Slow release fertilizer(ammonium nitrate) based on natural and synthetic rubber

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Abstract

Fertilizers losses due to leaching, volatilization and the activated risk of Fertilizers leaching after addition to the soil may be reduced through the use of slow release fertilizers. These membranes often consist of permeable polymers, waxes or sulfur. The aim of this project is to find a suitable material and method for coating of nitrogen fertilizer to achieve controlled release and also to evaluate the coating and the coating method in laboratory scale. The reason for choosing natural and synthetic rubbers that has been used as coating materials for the controlled release fertilizers to decrease the release rate. To evaluate the coating material a conductivity meter was used to measure the conductivity as a function of time. The conductivity was changed as the ammonium and nitrate ions were released through the membrane to the surrounding water. The results shows that it was possible to coat fertilizer particles with styrene butadiene (SBR), natural rubber(NR), butadiene rubber (BRcis) and butyl rubber. The release rate of ammonium nitrate from SBR and Butyl rubbers are higher than NR and BRcis rubbers.

INTRODUCTION

Fertilizers are one of the most important products of the agrochemical industry. They are added to soil to supply nutrients necessary for plant growth. However, about half of the applied fertilizers, depending on the method of application and soil properties, is lost to the environment, which results in the contamination of surface and ground water[1]. Use of conventional fertilizers may lead to the concentration levels that are too high for effective action which may produce undesirable side effects on the target and the environment[2,3].

Control release technology in agriculture includes the controlled delivery of plant nutrients such as fertilizers to a target in a manner which maximizes its use efficiency, minimizes potential negative effects associated with over dosage, and/or extends the time in which sufficient dosages are delivered[4]. The goal of controlled release fertilizer research since the 1944s has been the development of a product that delivers its nutrients at a rate matching the demand rate of the plant to which it is applied. Such a fertilizer would represent the ultimate in use efficiency; agronomic performance, i.e., crop yield, quality, and appearance; agronomic safety; and labor savings, i.e., reduced application frequency. It also would minimize potential losses to environment[5].

The rational application of fertilizer is a very important subject that is directly associated with saving energy and protecting the environment, farmland, and crops. The controlled release of fertilizer is an effective method for applying fertilizer rationally and represent one of the major developments in the fertilizer industry[6].

Fertilizer coating, which is also called fertilizer packing, is a universal controlled-release method. Fertilizer is insulated from the soil by a coating material and dissolves into the soil slowly[7].There are three major types of material used for coating. The first includes inorganic materials, such as sulfur, silicate, and phosphate, as reported by the Tennessee Valley Authority in 1961. The second consists of thermosetting resins, low-density polythene, polypropylene, ethylene/carbon monoxide copolymer, and poly(vinyl acetal) have been often used as coating materials for controlled release according to the demands of different fertilizers and soil conditions[8].The use of controlled release fertilizers (CRF) causes an increase in their efficiency and results in the reduction of nutrient loss by leaching due to heavy rainfalls into soil or groundwater[9,10]. Moreover, CRF application reduces the eutrophication of natural waters caused by excessive concentration of nitrogen and phosphorus compounds. The CRFs are not used in ordinary cultivation, but are recommended for special applications, such as tree nursery or ornamental plants in gardens, greenhouses. They can be applied in water protection areas where drinking water is collected and the nutrients leaching has to be minimized[11].These fertilizers can be physically prepared from the granules of the soluble fertilizers by coating them with the materials which reduce their dissolution rate. In most cases the fertilizer is encapsulated inside an inert material. The coating layer acts as a physical barrier which controls the nutrients release[12,13]. The use of controlled release fertilizers causes an increase in their efficiency, reduces soil toxicity and nutrient loss, minimizes the potential negative effects associated with over dosage, reduces the frequency of the application in accordance with normal crop requirement[14,15].The aim of this paper is to show that it is possible to coat nitrogen fertilizer with rubbers such as (NR, SBR, Butyl rubber, Brcis) and that the coating decreases the release of the fertilizer.

Experimental

Materials

The rubbers used as a matrix in this study are Natural rubber (NR) ,Styrene butadiene rubber(SBR 1500),Butyl rubber, and Butadiene rubber(BR-cis). Ammonium nitrate was used as an .inorganic fertilizer

Sample preparation

The raw NR, SBR, , Br-cis and Butyl rubber was masticated first on a two-roll mill by passing it through the rolls about 11 times For rubber compounding, we used a laboratory mill, which has outside diameter 150mm, working distance 300mm speed of the slow roll was 24 rpm and gear ratio 1.4 .Mixing time was 9minutes for rubbers. Compound recipes are summarized in Tables 1. After that, ammonium nitrate was added and mixed for 3 minutes with a rolling bank. The compounds were stored at room temperature for at least 8 hours. Finally we get pieces of 30cm width and 8-10cm thickness. Then the pieces was moved to the extruder where we get spherical pieces with 3-5 diameter.

Formulation of compounds

Formulations with different amounts of rubber are shown in Table 1. The content of all compounded ingredients are given as usual, based on a total of 100 parts of rubber by weight.

Table (1) Compound formulation of different rubber amount with fertilizer.

Phr	Phr	Phr	Phr	Ingredients
100	100	100	100	Styrene butadiene rubber
100	100	100	100	Natural rubber
100	100	100	100	Butadiene rubber (BR-cis)
100	100	100	100	Butyl Rubber
5	5	5	5	Ammonium nitrate

Fertilizer Loaded on Rubber

A loaded rubber sample are used in order to determine the amount of ammonium nitrate released from the rubber. The sample is weighted (5gm) , and then immersed in 200 ml of distilled water at room temperature. The amount of ammonium nitrate released was evaluated using conductivity meter for one hour each 18hours.

Release Rate Measurement

To control the release rate a conductivity meter was used to follow the conductivity with time. The conductivity changes as the ammonium and nitrate ions are released through the membrane. To measure the conductivity 200 ml of water was poured into a beaker into 5 grams of rubber coated fertilizer were added while measuring.

Results and Discussion

Rubbers types that affects the fertilizer release of prepared coating, in the case of SBR , NR, BR-cis and Butyl Rubbers are treated with ammonium nitrate. The results show that the release rate of fertilizer in SBR and Butyl Rubbers are higher than NR and BR-cis, due to both NR and BR-cis rubbers have regular structure and they tend to form crystalline region on mastication(16) which make these coating most compact and exhibited lower amount of fertilizer release from coated fertilizer based on SBR and Butyl rubber. It is clear that the release rate of fertilizer for SBR and Butyl Rubber are higher than NR and BR-cis because these rubbers proved to be effective in entrapping the fertilizer (ammonium nitrate), which in their conventional forms take longer time to dissolve in water than NR and BRcis coated fertilizer.Generally, the release rate of fertilizer were at least doubled for all of the fertilizer using either SBR and Butyl rubber. The SBR rubber give higher rate release of fertilizer than Butyl rubber, while BRcis give higher rate release of fertilizer from NR. The fertilizer release of ammonium nitrate are shown in figures (1 - 4).

It is important to notice that the matrix formulations technique used in this work can be used easily in industrial-scale level with a very low cost. Addition of any pesticides to the fertilizer rubber matrix can be carried out during the preparation of the matrix. This technique does not need to any type of solvent and high temperature. At the same time, the matrix for formulations technique does not demand costly or complex apparatuses, such as granulation drums or fluid beds usually employed for the coating of fertilizer granules or drills.

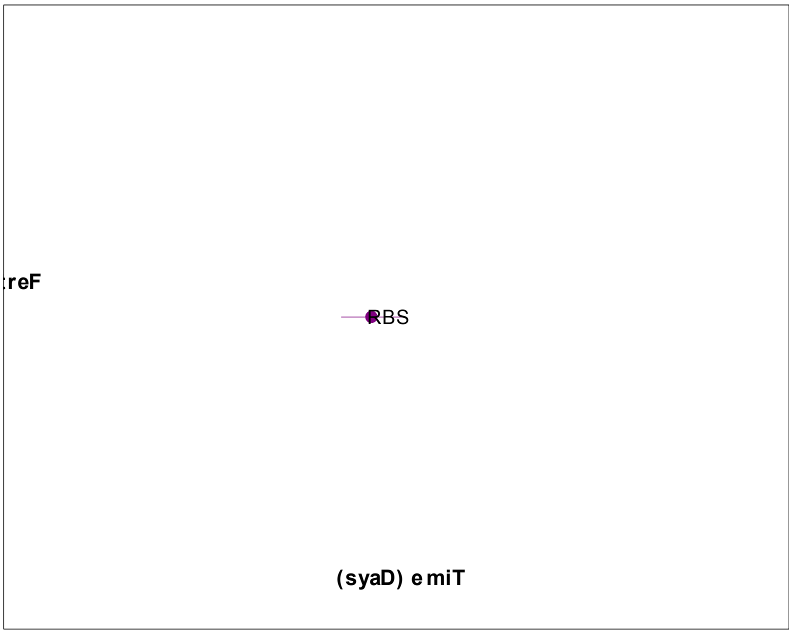

Figure (1). The release rate of ammonium nitrate from SBR

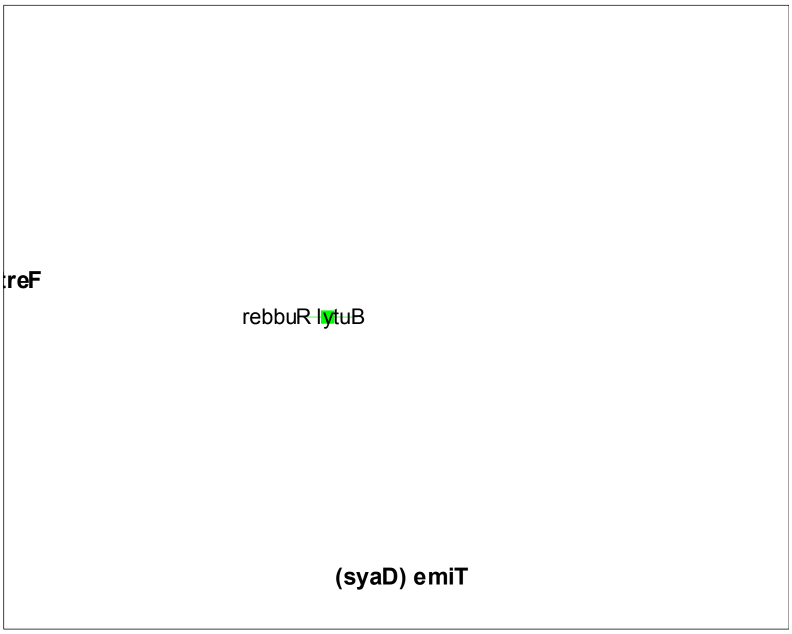

Figure (1). The release rate of ammonium nitrate from Butyl Rubber

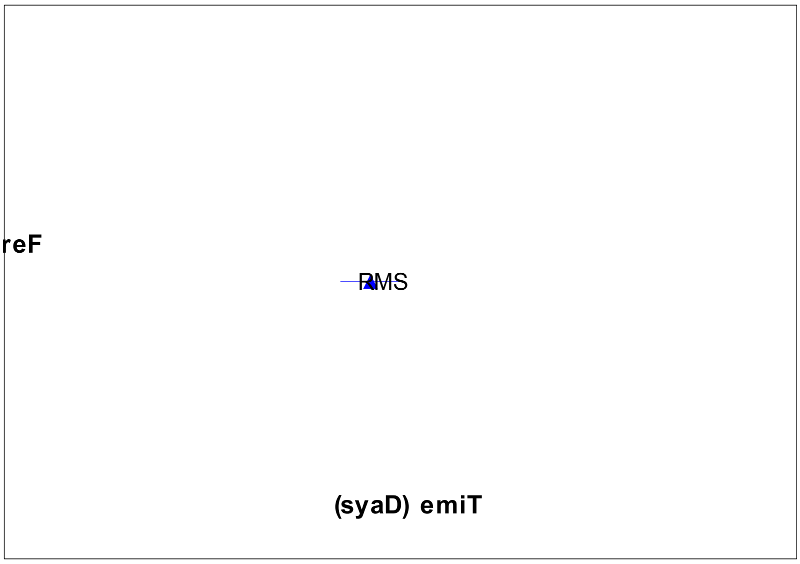

Figure (1). The release rate of ammonium nitrate from NR

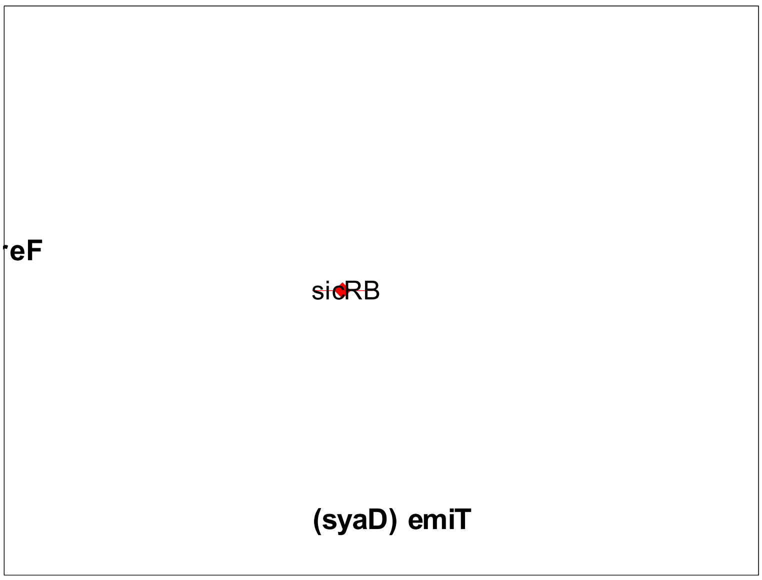

Figure (1). The release rate of ammonium nitrate from BR-cis

Conclusion

One aim of this project was to find a suitable material and method to achieve a coating of nitrogen fertilizers. The results show it was possible to coat fertilizer particles with rubbers and that the release rate decreased with types of rubbers. The rubber proved to be effective in entrapping fertilizers, which in their normal forms dissolve in water in a shorter time than the ordinary fertilizers.The method of preparation of the rubber matrix used in this work does not need a complicated and costly setup or any solvent, which makes this technique quite competitive and with a low-energy demand. In this work, the amount of the fertilizer released from the matrix in a given time was affected by the type of rubber used. It is clear that the release rate of fertilizer for SBR and Butyl Rubber are higher than NR and BR-cis rubbers.

التحرر البطيء لسماد(نترات الامونيوم) المعتمد على استخدام المطاط الطبيعي والصناعي

الخلاصة

يتم تقليل الفقدان نتيجة للترشيح والتطايرللاسمدة وخطر تنشيط ترشيح الأسمدة بعد إضافتها إلى التربة من خلال استخدام الأسمدة ذات التحرر البطيء. هذه الأغشية غالبا ما تتكون من البوليمرات النفاذة ، والشمع أو الكبريت. كان الهدف من هذا المشروع هو إيجاد مادة مناسبة وطريقة لطلاء الأسمدة النيتروجينية

لتحقيق التحرر المسيطر عليه وأيضا لتقييم طريقة الطلاء في نطاق المختبر. سبب اختيار المطاط الطبيعي والصناعي التي استخدمت كمواد طلاء للتحرر المسيطر عليه و لتقليل سرعة التحرر للأسمدة. لتقييم مواد الطلاء تم استخدام مقياس التوصيلية بوصفها دالة للزمن. تم تغيير التوصيلية كمقياس لتحرر ايونات الامونيوم والنترات من خلال الغشاء إلى المياه المحيطة بها. وأظهرت النتائج أمكانية طلاء السماد بالبيوتاديينالستايرين (SBR)، والمطاط الطبيعي (NR) ومطاط البيوتاديين (BRcis) ومطاط البيوتيل ولقد وجد أن تحرر نترات الامونيوم من SBR ومطاط البيوتيل أعلى من NRومطاط BR-cis .

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