Effect of organic and bio-fertilization on potato productivity

RASHA R. EID[1], S.F. EL-SAYED[2]

Abstract

A field experiment was conducted during the two summer seasons of 2009 and 2010 in sandy soil on potato "Sante" to study the effect of using 100% compost (15 t/fed.) and 50% compost + nitrogen fixing bacteria (Azotobacter, and Pseudomonas alone or together) on potato growth and yield as compared to the conventional mineral fertilization (120-75-150 kg/fed. NPK + 5 t compost/fed). No significant differences in tubers yield per plant and per hectare were detected between mineral fertilization (T1) and using 100% compost (T2); however, "T1" significantly produced a high yield per hectare than using 50% compost + any biofertilizer treatment.

***Keywords**: potato, compost, Azotobacter, pseudomonas, tuber yield.*

Introduction

Potato (*Solanum tuberosum* L.) is the world's fourth most important crop, after maize, wheat and rice, with annual production approaching 3643220 tons (FAO, 2010). Nitrogen fertilizer is one strategy to increase tuber yields in potato. The role of N fertilization for tuber growth, development, yield and quality of potato is well known (Morena et al., 1994 and Kumar et al., 2007). Due to consumer concern for excessive use of chemical fertilizers to avoid deleterious effects on the environment, there is increasing interest in the use of organic fertilizers. Organic fertilizers, such as compost, provide a slow release of nutrients as micro-organisms in soil (EL-Etr et al., 2004 and Hafez et al., 2004). However, use of organic fertilizers is limited by the threshold of nitrogen level, which is allowed, especially for exportation of organic products. Biofertilizers from microorganisms can replace chemical fertilizers to increase crop production. In principle, biofertilizers are less expensive and are more environmental-friendly than chemical fertilizers. The benefits from using biofertilizers , beside their role in saving chemical fertilizers is well known (Yazdani et al. 2009). The present work aimed to study the effect of using 100% compost (35.7 t/ha) and 50% compost + nitrogen fixing bacteria (azotobacter, or pseudomonas or both) on potato growth and yield as compared to the conventional mineral fertilization (285.7, 178.6 and 357.1 kg/ha NPK + 11.9 t compost/ha).

Material and Methods

A field experiment was carried out at Maba farm, Cairo – Alexandria desert rod, Egypt, during two summer seasons (2009 and 2010) in sandy soil using the potato variety "Sante". Treatments were arranged in a randomized complete block design with four replicates. Potato tuber seeds were planted on 6th February 2009 and 26th January 2010. Well-sprouted potato tubers were planted at the middle of row. The plot size was 108 m2 and contained four 30 meters long rows, and distance between rows was 90 cm. Potato tuber seeds were planted at a distance of 25 cm within the row. Spray irrigation system (pivot) was used for irrigation, while insects and diseases were biologically controlled. The experiment consisted of the following 10 treatments.

T1: Mineral NPK (476.2- 309.5 - 464.3 kg) + compost at 11.9 t/ha (Control),

T2: 100% compost (35,7 t/ha),

T3: 50% compost + *Azotobacter* 0, 6 (*Azotobacter* applied at 0 and 6 weeks form planting),

T4: 50% compost + *Azotobacter* 0, 3, 6, 9 (*Azotobacter* applied at 0, 3, 6 and 9 weeks form planting),

T5:50% compost + *Pseudomonas* 0, 6 (Pseudomonas applied at 0 and 6 weeks form planting),

T6: 50% compost + *Pseudomonas* 0, 3, 6, 9 (Pseudomonas applied 0, 3, 6 and 9 weeks form planting),

T7: 50% compost + *Azotobacter* 0, 6 + *Pseudomonas* 0, 6,

T8: 50% compost + *Azotobacter* 0, 6 + *Pseudomonas* 0, 3, 6, 9,

T9: 50% compost + *Azotobacter* 0, 3, 6, 9 + *Pseudomonas* 0, 6,

T10: 50% compost + *Azotobacter* 0, 3, 6, 9 + *Pseudomonas* 0, 3, 6, 9.

The total amount of N, P and K added to the control treatment was 476.2, 309.5 and 464.3 kg/ha, respectively. This was achieved by adding mineral N, P and K at rate of 285.7, 178.6 and 357.1 kg/ha, in addition to organic N, P and K (in the form of compost) at the rate of 190.5, 131 and 107.1

[1] Agriculture Research Center, Horticulture Research Institute, Giza, Egypt.
E-mail Rasha_351@yahoo.com,
[2] Cairo University, Faculty of Agriculture, Vegetable Crops Department, Giza, Egypt.
E-mail sayedfathey2000@yahoo.com

kg/ha, respectively (the chemical analysis of used compost showed that it has 2.15% total N, 1.5% P, 1.26% K, 26% moisture). Phosforus and potassium levels were constant in all organic and control treatments, i.e., 309.5 kg/ha P2O5 and 464.3 kg/ha K2O, by adding rock phosphate and feldspar to the different organic fertilization treatments. So, rock phosphate and feldspar were added at 0 kg and 1428.6 kg/ha to the treatment no. 2, while they were applied at 559.5 and 3023.8 kg/ha, respectively, to the treatments no.3 to no.10. Potato tuber seeds were treated at planting with a mixture of micro organisms, consisting of mycorrhizae, phosphate dissolving bacteria (*Bacillus megaterium* to release phosphate from the added rock phosphate and *Bacillus Cereus*, to help potassium to be released from the added feldspar. The mineral fertilizers (for the mineral control treatments), were added at two equal doses, during soil preparation and 45 days after planting, while rock phosphate and feldspar (for all other treatments) were added during soil preparation.

Data recorded: A random sample of twelve plants was randomly taken from each treatment 90 days after planting, and number of tubers/plant, tubers weight/plant (g), and average tuber weight (g) were determined. Harvest was done 105 days after planting in both seasons, where total yield per plot and in tons/ha was recorded.

Table 1 - *Effect of different fertilizer treatments on number of stems/plant, numbers of tubers weight/plant and average tuber weight, 90 days after planting (Combined data of the two summer seasons).*

Treatments		No. stems/plant	No. tubers/plant	Average tuber weight (g)
TT1	Mineral NPK (476.2-309.5-464.3 kg) + Compost at 11.9 t/ha (Control)	3.1ab	9.0abc	95.2a
TT2	100% Compost (35,7 t/ha)	3.6a	10.5ab	65.1bc
TT3	50% Compost + Azotobacter 0, 6	2.5 bc	11.8a	27.8d
TT4	50% Compost + Azotobacter 0, 3, 6, 9	2.3abc	11.7a	35.6cd
TT5	50% Compost + Pseudomonas 0, 6	2.2abc	11.8a	51.3 bcd
TT6	50% Compost + Pseudomonas 0, 3, 6, 9	2.8abc	10.5ab	38.87cd
TT7	50% Compost + Azotobacter 0, 6 + Pseudomonas 0, 6.	2.3abc	9.5abc	58.1bcd
TT8	50% Compost + Azotobacter 0, 6 + Pseudomonas 0, 3, 6, 9.	2.6abc	8.3bc	58.9bc
TT9	50% Compost + Azotobacter 0, 3, 6, 9 + Pseudomonas 0, 6.	1.7bc	9.5abc	64.9bc
TT10	50% Compost + Azotobacter 0, 3, 6, 9 + Pseudomonas 0, 3, 6, 9.	1.6c	7.4c	80.7ab

Results

Different letters within each column indicate significant differences between fertilizer treatments (po0.05) according to LSD test. 0, 3, 6, 9 = + Azotobacter and Pseudomonas were applied after 0, 3, 6 and 9 weeks after planting. Rock phosphate and feldspar were added to the treatments no. 2 to no.10 to have same levels of P and K added to the control treatment (309.5 kg/ha P_2O_5 and 464.3 K_2O kg/ha).

Generally, there were no significant differences between mineral fertilization (T1 control treatment) and all organic fertilizer treatments regarding number of tubers per plant. However, T10 (50% compost + Azotobacter 0, 3, 6, 9+ Pseudomonas 0, 3, 6, 9.) significantly produced a lower numbers of tuber per plant than T2 (100% compost), T3 (50% compost + Azotobacter 0, 6), T4 (50% compost + Azotobacter 0, 3, 6,9) and T5(50% compost + Pseudomonas 0, 6) and lower number of stems per plant than mineral fertilization (T1 control treatment) and 100% compost (T2 treatment). On the other hand, mineral fertilization significantly exceeded all other treatments but treatment T10 (50% compost + Azotobacter 0, 3, 6, and 9+ Pseudomonas 0, 3,6, and 9) in average tuber weight (Table1). Mineral fertilization gave the highest yield per plant and per hectare. However, there were no significant differences in tuber yield per plant and per hectare between mineral fertilization and using 100% compost (Table 2). It seems that the higher number of tubers per plant of T2 treatment versus the T1 control, balanced the lower average tuber weight of T2 compared to the T1 control, resulting in an overall non significant difference in total tuber production per hectare between T2 and T1 treatments.

On the other hand, using mineral fertilization (control) significantly produced a higher yield per hectare than all or-

Table 2 - *Effect of different fertilizer treatments on tuber weight/plant (g) and total yield (t/ha) (Combined data of the two summer seasons).*

Treatments		Tubers weight/plant (g)	Total yield (t/ha)
T1	Mineral NPK (476.2-309.5-464.3 kg) + Compost at 11.9 t/ha (Control)	795 a	32.86 a
T2	100% Compost (35,7 t/ha)	651.7 ab	29.67 ab
T3	50% Compost + Azotobacter 0, 6	338.2 d	14.90 e
T4	50% Compost + Azotobacter 0, 3, 6, 9	396 c	15.98 e
T5	50% Compost + Pseudomonas 0, 6	613.5 abc	24.21 bcd
T6	50% Compost + Pseudomonas 0, 3, 6, 9	396.4 cd	17.46 e
T7	50% Compost + Azotobacter 0, 6 + Pseudomonas 0, 6.	549.5 abcd	21.86 cde
T8	50% Compost + Azotobacter 0, 6 + Pseudomonas 0, 3, 6, 9.	481.43 bcd	21.19 de
T9	50% Compost + Azotobacter 0, 3, 6, 9 + Pseudomonas 0, 6.	542.9 abcd	22.64 cd
T10	50% Compost + Azotobacter 0, 3, 6, 9 + Pseudomonas 0, 3, 6, 9.	574.3 abc	23.95 bcd

Different letters within each column indicate significant differences between fertilizer treatments (po0.05) according to LSD test. 0, 3, 6, 9 = + Azotobacter and Pseudomonas were applied after 0, 3, 6 and 9 weeks after planting. Rock phosphate and feldspar were added to the treatments no. 2 to no.10 to have same levels of P and K added to the control treatment (309.5 kg/ha P_2O_5 and 464.3 K_2O kg/ha) ganic treatments using 50% compost + any biofertilizer treatment. These results were also recorded concerning tubers yield per plant between mineral fertilization and T3 (50% compost + Azotobacter 0, 6), T4 (50% compost + Azotobacter 0, 3, 6, 9), T6 (50% compost + Pseudomonas 0, 3, 6,9) and T8 (50% compost + Azotobacter 0, 6 + Pseudomonas 0,3, 6,9) (Table 2).

Discussion

Compost is a balanced organic fertilizer and it provides both macro and micronutrients to plants. The principle of composting is based on decomposition of organic matter which is facilitated by microorganisms. Composting converts organic substrates into utilizable forms in absence or presence of air to yield a sanitary soil supplement (Han & Lee 2005). Results of the present research confirmed such facts, since 100% compost (T2 treatment) did not differ from the T1 mineral control in all characters under study.These results were attributed to the use of the same amounts of N, P and K in both treatments, but in different forms i.e. mineral and organic. It was also clear the effectiveness of microorganism in releasing of P and K from natural rocks that were added to compost treatments. Soil microorganism such as *Pseudomonas* spp. and *Bacillus* spp. can release organic acid such as fumaric acid, acetat and lactate that solubilize phosphate making it available to the plant. Organic acids that are released by bacteria can increase solubilizing phosphates (Han & Lee 2005). Similarly, the phosphate solubilizing bacteria (*Bacillus megaterium*) and potassium solubilizing bacteria (*Bacillus mucilaginosus*), increased in soil the availability of P and K, respectively, enhanced N, P and K uptake, and promoted growth of eggplant (Han & Lee 2005). As previously reported some bacteria have a role in non-symbiotic nitrogen fixation such as *Azotobacter*, *Azospirillum* spp., that are able to fix atmospheric nitrogen in loose association with plant roots and provide the host plant by about 30-50% of nitrogen requirements (Dalla et al. 2004). *Azotobacter* spp., *Azospirillum* spp. and Pseudomonas spp. can also promote plant growth by production of phytohormon such as auxin, Cytokinin, Gibberellins and abscisic acid (Bottini et al. 2004; Safak and Nilfer. 2006) which can be beneficial to stimulate plant growth and increase plant production. Using 50% compost+ application of Pseudomonas alone after 0 and 6 weeks from planting (T5) or 50% compost + application of both .bacteria in combination after 0, 3, 6 and 9 weeks from planting (T10) were in the second rank concerning tubers yield per plant and per hectare , with no significant differences between both of these treatments and using 100% compost concerning total yield per hectare and using 100% compost or mineral fertilization (control) regarding tubers weight per plant. According to Tyagi et al. (1999) application of biofertilizers can not only reduce chemical fertilizer consumption by 20 to 50% but also can simultaneously increase the yield of crop by 10 to 20%. The contradiction between the previous results and the present ones in addition to nun effectiveness of Azotobacter in the present study may be a attributed to the variation in the effectiveness of the different strains used in the different studies.

Conclusion

The present study proved that we can produce organic potato in sandy soil by using100% compost without any significant differences in tubers yield per hectare as comparing to the conventional fertilization.

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