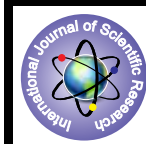


Plant Health and Yield Optimizing Testing with A Controlled Release Fertilizer



Veterinary Science

KEYWORDS : NPK fertilizers, controlled-release fertilizer, wheat

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ABSTRACT

The study was conducted over two years at INCDA-Bottom from Romania to the wheat crop. There were used complex chemical fertilizers NPK based and controlled release fertilizers (CRF). The experimental variants were:

V1 = N0P0K0; CRF V2 = 60 kg / ha + 40 kg / ha N; CRF V3 = 80 kg / ha + 40 kg / ha N; V4 = N120P80K40. The experimental results showed that the use of the controlled release of fertilizers CRF in a dose of 80 kg / ha + combined with 40 kg / ha N were obtained production of 5682.50 kg / ha with 158.0% more compared to the control. These findings identify mechanisms through which drought-induced changes in root systems affect soil C and N availability, and contribute to our understanding of how root traits modify soil processes in a changing world.

INTRODUCTION

The industrial revolution started in the mid-1800s and is marked by producing large quantities of food products and developing various industries together with intensive agriculture. In the main time, the exponential growth of the global population, led the agricultural sector to find solutions to increase the productivity. In this context, starting with starting with the 20th century and using industrial and chemical discoveries, the agriculture is bound to use ever larger quantities of fertilizers to augment the food supply which consequently increases food production costs. These processes led to a large part of the problems facing mankind today.

In order to increase the productivity one the most common are NPK fertilizers. For example the productivity of corn (*Zea mays* L.) and wheat (*Triticum aestivum* L.) increase by at least 30 to 60.5% when using NPK fertilizers [1, 2]. Data published by The World Bank show that in 2013, 151 kg of fertilizers consumed per ha arable land on average for the EU countries [3]. The 3 NPK fertilizers applied to agricultural land provide valuable plant nutrients but, if not managed correctly, excess N and P can have negative environmental consequences.

However, it is clearly demonstrated that the fertilizer use efficiency is low. For example, at traditional fertilizers NPK application, only about 30% to 35%, 10% to 20%, and 35% to 59% for N, P and K, respectively are used by plants [4].

Controlled- or slow-release fertilizers are broadly divided into uncoated and coated products. The uncoated products are in the form of spikes, tablets, balls, briquette, etc. with specific physical characteristics which make them low soluble, so will release slowly the nutrients in soil. Coated products are made by wrapping the NPK granules with a polymer membrane that prevents the NPK from releasing rapidly into the environment. The release rates for coated CRF, depend on coating thickness.

The controlled-release fertilizers polymer coating offer a better control over release in comparison to slow-release fertilizers and are also the ones with the largest growth rate. Currently a large numbers of studies are focused on description of release mechanisms and in modeling release because these are essential for predicting nutrient release under real conditions and which will can provide the technologists with tools for better design of CRFs [5].

The synthetic polymers possess very good mechanical and control release properties but are very hard destroyed by soil microorganisms so, cause soil pollution. In this context natural polymers are preferred because these are biodegradable. However natural biopolymers still have two major problems, namely the release of nutrients through them is more difficult to control and are more expensive [6, 7, 8].

The assessment of control release fertilizers in environment is complex because it involves a number of factors such as fertilizer grain size, coating thickness, depth to which these fertilizers are placed in soil, temperature, humidity, soil properties.

For example Hasan et al [9] established that in a rice crop the best results were obtained when NPK briquettes were placed at 8-10 cm depth in soil. The deep placement of NPK briquettes enhanced the recovery of applied N and N use efficiency [9].

The difference in thickness of coating, breakage of the coating by abrasion, residual moisture content and response of coating material to moisture, the age of coated fertilizers and other environmental conditions determine the ability of each granule to release the fertilizers [8, 10, 11].

In order to promote the sustainable agriculture it is still further developments in biodegradable coatings, improving the knowledge of how to release fertilizers into the environment, process modeling of fertilizers release in the soil,

the best process to obtain environmentally friendly fertilisers with low cost and high efficiency [7, 8].

This present report is based on the testing of Controlled Release Fertilizer product by Everris and its effects on wheat crop, which took place in the experimental field of Crop Fertilization department within NARDI Fundulea. The purpose of the experiment was to test these effects under the soil and climate conditions of the south-east region of Romania, in the Fundulea city, Calarasi county.

MATERIALS AND METHODS

Experimental playground

The experiments were performed on an arable land of National Agricultural Research and Development Institute Fundulea. Its geographical coordinates are: 44°33' Northern latitude and 24°10' Eastern longitude. The relief is generally flat, having the average altitude of 68 m. The climate is continental temperate with an average annual temperature of 10°C. The coldest month is January (average -3,0°C) and the absolute minimum temperature of 26,5°C. The warmest month is July, with average temperature of 22°C and the absolute maximum temperature of 41°C. Annual average rainfall is 571 mm, 72% occurring during growing season, mainly in May-June. Only 35% of the total annual precipitation falls during summer, having a torrential character. The frequency of droughty years is high, over 40%.

Drought periods of 10-14 days are frequent in May-June, and 30 days drought periods occur during early spring and, particularly, late summer. Winters are generally poor in snow.

Soil analysis where the experiment took place

The experimental field is placed in a geographic network with different climatic and soil conditions, which gives a great advantage not found in the other parts of the world to observe differential soil fertility, fertilizer impact on the environment, depending on the physicochemical properties of soil, in different climates and different crop plants systems.

The soils from south-east Romania belong to the chernozem family. The one from Fundulea is cambic chernozem.

For investigated soil samples, pH, soluble salts, mobile phosphorus and potassium, carbonates, humus (organic carbon) and nitrogen concentrations have been analysed.

pH was determined using the potentiometric method with the pH Cond 707 apparatus. When determining soluble salts, the level of inorganic soil components dissolved in water is evaluated. This is important because as this level gets higher, it can inhibit the plants growth.

In order to assess the mobile phosphorus concentration, a small amount from each soil sample, was extracted with ammonium acetate lactate. The phosphate was determined in the obtained solution as „molybdenum blue” using spectrometric measurements, performed with Cintra 404 UV-Vis apparatus.

The concentration of mobile potassium was determined using a Sherwood Model 410 Flame photometer.

Apart from the parameters described above, several others were examined. Total calcium carbonate concentration was measured using Schleibler gas volumetric method [12], and humus concentration by titrimetric method Walklei and Black [13].

Total nitrogen was determined through calculus from the humus concentration.

The assessment of the quality parameters of soils from the south-east Romania shows that all the nutritive elements content ranged from medium to very good.

The wheat variety used in the experiment was GLOSA obtained at National Agricultural Research and Development Institute Fundulea (NARDI Fundulea).

Glosa variety has a semi erect plant bush plant in the twinning phase. The kernels are medium-sized, oblong, red coloured and, under normal culture conditions, have the 1000 kernel mass of 42-43 grams and the hectolitre mass of 76-79 kg/hl.

Experimental set up

Experiments were conducted during periods of winter crops for a period of two years. The wheat was sown on autumn (October) and harvested in July in subsequent years. The results presented in this study are averages of the two years.

The experience was placed after the scheme depicted in table 2. Total number of the variants was 16, distributed in a 4x4 square system. Of the 16 variants, 8 were controls, and 8 plots treated with different doses of Controlled Release Fertiliser – CRF after a pre-determined protocol. Both the controls and treated plots received different doses of nitrogen, phosphorus, potassium and Controlled Release Fertiliser product, as follows:

First stage of nitrogen application – on frozen soil – end of January

For controls the rates used were $N_0P_0K_0$, an unfertilized soil;

For the treated plots, in order to compare them to their designated controls, two doses of Controlled Release Fertiliser were used, measured and applied by suggested protocol: 60 and 80 kg/ha of the product. These doses were applied along with the wheat seed, on sowing, as suggested by the product's protocol

Second stage of nitrogen application – end of March

Every plot, excepting the $N0P0K0$, received an extra dose of 40 kg a.s./ha nitrogen at the end of March so the final doses used in the experiment were as follows:

V1 = $N0P0K0$

V2 = CRF 60 kg/ha + 40 kg/ha N

V3 = CRF 80 kg/ha + 40 kg/ha N

V4 = $N120P80K40$

The fertilizer rate used in the current trial (V3) is the optimal-economical one, from those used in the long term experiments with fertilizers at NARDI Fundulea, and it's specific for this crop - wheat sown after corn (not usually a recommended crop rotation but still used in scientific experiments for analysing the striking effect of different rates of fertilizers on wheat crop, on the soil “drained” by the previous corn crop). The variants are interlaced and randomized for the accuracy of the results and for a good statistical insurance. The placement of the control and treated plots was made taking in consideration the wheat sowing-machine requirements and the type of product analysed (precision fertilizer).

Treatment day

The wheat was sown with the added CRF the months of

October. The product was applied according to the designed protocol, with a sowing machine adapted to place the fertilizer next to the wheat grain. The quantity was adapted to the surface of the present experiment. No issues occur during the operations and everything went accordingly.

Below is table with the average weather conditions from September to July for two successive years. As seen, this was an atypical year with an exceeding of rainfall in the beginning of the spring, followed by severe droughts peaking in June and July

Table – 1
Average weather conditions from September to July for two successive years

Month	Rainfall, (mm)	Relative air humidity, (%)
September	89.3	19.6
October	47.0	10.8
November	94.3	7.8
December	2.8	3.1
January	53.3	-4.3
February	10.3	6.2
March	54.9	7.7
April	81.2	16.1
May	73.7	13.7
June	43.7	22.9
July (1-15)	18.8	23.8

RESULTS

The crop from April

The first pictures of the treated field and the first measurements of the plants on the scaled grid were made on April. As seen in the pictures below, at a first glance the treated plots and the controls appear evenly developed, with not much difference between them, excepting the visual aspect of the unfertilized plot. At a closer inspection thought, some differences can be seen between the different rates of fertiliser used, and a striking difference can be seen in the first picture of the field where we have the V1 variant next to one treated with 60 kg/ha CRF (V2). The major differences can be seen on the grid where the plants treated with CRF and NPK doses are more vigorous in both foliar and root system compared with the untreated control. Based on the numbers above, the visual aspect of the field and the differences between the controls and the treated plants we can say that CRF product had indeed a positive impact on plant development (figure 1).



Figure 1. The comparative aspect of wheat plants developed with and without CRF technology

The crop from May

At this stage, as seen in the pictures below, the visual impact of the field is not that great compared to time when the plants were still small, due to the fact that the wheat crop has the tendency to become very uniform on the last stages of plant growth. On the grid on the other hand, the differences between controls and treated plots are maintained to a certain degree, which suggest the possible boost given by the product. The differences between the untreated control (V1) and the rest of the plants from the other three plots is obvious. The differences between V3 and V4 however tend to fade away, with a slight tent of fuller heads for the V3 variant compared with the CRF 80 kg/ha + 40 kg/ha N variant. For the treated plants (including the fertilized control), depending on the fertilizer rate used, the total length varied. Here are some pictures of the grill comparisons of that date.

In April, plant height ranged from 35.00 cm to control variant and 50.90 cm at V4. In July, the plant height was between 70.00 at control V1 and 78.50 cm at V4 (figure.2).

The correlation between plant height and fertilizing variant showed a very good relevance ($R^2 = 0.9376$) (figure.3).

The crop was harvested on July. At this point, as a whole, the entire trial field, both controls and treated plots, being fully dried, looked even, without visual differences between them. Several plants, from both controls and treated plots were pulled out of the soil for the visual inspection of the roots, leaves, straws and heads.

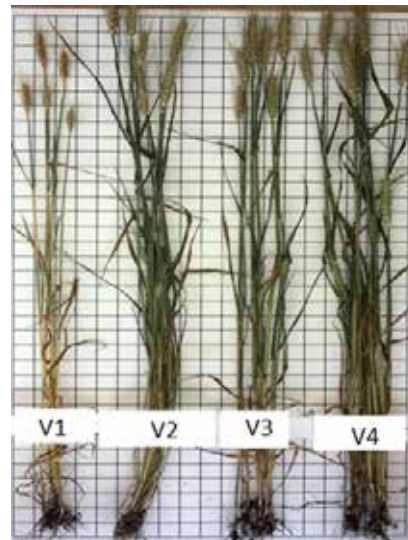


Figure.2. Comparison between variants

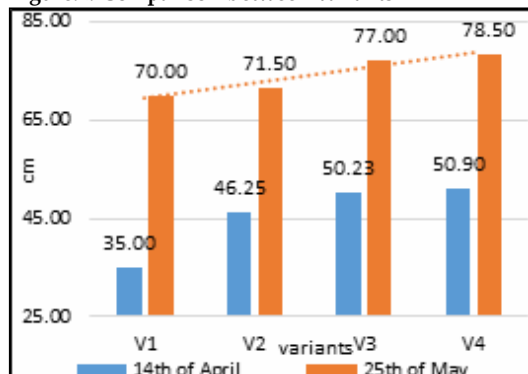


Figure.3.The height of wheat plants

No major differences were observed, with the exception of the heads, which seemed to be a bit fuller and heavier for the N120P80K40, but also for the CRF 80 kg/ha treated plants. This aspect was confirmed on the scaled grid as seen in the figure 4 all wheat heads samples measured around 6-6.5 cm, with the specified ones appearing slightly larger. This is an indication for a possible bigger yield, to be confirmed on data analysis.

From the experimental data sheet we can see that the CRF had a remarkable effect in terms of yield increases along with its application.

The differences between the four repetitions for each variant, through integration into 5% limits, provide the basis for safe conclusions.



Figure 4 Comparison between wheat heads

For the variant fertilized with CRF 60 kg/ha + 40 kg N/ha, yields up to 5075 kg/ha wheat grain were obtained, with 12% humidity. Compared with the untreated control (N0P0K0), yield increase is 2872,5 kg/ha. So, the production was 130.42% higher compared to the control. From the statistically point of view it is noticed a positive difference very significant.

Table.2.
Harvests at experimental variants (12% kernel humidity)

Variants	Yield, (kg/ha)	Differences		Significance
		(kg/ha)	%	
V1	2202.50	0.00	100.00	Mt
V2	5075.00	2872.50	230.42	***
V3	5682.50	3480.00	258.00	***
V4	6715.00	4512.50	304.88	***
Average	4918.75	2716.25	223.33	***
DL5% =	125.800	DL5% in % =	5.7117	
DL1% =	180.830	DL1% in % =	8.2102	
DL01% =	265.570	DL01% in % =	12.0577	

In the case of Variant 3, it was seen a very significant increase in production, as shown statistically too, production being by 3480.0 kg / ha higher compared to the control. Increased production being by 158.0% higher compared to the control.

Achieved the highest production was recorded at V4 with 204.88% upper compared to the control. We also installed the optimal fertilized variant in the climatic conditions from Fundulea, N120P80K40. This dose has led over the years in obtaining maximum yields. This year's yield for this dose was around 6700 kg wheat grains/ha. Regarding the economic peak, it could be quite close to the studied CRF 80 kg/ha + 40 kg N/ha variant.

CONCLUSIONS

Two successive years in an official trial station - INCDA-Fundulea from Romania, CRF Technology was tested to prove its performance comparing with the standard grower practice, especially in autumn application of base fertilizers. By using controlled release fertilizer at a rate of 80 kg / ha and 40 kg / ha N (V3) was obtained in a yield of 5682.5 kg / ha with 3480.00 kg / ha more compared to control (V1). In the case of variant 4, amount of NPK fertilizer was much higher but the difference of production was relatively small. In conclusion, the effects of CRF treatment in the presented weather conditions, with severe drought and laboratory specific non-irrigated conditions of Crop Fertilization Dept. From NARDI Fundulea is remarkable

REFERENCES:

- [1] Stewart, W.M., Dibb, D.W., Johnston, A.E. and Smyth, T.J. (2005). The Contribution of Commercial Fertilizer Nutrients to Food Production. *Agronomy Journal*, 97, 1-6.
- [2] Samimi, A.S. and Thomas, T., (2016). Effects of different levels of NPK on yield by wheat (*Triticum aestivum* L.). *International Journal of Multidisciplinary Research and Development*, 3(5), 224-227.
- [3] http://data.worldbank.org/indicator/AG.CON.FERT.ZS/countries?order=wbapi_data_value_2007%20wbapi_data_value&sort=desc&display=default
- [4] Xiaolin, F. and Zongwen, L., (1998). Increasing fertilizer use efficiency by means of controlled release fertilizer (crf) production according to theory and techniques of balanced fertilization. *Plant Nutrition and Fertilizer Science*, 03, S147.
- [5] Shaviv, A., (2001). Advances in controlled-release fertilizers. *Advances in Agronomy*, 71, 1-49.
- [6] Tomaszewska, M., Jarosiewicz, A. and Karakulski, K., (2002). Physical and chemical characteristics of polymer coatings in CRF formulation. *Desalination* 146(1-3), 319-323.
- [7] Timilsena, Y.P., Adhikari, R., Casey, P., Muster, T., Gilla, H. and Adhikaria, B., (2015) Enhanced efficiency fertilisers: a review of formulation and nutrient release patterns. *J Sci Food Agric*, 95(6), 1131-1142.
- [8] Faez, R., Messa, L., Froes, J. and Souza, C., (2015). Sustainable practices for fertilizer use through controlled release techniques. *Geophysical Research Abstracts*, Vol. 17, EGU2015-2993, EGU General Assembly 2015.
- [9] Hasan, S.L., Islam, R., Sumon, M.H. and Huda, A., (2016). Deep placement of N fertilizers influences N use efficiency and yield of BRRI dhan29 under flooded condition. *Asian J. Med. Biol. Res.* 2 (2), 279-284.
- [10] Shaviv, A., Raban, S and Zaidel, E., (2003). Modeling controlled nutrient release from polymer coated fertilizers: Diffusion release from single granules. *Environ Sci Technol* 37, 2251-2256.
- [11] Ellison, E., Controlled Release Nitrogen Fertilizers for Agriculture. *Agrium Advanced Technologies*, <https://www.researchgate.net>
- [12] Eijkelkamp - Agriresearch company (2012). 08.53 calcimeter. http://www.ecosearch.info/sites/default/files/prodotto_scheda_tecnica/calcolmetro.pdf
- [13] Walkley, A. and Black, I.A. (1934). An examination of Degjareff method for determining soil organic matter, and proposed modification of the chromic acid titration method. *Soil Science* 37:29-38