse of this product or failure to comply with the information stated within.

Material Safety Data Sheet2
Pro-Plant Microbial Liquid 100% Organic Bio-fertilizer

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME:	Pro-Plant.
PRODUCT DESCRIPTION:	Liquid, 100% organic bio-fertilizer made from fermented fresh fish.
MANUFACTURER:	Artemis & Angel Ltd., 99/296 Sukhumvit 24, Klongtan, Klongtoey, Bangkok 10110, Thailand Tel.: (President) +66-86-973-3813; (Sales): +66-82-727-9273 Fax: (Sales) +66-2-262-9010 Website: www.artemisthai.com E-mail: peter_mcalpine@artemisthai.com

2. COMPOSITION / INFORMATION ON INGREDIENTS

INGREDIENTS APPROX.% BY WT: This cannot be calculated as this is a liquid bio-fertilizer. The whole bio-fertilizer is the food for the plants. No water or filler are added to increase the weight.

COMPONENTS:

N	:	4.4 % (Minimum amounts.)
P_2O_5	:	0.5 %
K_2O	:	0.7 %
MgO	:	0.1 %
CaO	:	2.5 %
S	:	0.3 %
B	:	0.006 %
Cl	:	5.4 %
Mn	:	0.0002 %
Zn	:	34.8 ppm.
Fe	:	181.2 ppm.
Cu	:	2.2 ppm.
Mo	:	2.4 ppm.
pH	:	4.9

3. HAZARDS IDENTIFICATION

PHYSICAL APPEARANCE:	Dark brown liquid.
IMMEDIATE CONCERNS:	There are no specific hazards known to be associated with this product, although precautions should be taken to avoid unnecessary contact with eyes and mouth. There are no chemicals in it.

4. FIRST AID MEASURES

EYES:	Irrigate thoroughly with water for at least 10 minutes. If any discomfort persists, obtain medical attention.
SKIN:	No need for concern or medical attention. Just wash skin with water and soap.

INGESTION:	Wash out mouth with water. Obtain medical attention for stomach-pumping if drunk.
INHALATION:	No concern.

5. <u>FIRE FIGHTING MEASURES</u>

GENERAL HAZARDS:	No hazards.
EXTINGUISHING MEDIA:	We do not know how you could set it alight as it does not contain any chemicals. It is just fermented fish. If you manage to set it alight, use either water spray, foam, dry chemical, or carbon dioxide.

6. <u>ACCIDENTAL RELEASE MEASURES</u>

SMALL SPILL:	No hazard. No need for any protective clothing. Flush down a drain or deposit on soil. There are no chemicals in it.
LARGE SPILL:	No hazard. It can disposed of on the nearest soil or down a drain. If it enters a waterway, there is no need for concern. The micro-organisms will help to clean the water.

7. <u>HANDLING AND STORAGE</u>

HANDLING:	No protective clothing is needed. You can handle it with your bare hands with no negative effect. It can touch your hands or skin with no harmful effects.
STORAGE:	Store in a cool or shaded, dry place in original container. You can leave the bio-fertilizer exposed to the air without any concern.

8. <u>EXPOSURE CONTROLS/PERSONAL PROTECTION</u>

EYES AND FACE:	No need for appropriate clothing and eye protection.
RESPIRATORY:	No need for appropriate clothing and eye protection.
PROTECTIVE CLOTHING:	No special clothing is needed.
WORK HYGIENIC PRACTICES:	If it gets onto your hands or skin, wash your hands or skin in case your hands touch your eyes later on.

9. <u>PHYSICAL AND CHEMICAL PROPERTIES</u>

PHYSICAL STATE:	Liquid, made from fresh fish
ODOR:	Fish
APPEARANCE:	Liquid
COLOR:	Dark brown
PH:	4.9
BOILING POINT:	About 100 degrees Celcius.
FREEZING POINT:	About 0 degrees Celcius.
MELTING POINT:	Not relevant
SOLUBILITY:	Liquid

10. STABILITY AND REACTIVITY

STABLE:	Yes
HAZARDOUS POLYMERIZATION:	No
HAZARDOUS DECOMPOSITION PRODUCTS:	None

11. TOXICOLOGICAL INFORMATION

TARGET ORGANS:	There are no toxins or pathogens. No target organs.
CARCINOGENICITY:	None.
IARC:	None of the materials used in this product contain chemicals on the IARC list.
NTP:	None of the materials used in this product contain chemicals on the NTP list as there are no chemicals in it.
GENERAL COMMENTS:	The product has no has carcinogenic properties or mutagenic or teratogenic effects. It is 100% bio-organic and chemical-free.

12. ECOLOGICAL INFORMATION

GENERAL COMMENTS: Pro-Plant is 100% organic, so you can pour it onto the soil and it will make the plants grow well. If it enters a waterway, it will not cause any harm, and the micro-organisms will merely clean the water. There is no concern for the environment.

13. DISPOSAL CONSIDERATIONS

DISPOSAL METHOD: Throw it onto soil so that the soil and plants benefit. There are no chemical residues. Indeed, it will enrich the soil.

14. TRANSPORTATION INFORMATION

SPECIAL SHIPPING NOTES: This product is not regulated under national or international transport regulations.

15. REGULATORY INFORMATION

GENERAL COMMENTS: This product is not regulated by any known government agency as hazardous.

16. OTHER INFORMATION

MANUFACTURE DISCLAIMER: The information supplied on this sheet is to the best of our knowledge accurate at the time of preparation. It does not relieve the user of this product of any responsibility to comply with local, national, or international laws relating to the handling or use of this product. The supplier does not accept responsibility for any claims resulting from the misuse of this product or failure to comply with the information stated within.

Appendix 2: Rainfall Data

Appendix 2a: Daily rainfall at Bembeke during 2009/10 season

Date	Amount of Rainfall (mm) 2009/10					
	Nov	Dec	Jan	Feb	Mar	Apri
1	-	-	-	3.9	63.4	-
2	-	-	-	32.7	3.6	-
3	-	-	-	-	61.6	7.5
4	4.5	4.5	11.6	42.2	62.2	-
5	-	-	1.1	-	-	32.5
6	-	-	2.9	12.8	-	6.7
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	16.3	3.2	-
10	-	1.7	-	44.1	2.2	-
11	-	-	-	-	13.5	-
12	17.5	12.2	15.6	-	-	12.0
14	-	-	10.4	11.7	1.1	-
15	-	-	-	49.6	1.5	-
16	-	-	15.0	17.2	11.2	-
17	-	10.5	-	38.0	-	-
18	8.0	-	-	4.2	2.2	-
19	-	-	9.8	4.8	35.6	-
20	-	-	-	-	-	-
21	-	-	5.0	4.0	-	-
22	2.6	-	16.5	19.5	-	14.2
23	13.3	-	4.5	18.2	-	20.0
24	-	-	-	4.8	15.4	-
25	-	-	-	3.1	-	-
26	-	-	-	21.3	10.0	5.0
27	-	-	-	3.2	-	-
28	-	16.4	2.2	-	-	-
29	-	11.7	0.7	26.5	-	-
30	-	3.2	2.5		7.1	-
31	-	62.5				-
Total	**45.9**	**107.7**	**97.8**	**368.1**	**292.7**	**97.9**
Daily Mean	**1.5**	**3.5**	**1.3**	**12.7**	**9.8**	**2.9**

Appendix 2b: Minimum and maximum daily temperatures (ºC) at Bembeke

Date	Daily Temperatures (ºC) at Bembeke (2009/10 season)											
	Nov		Dec		Jan		Feb		March		April	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	21.3	15.1	23.4	16.3	22.5	16.5	22.8	13.8	25.0	16.7	23.5	16.0
2	25.1	13.7	22.5	13.9	21.4	16.1	23.8	13.5	22.5	16.5	23.5	14.6
3	24.5	14.3	23.6	16.4	20.3	16.7	24.3	14.6	23.0	15.4	20.6	13.8
4	23.7	13.3	22.4	14.0	22.5	15.1	22.0	14.0	23.1	15.3	22.3	14.9
5	24.5	13.0	23.5	12.9	23.6	15.3	20.3	14.2	22.3	14.3	20.4	13.5
6	19.5	14.0	23.5	12.9	23.6	15.3	20.3	14.2	20.0	15.4	20.0	14.0
7	21.8	13.4	23.0	13.5	22.4	14.3	21.6	15.0	23.5	16.0	20.0	14.2
8	22.5	14.0	26.5	15.1	23.3	15.5	23.4	13.5	21.8	16.2	21.6	12.7
9	24.1	13.7	24.1	16.1	22.8	14.6	23.5	13.6	22.3	14.9	22.8	13.2
10	20.5	15.3	23.5	14.5	20.4	13.2	21.6	14.2	23.3	15.4	23.6	14.0
11	22.8	14.3	23.5	13.7	23.1	14.0	20.3	14.6	22.8	15.1	23.7	14.2
12	20.9	15.2	21.6	13.4	23.0	14.2	21.5	13.8	20.8	14.5	23.4	14.3
13	23.6	15.5	21.3	12.9	22.3	13.9	23.8	13.3	20.3	14.3	22.3	14.2
14	23.5	14.3	22.4	13.5	20.4	14.3	21.5	13.5	22.4	15.1	20.0	15.2
15	24.3	14.5	23.5	13.2	22.5	15.4	22.4	14.7	23.3	14.6	20.3	14.4
16	23.1	13.5	22.5	14.0	23.4	13.8	24.3	13.6	20.4	12.8	22.4	14.3
17	22.3	12.6	23.5	13.5	19.4	13.9	22.9	13.5	22.1	14.0	23.5	15.4
18	24.3	14.5	21.5	13.8	20.0	13.2	21.6	12.8	23.3	14.0	23.5	15.4
19	23.0	13.4	22.3	14.0	21.5	14.3	22.3	14.2	22.0	13.4	23.4	14.0
20	20.9	14.0	19.3	12.6	22.5	14.5	23.4	14.0	23.0	12.8	22.0	13.3
21	21.4	13.9	20.6	13.1	20.4	14.3	23.0	13.7	19.8	14.2	21.0	15.6
22	22.5	14.3	23.3	12.8	23.5	13.5	20.3	14.2	20.1	13.3	20.0	14.4
23	23.3	14.0	21.3	13.0	23.5	14.0	22.6	14.0	21.6	13.0	19.8	13.8
24	26.3	14.8	22.7	12.1	21.6	13.1	21.7	13.6	20.4	13.4	20.4	14.1
25	24.4	15.0	20.4	13.2	22.5	13.5	19.8	13.5	22.3	14.4	18.6	15.2
26	22.3	13.5	23.5	15.0	20.3	12.8	20.4	12.8	21.3	14.3	22.2	13.8
27	24.0	15.6	23.4	12.4	22.1	13.3	22.3	13.2	21.8	15.6	21.2	13.5
28	26.0	13.9	22.5	13.2	22.5	14.0	21.6	13.0	22.5	14.4	20.2	14.0
29	23.1	14.0	23.2	14.3	23.2	14.2			21.3	14.3	23.2	14.0
30	24	13.6	21.7	12.1	22.1	13.5			22.3	13.7	23.3	13.7
31			20.51	20.0	13.7			20.6	14.0			
Total												
Daily Mean												