International Journal of Agricultural and Natural Sciences
E-ISSN: 2651-3617 15(1): 49-54, 2022
Research Article

DETERMINATION OF THE RELEASE OF NUTRIENTS FROM COATED FERTILIZER GRANULES BY COLD WATER TEST (CWT)

Bahar KANCI BOZOĞLAN*

Doktor Tarsa Tarım Sanayi ve Ticaret A.Ş. Antalya, Turkey

**Corresponding author:*
Email: bahar.bozoglan@drt.com.tr

(Received 03rd November 2021; accepted 12th March 2022)

ABSTRACT. European Standard of EN 13266 points out a method for the determination of the release of the nutrients from coated release fertilizers (CRF). Principle of the method depends on elution of a test portion of a fertilizer with a specified volume of water. Determination of the concentration of the nutrients, that have been dissolved in definite time intervals. In this study, 16-10-17 fertilizer granules were coated with polymers with different thickness. After that, the release of N, P, and K nutrients were followed at definite time intervals by CWT method. The amounts of nutrients released at the end of each period were analyzed and these values were recorded. The coating provides a controlled release of nutrients and determination of 'M' value, means month, for each type of CRF as 2, 4, 6, 12 or 18 months etc. So, the effect of the coating on the nutrient release was investigated by CWT method. According to this study, 50 µm coating of polymer provides the release time of 2M. Similarly, when the coating thickness is increased to 100 µm and 180 µm, the release time reached to 4M and 6M, respectively. As a result, it was seen that the increment of coating ratio causes the reduction of release of nutrients. It means that release times of the nutrients can be controlled by coating thickness. Also, release period could be fixed by this method. This situation ensures using less fertilizer, with the benefit of leaching fewer nutrients, provides ease of use, reduce the application costs compared to water-soluble fertilizers.

Keywords: *Cold water test, CWT, controlled release fertilizer, CRF, nutrient release*

INTRODUCTION

The population of the world is expected to rise by one third in the next thirty years. With the continued population growth, the demand for food is expected to increase as well. Fertilizers are vital for meeting this demand. Fertilizers are the most important nutrient suppliers for soil and plants and ensure the global food security. For this purpose, many fertilizers have been developed with enhanced qualifications such as controlled release fertilizers (CRFs). CRFs are specially developed fertilizer which releases fertilizing nutrients in a controlled and delayed manner corresponding with the essential needs of plants for nutrients [1, 2]. CRFs are enable to dose of nutrients regularly in a continuous style, which means that there is no need to fertilize several times. CRFs have the advantage of pattern, quantity, and time of release are predictable. Also, CRFs provide sustaining of the nutrients in the soil for longer at desired concentration level and rate. CRFs perform in safer, economical and efficient way [1, 3, 4]. Coated fertilizers, the most attractive side of CRFs, serves optimal supply of nutrients during growth period of crops and application of coated fertilizer should benefit the environmental and economic aspects. Nowadays, several materials have been used as covering materials to produce CRFs. Coating materials can be divided into two subclasses, one is inorganic materials and the other is organic polymers. Some examples can be given for inorganic materials such as sulfur, bentonite, and phosphogypsum. Moreover, organic polymers can be either synthetic polymers, such as polyurethane, polyethylene, alkyd resin, etc., or natural polymers such as starch, chitosan, cellulose, and others [1, 5]. In literature, Morikawa et al. studied polyoleofin resin-coated NPK granules enriched with micronutrients in order to control iron deficiency by co-situs applications together with seeds or seedlings [6]. Rosin modified with paraffin wax was prepared by Mumtaz et al. to control release of potassium sulphate as fertilizer [7]. Muslim et al. developed controlled release fertilizers using a mixture of polystyrene with starch as covering material [8]. Also, different combinations of these materials were studied to explore the effect on the release. Ibrahim et al. combined gypsum and sulfur with different proportions as coating material and reported that an equal ratio of gypsum and sulfur results in the best efficiency and lowest urea release [9]. Babadi et al. also presented similar results with gypsum/ground magnesium lime coating [10]. Cui et al. suggested using natural rubber based and multi coated fertilizer [11]. In another study, polyether sulfone, was also used together with Fe_2O_3 nanofiller as a CRF. The addition of Fe_2O_3 nanoparticles get more thicker the coating layer, which slows down the release of nutrients [12]. As understand from this study, coating thickness have essential role in terms of releasing time. Also, Mulder et al. explained that the mechanism of improving fertilizer efficiency is related with core of fertilizer and a coating layer [13].

European Standard of EN 13266 defines a method for the determination of the release of the nutrients from coated fertilizers. This method has the principle of nutrient(s) elution of exact volume of water and the determination of the concentration of the nutrient, which is dissolved in defined time intervals.

The specified method is only applicable to products releasing nutrients by means of a non-biological process (means for coating acting by physical mechanism); microbial attack on the coating and the consequences thereof are not measurable by the technique described. Also, pH-dependent hydrolysis and degradation by biological or microbial mechanisms are excluded.

***Criteria for the “slow release" are*.**

1) not more than a mass fraction of 15 % of a nutrient released in 24 h;
2) not more than a mass fraction of 75 % of a nutrient released in 28 days;
3) at least a mass fraction of 75 % of a nutrient released at the stated release time [14, 15].

Polymer coating is an the most developed way so as to control the release properties of the nutrients in the soil. Currently, thickness value of the coating layer is very low and sufficient to meter out the nutrients over a period ranging from about 3 weeks to about 2 years. Coating thicknesses of 50 micrometer are widespread nowadays. The release of CRF’s is measured mostly by specific methods at constant temperatures under laboratory conditions to predict the performance under real field conditions [16]. In this study, Doktor Tarsa (DRT) 16-10-17 fertilizer granules were coated with polymers with different thicknesses. So, the effect of the coating on the nutrient release was investigated by CWT method according to EN 13266.

MATERIALS AND METHODS

DRT 16-10-17, N-P-K granules were used for CWT analysis. Definite amount of DRT granules was weighed and added into the water in beaker. Their total weight containing fertilizer, water, beaker and magnetic stirrer was recorded. Simultaneously, time was launched and magnetic stirrer started to rotate at a rotational frequency of approximately 300 min^{-1}. Also, the beaker is covered with a lid to avoid evaporation of water and keep the temperature constant at (25±0.5) °C with the temperature control equipment.

Each time nutrient determination was desired to analyze, the solution containing fertilizer was decanted into another beaker, it is important to take care to avoid any of the undissolved fertilizer being carried over. Then, the beaker was refilled with water again at 25°C until receiving the previously recorded mass. This procedure was repeated until more than 75 % of the nominal quantity of water soluble nutrients has been leached. Aliquots were taken as appropriate in order to determine the concentrations of the nutrients, using standard analytical methods. After that, the total extracted amount of nutrients was calculated.

RESULTS AND DISCUSSION

Nowadays, polymer coating materials become more popular due to their properties of being insensitive to environmental factors and able to alter for the controlled release of fertilizers. Release patterns of nutrients from polymeric coatings depend on thickness of the coating and soil temperature [17]. DRT 16-10-17 fertilizer granules which have the coatings of different thickness which are 50 µm, 100 µm and 180 µm were used to investigate their release amounts and their release time in this study. So, the effect of the coating on the nutrient release was investigated by CWT method. When coating thickness was fixed at 50 µm, the release behavior of coated DRT granules was represented at Fig. 1.

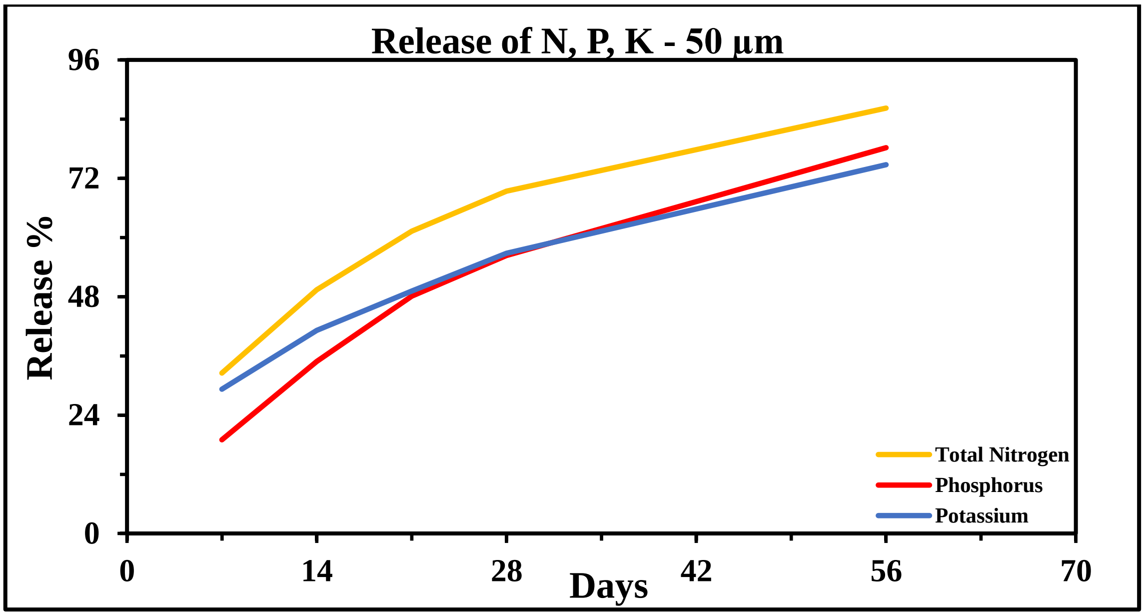

Fig. 1. *Release of the N, P and K nutrient elements from 16-10-17 DRT granules with 50 µm thickness coating*

According to the standard of the analysis, minimum 75 % of nutrient must be released at the stated release time. As seen from Fig. 1., release of N, P and K values reached to 75 % almost 56th day of the experiment. It means that this coating value makes the granules provide controlled release for 2 months. Thickness of the coating was increased to the 100 μm in this part of study, so: the changes that occur with this increment are illustrated at Fig. 2.

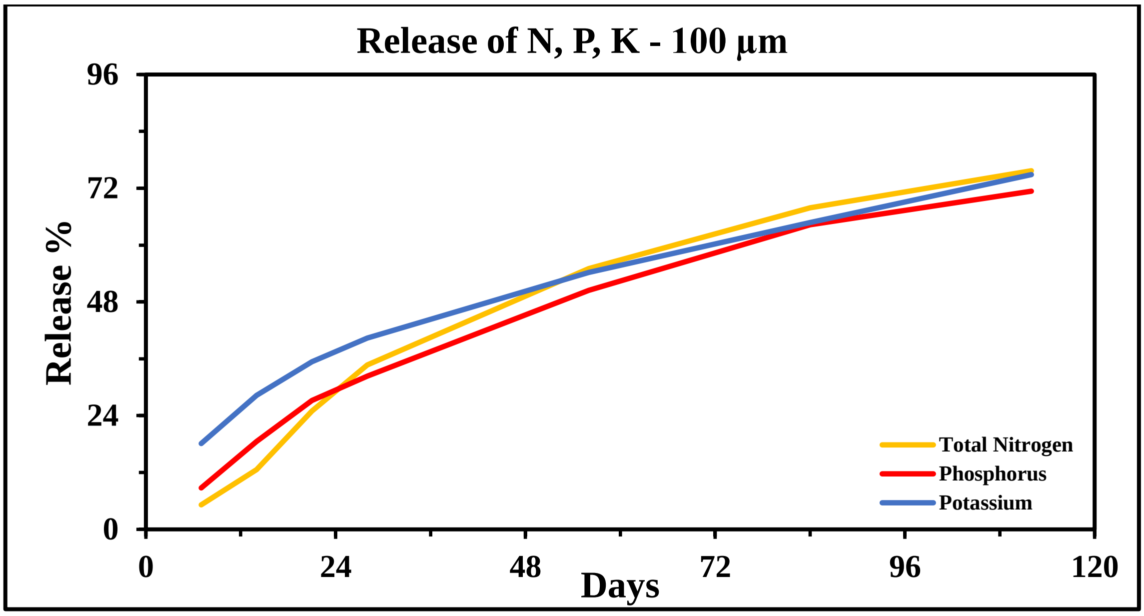

Fig. 2. *Release of the N, P and K nutrient elements from 16-10-17 DRT granules with 100 μm thickness coating*

Similarly with Fig. 1., Fig. 2 explains that the release of nutrients is showing an increment with time. Moreover, release time was extended until 112 days in order to reach 75 % release. It means that, more thicker coating causes less release. Alike, You and Li synthesized CRF of urea coated with paraffin. They also explain that its release rate slows down significantly as the particle size and thickness of paraffin coating increase [18]. Correspondingly, Fig. 3 was shown the 180 μm coating makes the longest delivery time when compared with 50 μm and 100 μm. The release time for nutrient elements is correlated with 6 months as shown from Fig. 3. Moreover, Du et al. prepared granule fertilizers with same core but different coating thickness of 65 μm and 96 μm with ‘‘polyurethane-like’’ coating material for comparing the effect of membrane thickness on the release characteristics of nutrients release. They concluded that nutrients release from polymer coated CRF was mainly controlled by diffusion mechanism.

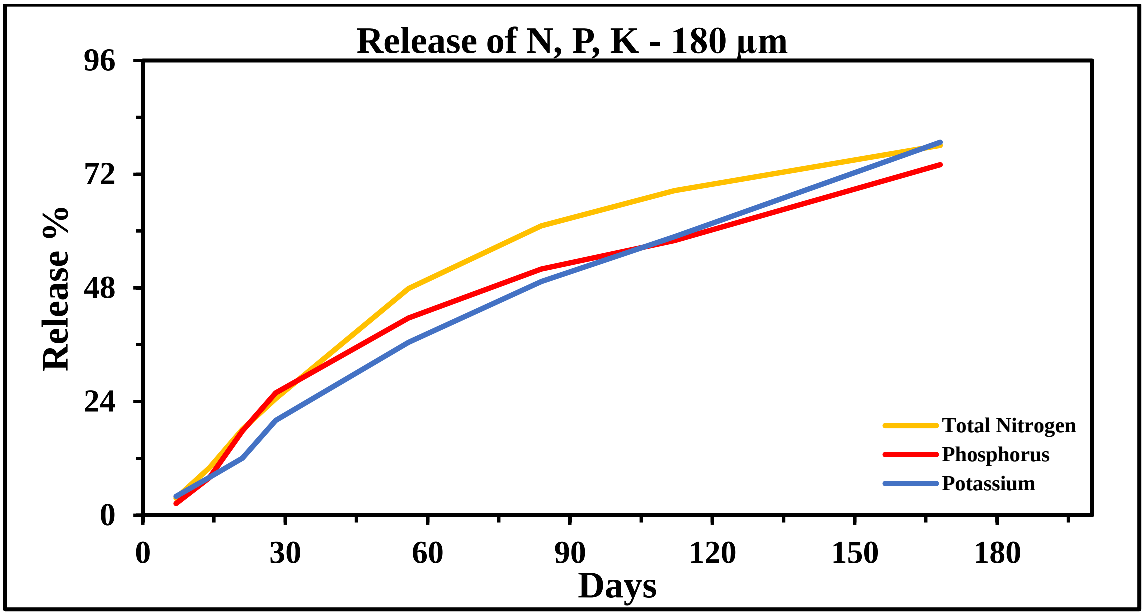

Fig. 3. *Release of the N, P and K nutrient elements from 16-10-17 DRT granules with 180 µm thickness coating*

The temperature and coated membrane thickness were the most important factors. Lower temperature and thicker membrane made a lower diffusion coefficient of coated membrane, which slowed the nutrients release rate [19].

CONCLUSION

An essence principle of modern agriculture is supplying the nutrients to the plants and soil at the same time declining environmental impact. Traditional fertilizers have begun to lose their popularity due to over-fertilization, leaching of microelements to deeper soil layers, ground water and surface water, and poor nutrient use. Precise fertilization techniques such as coated fertilizers are admired in agriculture. The release mechanism of improving fertilizer efficiency is depend on both of a core fertilizer and a coating layer. In this study, fertilizers with same core composition and size, with different thickness of coated were compared and their release time was determined by CWT method. They are obviously seen that release rate slows down and release % also decreases significantly as the thickness of the coating material increase.

Acknowledgement. The author would like to acknowledge the Doktor Tarsa Tarım Ticaret ve Sanayi A.Ş. for initiating and supporting this work and furthermore are grateful to Research & Development team of Doktor Tarsa and Plantacote Tarim Sanayi ve Ticaret A.Ş.

REFERENCES

[1] Lawrencia, D., Wong, S. K., Low, D. Y. S., Goh, B. H., Goh, J. K., Ruktanonchai, U. R., Soottitantawat, A., Lee, L. H., Tang, S.Y. (2021): Controlled Release Fertilizers: A Review on Coating Materials and Mechanism of Release. Plants 10: 238-263.

[2] Fertahi, S. Ilsouk, M., Zeroual, Y., Oukarroum, A., Barakat, A. (2021): Recent trends in organic coating based on biopolymers and biomass for controlled and slow-release fertilizers. Journal of Controlled Release 330: 341-361.

[3] dos Santos, A. C. S., Henrique, H. M., Cardoso, V. L. and Reis, M. H. M. (2021): Slow release fertilizer prepared with lignin and poly(vinyl acetate) bioblend, International Journal of Biological Macromolecules 185: 543-550.

[4] Gil-Ortiz, R., Naranjo, M. Á., Ruiz-Navarro, A., Atares, S., García, C., Zotarelli, L., San Bautista, A. and Vicente, O. (2020): Enhanced Agronomic Efficiency Using a New Controlled-Released, Polymeric-Coated Nitrogen Fertilizer in Rice. Plants 9: 1183-1200.

[5] Trenkel, M. E. (2010): Slow-and Controlled-Release and Stabilized Fertilizers: An Option for Enhancing Nutrient Use Efficiency in Agriculture; IFA, International Fertilizer Industry Association: Berlin, Germany.

[6] Morikawa, C. K., Saigusa, M., Nishizawa, N. K. and Mori, S. (2008): Importance of contact between rice roots and co-situs applied fertilizer granules on iron absorption by paddy rice in a calcareous paddy soil. Soil Science and Plant Nutrition 54: 467-472.

[7] Mumtaz, I., Majeed, Z., Ajab, Z., Ahmad, B., Khurshid, K., Mubashir, M. (2019): Optimized tuning of rosin adduct with maleic anhydride for smart applications in controlled and targeted delivery of urea for higher plant’s uptake and growth efficiency. Industrial Crops and Products 133: 395-408.

[8] Muslim, S., Salman, Fitriani, L., Suharti, N., Erizal, Z., Febriyenti, Aldi, Y., Akmal, D. (2015): Use of bioblend polystyrene/starch for coating urea granules as slow release fertilizer. Journal of Chemical and Pharmaceutical Research 7(11): 478-484.

[9] Ibrahim, K. R. M., Babadi, F. E., Yunus, R. (2014): Comparative performance of different urea coating materials for slow release. Particuology 17: 165-172.

[10] Babadi, F. E., Yunus, R., Rashid, S. A., Salleh, M. A. M., Ali, S. (2015): New coating formulation for the slow release of urea using a mixture of gypsum and dolomitic limestone. Particuology 23: 62-67.

[11] Cui, Y., Xiang, Y., Xu, Y., Wei, J., Zhang, Z., Li, L., Li, J. (2020): Poly-acrylic acid grafted natural rubber for multi-coated slow-release compound fertilizer: Preparation, properties and slow-release characteristics. International Journal of Biological Macromolecules 146: 540-548.

[12] Emami, N., Razmjou, A., Noorisafa, F., Korayem, A.H., Zarrabi, A., Ji, C. (2017): Fabrication of smart magnetic nanocomposite asymmetric membrane capsules for the controlled release of nitrate. Environmental Nanotechnology, Monitoring and Management 8: 233-243.

[13] Mulder, W. J., Gosselink, R. J. A., Vingerhoeds, M. H., Harmsen, P. F. H. Eastham, D. (2011): Lignin based controlled release coatings. Industrial Crops and Products 34: 915-920.

[14] European Standard EN 13226. (2001): Slow-release fertilizers - Determination of the release of the nutrients - Method for coated fertilizers.

[15] Trenkel., M. E. (2010): Slow and controlled-release and stabilized fertilizers, An Option for Enhancing Nutrient Use Efficiency in Agriculture." International Fertilizer Industry Association (IFA) Paris, France

[16] Review of Analytical Methods for Slow- and Controlled Release Fertilizers International (2020): Fertilizer Industry Association (IFA), Paris, France.

[17] Azeem, B., Kushaari, K., Man, Z. B., Basit, A., Thanh, T.H. (2014): Review on materials & methods to produce controlled release coated urea fertilizer. Journal of Controlled Release 181: 11-21.

[18] Yu, X., Li, B. (2019): Release mechanism of a novel slow-release nitrogen fertilizer. Particuology 45, 124-130.

[19] Du, C. W., Zhou, J. M., Shaviv, A. (2006): Release characteristics of nutrients from polymer-coated compound-controlled release fertilizers. Journal of Polymers and the Environment 14(3): 223-230.