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Nutrients Release and Biological Aspects of Butadiene Styrene – Fertilizer Mixtures

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BUTADIENE styrene (24/76) latex emulsion, 50 % active materials mixed with the complex N, P and K treatment fertilizer 19:19:19 has been evaluated biologically in two steps using sandy calcareous soil. Firstly a completely randomized incubation experiment with the following treatments 1) T. Control, 2) T1 (1.0 % polymer fertilizer mix), 3) T2 (2.0 % polymer fertilizer mix) and 4) T3 (3.0 % polymer fertilizer mix) with three replications were performed for three months to examine the release rate and decomposition of studied fertilizer. In the second step, greenhouse experiment using maize (*Zea maye* L.-Giza 20) as the indicator plant was conducted to examine nutrients uptake by the plants and the biological activity of the soil.

In the incubation experiment, the released macronutrients under this study were greatly affected by the application rate in the polymer fertilizer mixture. The fertilizer mixture T1 or T2 increased the total number of bacteria, fungi, and actinomycetes compared with the control treatment. T3 decreased the population of actinomycetes in incubated soil as compared with T1 or T2, but the counts of actinomycetes was still higher than that of the control treatment.

In the greenhouse experiment, the nutrients uptake by maize negatively proportional with the application rate of the polymer without any toxic effects on growing plants. The same trend was observed for nutrients availability in the soil. Treated soil significantly affected microbial population in the rhizosphere of maize plants. *Alternaria, Aspergillus, Fusarium, Mucor, Penicillium, Rhizopus* and *Trichoderma* were the common macrofungi found in soil treated with latex.

It was concluded that butadiene styrene emulsion can be used as a good coating material for fertilizers. Nutrients status of both soil and plant and biological activity of the soil are greatly affected by the application rate of the polymer *i.e.* coating thickness.

Keywords: Butadiene styrene fertilizer mixtures, Nutrients release, Biological aspects, Calcareous soil, Maize plant.

Controlled–release fertilizers technology offers a number of advantages in relation to crop production including sustained correction of mineral deficiency, decreased application frequency, and thus reduces cost and risk of machinery damage to crop. It decreases fertilizer loss to leaching, with concurrent minimization of environmental hazard (*e.g.*, pollution of water courses), and possible reduction in the total amount of nutrient required because of sustained rather than erratic supply is maintained. Additionally, the risk of salt injury to roots of young seedling may be reduced. Controlled release fertilizers are made by coating the active soluble component with a membrane that serves as a diffusion barrier. Variation in the characteristics of the polymers which used as coatings would be utilized in producing controlled release fertilizer that fit the requirements of growing plants. Styrene butadiene and other different polymers can be used as binding matrices to control the release of macro and micronutrients for plants (Prasad & Power, 1995; Hanafi *et al.*, 2000; Helaly & EL Nashar 2002; Bajpai & Giri 2002; El-Hady *et al.*, 2003 and Abd El-Kader & El-Ashker, 2005). Additional research with these slow and controlled release fertilizers and their interaction with different management situations, biological degradation, soil types and cropping systems were needed.

The present study was carried out to evaluate the effect of N, P and K (19:19:19) complex fertilizer coated with three rates of butadiene styrene 24/76 (latex) emulsion on the nutritional status of soil and plant on one hand and biological activity of the soil on the other hand.

Material and Methods

Preparation of slow release fertilizer

Mixtures of butadiene styrene (24/76) emulsion (50 % active material) and a complex fertilizer 19:19:19 were prepared. Main constituents and properties of the polymer are shown in Table 1 (Abd El -Kader & El-Ashker, 2005). The polymer emulsion was mixed with the fertilizer at the rates of 1.0; 2.0 and 3.0 % (active material). Contents were continuously stirred for 30 min. The products were air dried and segmented in 2 to 5 mm pellets.

TABLE 1. Description of the main constituent and properties of polymer.

a. Main constituents	
Active substance	Butadiene styrene 24/76 latex emulsion. (anionic polymer)
b. Properties:	
- Physical appearance	Milky white
- Total solid weight percentage	50 ± 1
- pH (1:1)	9-10
-Viscosity, 30C by Brookfield RVT, Sp.3; 20 rpm (poise) :	5-10
- Particle size (µm)	0.5-2

Experimental design

Incubation experiment

Sandy calcareous soil samples collected from Giza Governorate were used. Some physical and chemical properties of the soil are presented in Table 2.

A completely randomized incubation experiment with three replications was performed for three months to study the release and decomposition rate of studied fertilizer. The treatments were as follows: 1- T control, *i.e.*, untreated soil, 2-T1 (soil treated with fertilizer mixture containing 1.0 % polymer), 3-T2 (soil treated with fertilizer mixture containing 2.0 % polymer) and 4- T3 (soil treated with fertilizer mixture containing 3.0 % polymer).

TABLE 2. Some physical and chemical properties of the soil .

Particle size distribution (%)						
	Sand	Silt	Clay	texture		
	89.7	5.4	4.9	sandy		
Chemical properties						
Soil	EC (1:5) dS/m	pH (1:2.5 susp.)	CEC cmol/kg	O.M %	$CaCO_3$ %	
	1.1	7.4	4.3	0.06	13.2	
Macronutrients						
	Total (mg /kg)			**Available (mg/kg)**		
	N	P	K	N	P	K
Soil	640	561	270	12.0	17.0	10.6

One kilogram portion of the soil was taken in plastic cups containing the fertilizer pellets at rate of 0.5 g/kg soil. All treatments were incubated at 25°. During the experiment, soil moisture content was maintained at 70 % of the field capacity by periodic addition of distilled water. At the end of the incubation period, soil samples were taken for available N, P and K and microbiological analysis.

Greenhouse experiment

A completely randomized design pot experiment was conducted in 1.0 kg portion of soil. During the experiment, soil moisture content was maintained at 70 % of the field capacity. Maize (*Zea maye* L.-Giza 20) was taken as the indicator plant to study the nutrients uptake and diversity of soil and plant rhizosphere microorganisms as affected by the studied mixtures.

Soil analysis

Available N, P and K in soil samples were determined according to Page *et al.* (1982) and Cottenie *et al.* (1982).

Microbiological analysis

Microbial diversity of soil samples from the incubation experiment and plant rhizosphere from the greenhouse experiment were analyzed using the standard procedures described by Page *et al.* (1982). The serial dilution plate method was used for counting total bacteria on Tryptic-Soy agar medium (TSA) for total bacteria, fungi on Martin's medium and actinomycetes on dextrose-nitrate medium (Allen, 1959). Representative colonies from the most predominant organisms were isolated and purified on their specific media. The purified colonies were next examined microscopically to determine differences between them by cell morphology. The common microflora was identified according to Nautiyal & Dion (1990).

Statistical analysis

Results obtained were analyzed statistically by SPSS/ PC^{+}(1999) software.

Results and Discussion

Incubation experiment

Nutritional status

Table 3 presents the effect of the studied polymer- fertilizer mixtures at the end of the incubation period on available N, P and K in the soil. Data showed the low content of N,P, and K in soil which reflect its poor nutritional status.

Considerable increases in the availability of studied were noticed due to soil fertilization by pellets of butadiene - styrene and fertilizer mixtures. The released macronutrients were greatly affected by the application rates of studied polymer. Using 1.0 % polymer fertilizer mixture (T1) as slow release fertilizer for incubated sandy soil raised its nutrients availability by 126.1 %, 150.6 % and 247.2% for N, P and K, respectively. Doubling the application rate of the polymer in the mixture (T2) to be 2.0 % decreased the availability of the three nutrients to be 185.7, 202.9 and 276 % that of untreated soil, respectively. An other insignificant decrease in available nutrients were noticed by applying 3.0% polymer fertilizer mixture (T3) to be 150% for N, 156.6% for P and 208.3 for K if compared to that of the control treatment..

The obtained results are in agreement with findings of El–Hady *et al.* (2003) and Abd El-Kader & El-Ashker (2005), who pointed out that the chemical composition of added polymer and its application rate.*i.e.* coating thickness greatly affects nutrients release. Susanta *et al.* (2004) mentioned that initially the extent of degradation is mainly confined to the surface regions (a few nanometers) but with longer exposure (*e.g.*, 12 weeks) it extends to below the subsurface region of the fluoroelastomer. This leads to double bond formation on the rubber backbone which accelerates the degradation even further with longer exposure.

TABLE 3. Effect of studied polymer-fertilizer mixtures at the end of the incubation period on available macro- nutrients in the soil.

Treatments	Available macronutrients (mg/kg)		
	N	P	K
T	70 .0	41.5	60.0
T1	158.3	104	208.3
T2	130.0	84.2	165.6
T3	105.0	65.0	125.0
LSD at 0.5	56.3	20.2	22.3

Microorganisms

Total bacteria, fungi, and actinomycetes occurred in higher densities in the incubated soil treated with different doses of coated fertilizer comparable to the control treatment (Table 4). The fertilized soil with T1 or T2 increased the total number of bacteria, fungi, and actinomycetes compared with treatment received fertilizer mixture containing 3.0 % polymer (T3).

TABLE 4. Effect of studied polymer–fertilizer mixtures on microorganisms of incubated soil.

Treatments	Bacteria	Fungi	Actinomycetes
T	$63x10^6$	$4.19x10^3$	$23x10^4$
T1	$7x10^7$	$13.4x10^3$	$33x10^4$
T2	$4.3x10^7$	$28.5x10^3$	$69x10^4$
T3	$3.5x10^7$	$9x10^3$	$60x10^4$

The unicellular yeasts (mostly *Saccharomyces* sp.) were the most probable fungi in all treatments. *Alternaria, Aspergillus, Fusarium, Mucor, Penicillium, Rhizopus* and *Trichoderma* were the common macrofungi found in soil treated with polymer- fertilizer mixtures. Few actinomycetes were isolated from T2 and T3 especially *Streptomycetes* spp.

Table 5 shows, in general, the percentages of bacteria percent in the soil fertilized with coated NPK. It was found that fluorescent pseudomonad's occupied 19.4% of the total rod shape Gram negative bacteria while the spore-forming bacteria of *Bacillus* spp. was the most common Gram positive bacteria isolated from all fertilized soil which occupied 96.7%. Commonly, it was found that the ratio between Gram negative and Gram positive bacteria in all fertilized soils was 2.3. The numbers of total bacteria were stimulated greatly in the soil fertilized with T2 (Table 4). However, soil fertilized with T3 allowed population of total bacteria to maintain higher number in the fertilized soil compared to control (Table 4).

TABLE 5. Percentage of bacteria population in the incubated soil treated with latex-fertilizer mixtures.

Microbial population	%
Gram negative	69.7
Rod shape	87.2
Fluorescent pseudomonades	19.4
Gram positive	30.3
Rod shape	91.4
Bacillus spp.	56.1
Aerobic spore-forming	96.7

Greenhouse experiment

Effect of polymer- fertilizer mixtures on nutrients uptake by maize plant

Uptake of N, P and K by maize plants is shown in Table 6. Data of plants grown in the untreated soil (treatment T) refer to poor nutritional status of such soil. Considerable increases in the uptake of nutrients were noticed due to soil fertilization. Using 1.0 % polymer-fertilizer mixture (T1) as slow release fertilizer raised the uptake by 265.1 %, 258.6 % and 418.1 % for N, P and K, respectively.

TABLE 6. Effect of fertilizer mixture on nutrients uptake by maize plants.

Treatments	Nutrients uptake of Maize (mg/plant)		
	N	P	K
T	17.5	8.7	8.8
T1	63.9	31.2	45.6
T2	48.1	19.4	23.2
T3	28.9	17.0	17.3
LSD at 0.5	1.1	3.6	3.3

Doubling the application rate of the polymer in the polymer-fertilizer mixture (T2) to be 2.0 % decreased the uptake of the three nutrients to be 274.9, 223.0 and 263.6 % that of untreated soil, respectively. By applying 3.0 % polymer-fertilizer mixture (T3) to sandy soil, more decrease in the uptake of the aforementioned nutrients by maize plants was noticed to be 165.1 for N, 195.4 for P and 196.6 % for K that of the treatment T.

Data refer to the better protection of fertilizer nutrients mixed with butadiene styrene as binding agent and at the same time remained available for plant. The obtained results are in agreement with finding of El-Hady *et al.* (2003) and Abd El-Kader & El-Ashar (2005).

Effect of fertilizer mixtures on nutrients availability

As shown in Table 7, availability of nutrients in untreated sandy soil is low. Under the conditions of conducted experiment, available N, P and K were 13.3, 18.1 and 15.6 mg/kg soil, respectively, that refer to poor nutritional status of the soil.

TABLE 7. Effect of fertilizer mixtures on nutritional status of studied soil .

Treatments	Soil pH	Available macronutrients (mg/kg)		
		N	P	K
T	7.45	13.3	18.1	15.6
T1	7.28	42.3	47.3	60.2
T2	7.28	35.0	24.4	43.8
T3	7.36	28.3	20.7	34.0
LSD at 0.5	--	2.97	2.32	4.15

Considerable increases in the availability of studied nutrients were noticed due to soil fertilization. Using 1.0 % polymer- fertilizer mixture (T1) as slow release fertilizer for sandy calcareous soil raised its nutrients availability by 218.0 %, 161.3 % and 285.9 % that of untreated soil for N, P and K, respectively. Doubling the application rate of the polymer (T2) to be 2.0 % slightly decreased the availability of the three nutrients to be 263.2, 134.8 and 280.8 % that of untreated soil, respectively. By applying 3.0 % polymer -fertilizer mixture (T3), the availability of the aforementioned nutrients were 12.7% for N, 14.0 for P and 17.9% for K that of the control treatment. Coated fertilizer slightly decreased soil pH due to the acidic effect of the fertilizer which increased nutrients availability.

Microorganisms

Similar trend of banded microorganisms in the incubation experiment was found in the greenhouse experiment. Fertilized soil significantly affected microbial population in the rhizosphere of maize. T1 and T2 resulted in more numbers of bacteria, fungi and actinomycetes in the rhizosphere compared to the control (T), (Table 8). Increases in the population of rhizosphere microorganisms were 575, 4650 and 420 % for bacteria, fungi and actinomycetes when applying treatment T1. Relevant values for the treatment T2 were 300 , 5150 and 1165 in sequence. Using coated fertilizer by the higher dose of butadiene styrene, *i.e.*, T3 treatment decreased the population of the aforementioned rhizosphere micro-organisms by 27.5 , 47.6 and 68.4 % , respectively compared to the treatment T2 but in all cases the biological activity of the soil is higher than that of the control. Under such conditions, rhizosphere microorganisms of treatment T3 are 2.9, 27.5 and 4 folds that of treatment T for bacteria fungi and actinomycetes, respectively.

TABLE 8. Effect of studied mixtures on microorganisms counting in the rhizosphere of maize plant.

Treatments	Bacteria	Fungi	Actinomycetes
T	$2x10^8$	$0.8x10^4$	$20x10^4$
T1	$13.5x10^8$	$38x10^4$	$104x10^4$
T2	$8x10^8$	$42x10^4$	$253x10^4$
T3	$5.8x10^8$	$22x10^4$	$80x10^4$

Conclusion

On conclusion , butadiene- styrene 24/76 latex emulsion can be considered as a good binding agent for nutrients. The nutrients release, uptake and biological activity of the soil depend on the rate of applied polymer. In other words they depend on the thickness of polymer coating.

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الامـــداد بالعناصر و بعض السمات البيولوجية لمخاليط البيوتادين ستيرين و السماد المعدنى

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تم تحضير ٣مخاليط من مستحلب بيتادين ستيرين (٧٦/٢٤ – ٥٠٪ مادة نشطة) مع السماد المركب ١٩–١٩–١٩ كسماد بطيئى الامداد وذلك بخلط البوليمر مع السماد بنسب ١و٢ و ٣ ٪ و تم التقييم من خلال تجربتين بإستخدام ارض رملية جيرية لدراسة اثر استخدام البوليمر على معدل تيسر العناصر الغذائية من المخلوط و امتصاص النبات للعناصر السمادية و النشاط البيولوجى.

أولا: تجربة تحضين بنظام تام العشوائية فى ثلاثة مكررات و كانت المعاملات كالاتى : ١– كنترول ٢–١,٠ ٪ مخلوط البوليمر و السماد وزنا ٣– ٢,٠ ٪ من مخلوط البوليمر و السماد وزنا ٤– ٣,٠ ٪ من مخلوط البوليمر و السماد وزنا.

ثانيا: تجربة اصص بنفس المعاملات السابقة و استخدام نبات الذرة كنبات دليلى .

و يمكن تلخيص النتائج المتحصل عليها كمايلى:

١. كان معدل تيسر العناصر الكبرى و معدل اعداد الكائنات الدقيقة متناسباعكسيا مع نسبة الخلط (البوليمر الى السماد) مما يعكس قدرة البوليمر على الاحتفاظ بالسماد.
٢. كان معدل امتصاص العناصر الكبرى بواسطة نبات الذرة متناسبا عكسيا ايضا مع نسبة الخلط دون اى تاثير سام على النبات.
٣. كانت أهم الكائنات الحية التى نمت فى بيئة المركب هى:
Alternaria, *Aspergillus*, *Fusarium*, *Mucor*, *Penicillium*, *Rhizopus*

توضح النتائج السابقة كفاءة البيوتادين ستيرين على حمل المادة السمادية .