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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Effects of Effective Microorganisms on Yield and Quality of Vegetable Cabbage Comparatively to Nitrogen and Phosphorus Fertilizers

Kwizera Chantal[1,2], Shao Xiaohou[1,2], Wang Weimu[1,2] and Basil T. Iro Ong'or[3]
[1]Key Laboratory of Efficient Irrigation-Drainage and Agricultural Soil-Water Environment in Southern China, Hohai University, Ministry of Education, China
[2]College of Water Conservancy and Hydropower Engineering, Hohai University, Nanjing 210098, China
[3]Department of Civil and Structural Engineering, Masinde Muliro University of Science and Technology, Kakamega, 190-50100, Kenya

Abstract: The misuse and excessive use of fertilizers resulted in the loss of soil sustainability and a declined productivity, have increased the need of use of Effective Microorganisms Technology (EM) as an alternative to such practices to meet the future nutritional requirements of the people. This study aimed at appraising the effects of EM on Leaf Area (LA) and Photosynthesis (PH) of vegetable cabbage comparatively to Nitrogen (N) and Phosphorus (P) fertilizers. Results showed an increased leaf area for treatments with EM, while others demonstrated its reduction. Significant among treatments was recorded with $p<0.05$. Likewise, EM has improved photosynthesis. This suggested that EM improve plant yield and quality, resulting in a fulfillment of a sustainable agriculture.

Key words: EM Technology, chemical fertilizers, vegetable cabbage, leaf area index, photosynthesis

INTRODUCTION

From the ancient times, the principal objective of using chemical fertilizers in agriculture has been to approach the best production in quantity and quality for the humankind (Parr *et al*., 1992). Unfortunately, their excessive use has caused many problems as soil degradation leading to the reduction of plant yield and quality. To reverse these trends, Effective Microorganisms Technology (EM) has been adopted as an alternative solution.

Developed by Professor Teruo Higa in Okinawa in the 1970's (Yamada and Xu, 2000), Effective Microorganisms has been put into application since 1980 (Teruo Higa, 2005). It is a mixture of three principal microorganisms (photosynthetic bacteria, lactic acid bacteria and Yeasts) applied to alter the use of chemical fertilizers and change the microbial diversity and interaction in soils and plants (Primavesi and Kinjo, 1997). Yamada and Xu (2000), affirmed higher crop maze productivity due to the use of EM (Yamada and Xu, 2000). Foregoing research reported an increased crops production by using EM (Teruo Higa, 2005). In this study, a comparative assessment on the responses of Cabbage to Effective Microorganisms and chemical fertilizer (NP) was done. Specifically, the:

- Influence of EM and Chemical fertilizer on leaf area of cabbage is analyzed
- Effectiveness of Effective Microorganisms on photosynthesis of cabbage is determined

MATERIALS AND METHODS

Experimental site: The study was carried out in Greenhouse of Water-Saving Park, located in Jiangning Campus of Hohai University. The climate is sub- humid, which belongs to the north subtropical climate zone with an average rainfall of 1.106 mm.

Experimental design: EM, N and P were considered with two levels for each: L1 (2% of EM regarding to the water requirement, 100 mg N/kg of dry soil and 75 mg P_2O_5/Kg of dry soil) and L2 (5% of EM regarding to the water requirement, 200 mg N/kg of dry soil and 150 mg P_2O_5/Kg of dry soil). 150 mg K_2O/Kg were supplied as a basal fertilizer. All treatments were replicated 3 times as depicted in the Table 1 below. The vegetable Cabbage was sown on 28th November 2006 and transplanted on 1st January 2007 in 39 pots with 7.5 kg of dry soil and 4 plants per pot.

Samples and data analysis

Samples: Three PH measurements were done on 7th February, 9th March and 20th March 2007 using LI-6400 portable photosynthesis system, while LA was measured after every 2 weeks until 20th March 2007.

Data analysis: Statistic comparative analysis of photosynthesis (transpiration rate (E), net photosynthetic rate (P_n), stomatal conductance (G_s), Intercellular CO_2 content (ci)) and plant leaf area between all treatments

Corresponding Author: Kwizera Chantal, Key Laboratory of Efficient Irrigation-Drainage and Agricultural Soil-Water Environment in Southern China, Hohai University, Ministry of Education, China

Table 1: Treatment design

Treat. No.	Treatments	EM	Fertilizers (g/pot) NH_4NO_3	KH_2PO_4	K_2SO_4
1	CK	0	0	0	0
2	EM1N1/EM1P1	2%	2.143	1.077	1.393
3	EM1N2	2%	4.286	1.077	1.393
4	EM2N1/EM2P1	5%	2.143	1.077	1.393
5	EM2N2	5%	4.286	1.077	1.393
6	EM1P2	2%	2.143	2.154	0.704
7	EM2P2	5%	2.143	2.154	0.704
8	N1	0	2.143	1.077	1.393
9	N2	0	4.286	1.077	1.393
10	P1	0	2.143	1.077	1.393
11	P2	0	2.143	2.154	0.704

Treat. No. = Treatment Number

was conducted, with a probability value $p<0.05$ using Excel and SPSS.

RESULTS AND DISCUSSION

Effect of EM on the leaf area: Result showed an increased LA for treatments with EM than others (Fig. 1 and 2). The highest increase was recorded by EM2N2 (167.056%, 16.014%) comparatively to CK and N2 respectively (Fig. 1). On the other hand, EM2P2 (170.702%, 27.051%) exhibited the greatest increase as compared to CK and P2. However Significant among treatments was recorded with $p<0.05$. Higher LA may be due to the effect of EM on plant root development, followed by better fostering with nutrients to the plant. This indicates an enhanced biomass production and photosynthetic capacity. Primavesi and Kinjo (1997) reported an increased LA on beans) (Primavesi and Kinjo, 1997). Higa and Parr (1994) argued a better photosynthetic capacity with an increased LA on maze (Higa and Parr, 1994).

Effect on photosynthesis: Result demonstrated an increased P_n for treatments with EM than others except EM1N2 and EM2P2 (Fig. 3, 4). The highest P_n was recorded by EM2N2 (23.188%, 18.592%) as compared to CK and N2 respectively (Fig. 3). Significant increase was observed for EM1P2 (12.229%, 6.961%) comparatively to CK and P2 successively (Fig. 4). Matthew Wood and Higa (2005) reported an increased P_n on plant maze due to the continual supply of nutrient and hormones from EM (Matthew Wood and Higa, 2005). Study of Yamada and Xu (2000), argue that EM contains phytohormones or others biologically active substances that cause the delay of senescence of plants and increase P_n (Yamada and Xu, 2000). The P_n reduction recorded by EM1N2 (4.869%, 8.418%) and EM2P2 (3.88% 3.78%) comparatively to the others was attributed to the reduction of stomata conductance. This is in support with results found by Meloni *et al.* (2003) and Dubey (2005), who reported a reduced P_n for cotton crop due to the reduction of stomata conductance (Meloni *et al.*, 2003; Dubey, 2005).

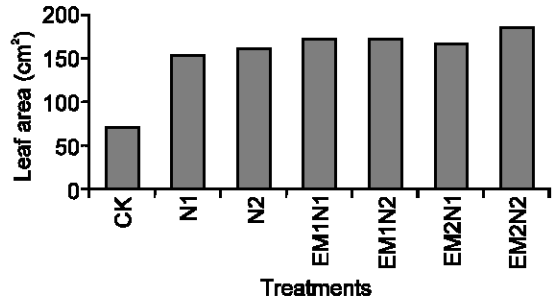

Fig. 1: Leaf area analysis with EMN

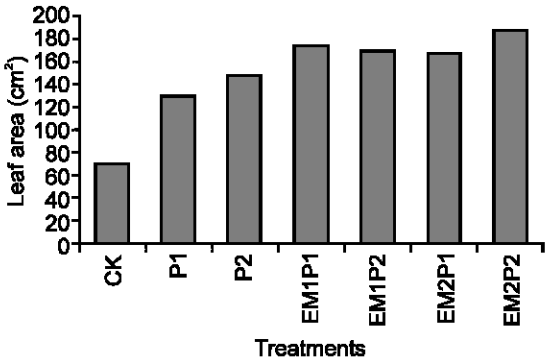

Fig. 2: Leaf area analysis with EMP

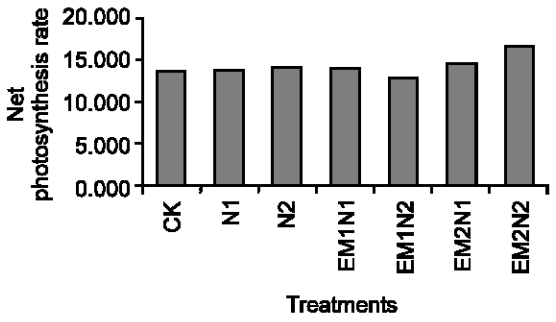

Fig. 3: Net photosynthesis rate (P_n) (µmol m^{-2} s^{-1}) analysis with EMN

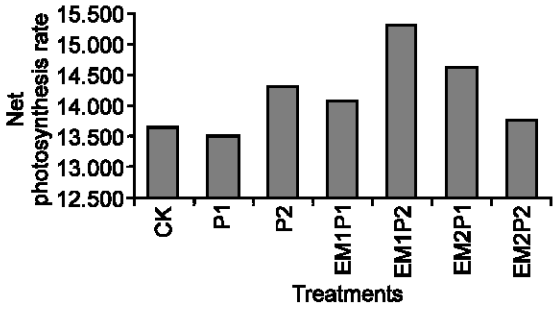

Fig. 4: Net photosynthesis rate (P_n) analysis (µmol m^{-2} s^{-1}) with EMNP

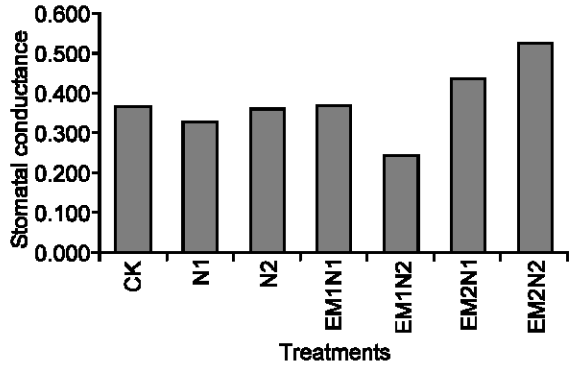

Fig. 5: Analysis of stomata conductance (G_s) (µmol m^{-2} s^{-1}) with EMN

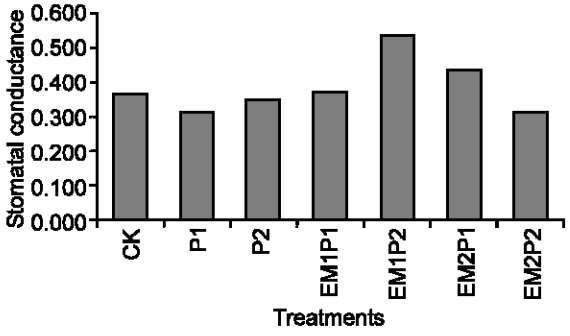

Fig. 6: Analysis of stomata conductance (G_s) (µmol m^{-2} s^{-1}) with EMP

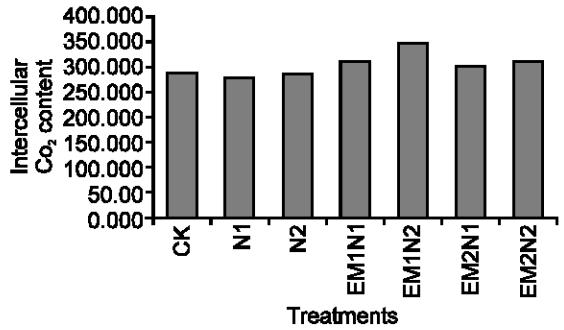

Fig. 7: Analysis of Intercellular CO_2 content (ci) (µmol mol^{-1}) with EMN

G_s was higher for all treatments applied with EM except EM1N2 and EM2P2 (Fig. 5, 6). The highest level was shown by EM2N2 (43.68%, 45.48%) comparatively to the control and N2 (Fig. 5). On the other hand, treatment EM1P2 (46.79%; 52.81%) was the most efficient in increasing G_s (Fig. 6). E differs much among the treatments (Fig. 9, 10). It was higher in control and others treatments without EM than these fertilized with EM. Little difference among treatments was observed for Ci (Fig. 7, 8). It was higher for treatments applied with

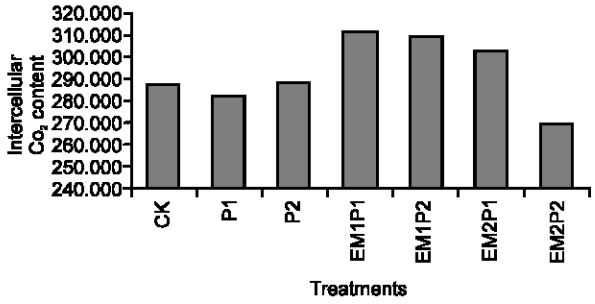

Fig. 8: Analysis of Intercellular CO_2 content (ci) (µmol mol^{-1}) with EMP

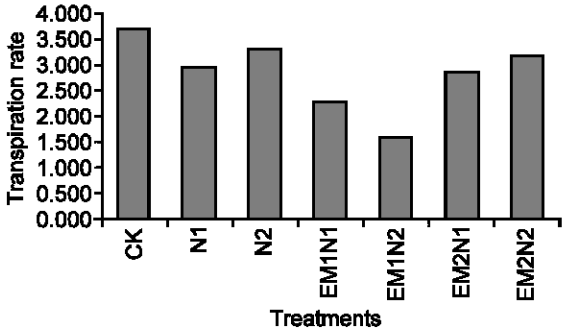

Fig. 9: Analysis of transpiration rate (E) (µmol m^{-2} s^{-1}) with EMN

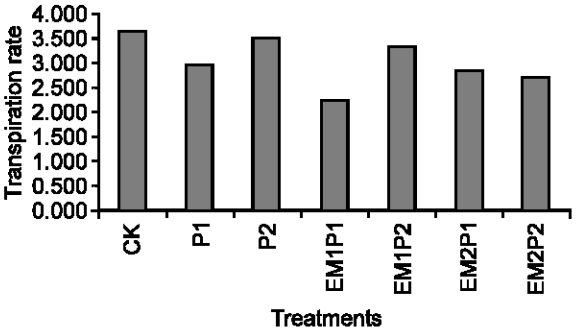

Fig. 10: Analysis of transpiration rate (E) (µmol m^{-2} s^{-1}) with EMP

EM than others and the control. The maximum was shown by treatment EM1N2 (21.58%) comparatively to both the control and N2 (Fig. 7). With Figure 8, the greatest level was recorded by EM1P1 (8.43%, 10.48%) comparatively to the control and P1 respectively. All this could conclude that the effects in improving photosynthesis could be expected from EM Technology.

Conclusion: By using these results above as basis, the following conclusions could be drawn:

1. EM effectively increases the leaf area; hence significant increase in yield, ascribed mainly to the stimulation of vegetable biomass production.

2. These data also enable a more precise assessment of the economic benefits that greenhouse growers can expect from Effective Microorganisms Technology, taking into account the specificity of the winter climatic conditions and greenhouse characteristics.
3. Compared to fertilizer applied and controlled grown vegetable-cabbage, the EM positively impacts by increasing the photosynthesis.
4. Producing safe food is the important target worldwide. However outcomes showed a little improved production due to the effect of EM. Hence it should be considered as a support fertilizer, to enhance other fertilizer's capacity to supply nutrients to plants and fulfill sustainable development of agriculture. At the same time furthers research on photosynthesis are recommended for more understanding.

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