# THE EFFECT OF SEVERAL FERTILIZER RATES ON WINTER WHEAT YIELD AT ARDS CARACAL

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***Abstract:*** *The paper presents the results of researches carried out within 2008 – 2011 period at ARDS Caracal, District Olt regarding the effect of several fertilizers on winter wheat crop on the cambic baticalcaric chernozem of the zone. The 2008 and 2009 years of the experiment have been less favorable for winter wheat crop yet 2011 has been very favorable which determined much higher yields. On average for three years of research the yields have been directly influenced by fertilizer rates, the nitrogen ones having the highest contribution to the wheat yield increase; however, little differences have been noticed between N 150 and N 200 rates and that proves the low efficacy of higher rates of nitrogen. The interaction between nitrogen and phosphorus is favorable for winter wheat when the nitrogen rates are applied on P 40-80 background, which determine yields of 4,243 – 5,455 and 4,493 – 5,854 kg/ha; the applying of nitrogen different rates on higher P background of P 120 has determined pretty the same yield results, so, they are not recommended. Nitrogen fertilizers determine the highest increase in winter wheat yield yet the highest nitrogen rate, N 200 has limited the yield. Nitrogen – phosphorus interaction is favorable to winter wheat crop when the yield ranges between 4,243 – 5,455 kg/ha and 4,493 – 5,854 kg/ha; the highest phosphorus background, P 120 has limited the yields and it is not feasible economically. Productivity elements: plants height at harvest, the length of the ear, the number of ear branches and the number of grains in an ear has been favorable influenced by nitrogen and phosphorus rates yet the best results were given by the interaction between two fertilizers. The mass of 1,000 grains has been correlated with the yield, being higher were the yields were bigger: P 80 K 80 N 150 yet, especially, N 150 – N 200 P 80. The mass of 100 liters of grains has decreased or stayed at the same level as a result of different phosphorus rates, has increased after potassium application and has decreased after nitrogen rates application; this parameter has increased as a result of interaction between nitrogen and phosphorus and, especially with nitrogen – potassium. On the basis of researches carried out at ARDS Caracal within 2008-2011 period there can be recommended on the chernozem soil of the zone, in climatically favorable years, the following rate: N100-150 P 80; in less favorable years regarding rainfall: N 50-100 P80.*

***Key words*****:** *fertilizers, winter wheat, chernozem,*

## INTRODUCTION

In order to feed increasingly world population (9.2 billion by 2050) there is need a 70% increase of agricultural production (FAO 2009).

The Committee of Food Security of FAO has set up its objective since 1990: providing food for every human being with the complying of three conditions:

- sufficient food supplying;
- evaluation of food reserves;
- access of everyone to food sources, especially for poor ones.

The International Conference for Food held in 1992 has, also, stated the „nutritional dimension" by which everybody, always, has to have access to nutritious and healthy food that allow an active and healthy life (DUMITRU, 2010).

The paramount task in supplying food for mankind is, mainly, accomplished by agriculture that is a very important economic activity as long as everybody needs to eat three

times a day. This task can be achieved in proper conditions if suitable crops are cultivated. Among them, wheat is the most important crop in the world. Along with rice, maize, rye, barley, sorghum, millet it provides 50% of world protein necessary, 70% of carbohydrates, 15% of fats and 55% of all calories eaten all over the world (NICOLESCU, 2008).

One of the most important cropping zones in Romania for wheat is Romanian Plain which has fertile soils and within this zone, a significant area is the one covered by chernozem soil from Oltenia, the Southern part of Olt District where ARDS Caracal is located. Here there have been made long term researches on the effect of several fertilizer rates on winter wheat yield, in 2008-2011 periods.

## MATERIAL AND METHODS

The trials have been located on the cambic baticalcaric chernozem from ARDS Caracal, using the subdivided plot pattern, with three researching factors and three replications, as follows:

The A factor – phosphorus fertilization (kg a.i./ha): a1 = 0; a2 = 40; a3 = 80; a4 = 120.

The B factor – potassium fertilization (kg a.i./ha): b1 = 0; b2 = 40; b3 = 80.

The C factor – nitrogen fertilization (kg a.i./ha): c1 = 0; c2 = 50; c3 = 100; c4 = 150; c5 = 200.

The winter wheat variety was Crina. The phosphorus and potassium fertilizer have been applied in the fall, before seedbed preparation and they have been incorporated into the soil; nitrogen fertilizers have been applied in two phases: first with seedbed preparation and the second one in early spring. The winter wheat crop followed after soybean in the following crop rotation: soybean – winter wheat – corn.

The soil where the experiment took place has the following horizons: Ap = 0-23 cm, Am = 25 – 51 cm, A/B = 51 – 70 cm, Bv = 70 – 105 cm, B/C = 105 – 140 cm, Cca = 140-150 cm. The soil is low to moderate compacted (Bulk density = 1.42 – 1.57 g/cm$^2$), the soil texture is silt – clay (3.6-4.2 thick sand, 31.5-38.0% fine sand, 24.2 – 28.2 % silt and 34.0 – 38.8% clay). The soil reaction is neutral to low alkaline (pH = 7.1 – 7.7). It is average supplied by nitrogen (N = 2.76 – 3.18 %, Nitrogen Index = 2.2 – 2.6), good supplied by phosphorus and potassium (15.5 – 43.0 ppm P, 150 – 233 ppm K).

Clime conditions during the experiment have determined the following characterization as regard crop favorability: 2008-2009 and 2009 – 2010 years have been little favorable and 2010 – 2011 has been very favorable.

There were, also, studied the soil agrochemical features at the start and at the end of the experiment. Besides soil studies there have been made plant determinations as follows:

- plant height at harvest;
- the length of the ear;
- the number of ear branches and the number of grains in an ear branch;
- the mass of 100 liters of seeds;
- the mass of 1,000 grains.
- the yield, kg/ha.

## RESULTS AND DISCUSSIONS

1. The influence of several fertilizer rates on productivity elements (average 2008-2011).

As we presented upward, the main productivity elements, as the plant height, the length of an ear, the number of ear branches and the number of grains in an ear branch, the mass of 100 liters of seeds and the mass of 1,000 grains were, also, determined. They have been interpreted as a result of influence of all three researching factors as well as of separate

influence of each factor. Because there are too many data, we will present only the influence of the interaction between nitrogen and phosphorus.

1.1. The influence of the interaction between nitrogen and phosphorus on growing and development elements of winter wheat plants.

The productivity element of the wheat plants have been obviously influenced by the fertilizer rate and interaction (table 1). This way, the plants height at harvest has been 74 cm without fertilizers, reaching 84.3 cm with N 200 rate and 78 cm with P 120 rate. Mix application of both nitrogen and phosphorus has determined evident increase of plant height to 88 cm with N 200 P 40 and 90.7 cm with N 200 P 80.

The length of the wheat ear has had values of 6.67 cm with not fertilized control treatment and 8,03 cm with N 150; 7.40 cm with P 120 and 8.03 – 8.10 cm with N 150 – N 200 P 80.

The number of ear branches has been of 14.6 with not fertilized control treatment and it has increased to 15.67 with P120 while after applying nitrogen on phosphorus background the value of this parameter reached 17.00, with N200P80.

The number of grains in an ear has followed the same pattern of increase: 34.87 with not fertilized control treatment, 38.13 with P 120 and 44.46 with N 150 P 80.

*Table 1*

The influence of nitrogen – phosphorus influence on productivity elements with winter wheat cropped at ARDS Caracal (average 2008-2011)

| Research factors | | Plant height (cm) | Ear lenght (cm) | Number of ear branches | Number of grains in an ear |
|---|---|---|---|---|---|
| $P_0$ | $N_0$ | 74.0 | 6.67 | 14.6 | 34.87 |
| | $N_{50}$ | 76.7 | 6.83 | 15.47 | 36.73 |
| | $N_{100}$ | 81.0 | 6.87 | 15.13 | 37.00 |
| | $N_{150}$ | 81.7 | 8.03 | 16.73 | 44.47 |
| | $N_{200}$ | 84.3 | 7.57 | 16.46 | 43.20 |
| $P_{40}$ | $N_0$ | 79.7 | 6.67 | 15.53 | 34.0 |
| | $N_{50}$ | 84.7 | 7.17 | 15.67 | 37.73 |
| | $N_{100}$ | 86.0 | 7.33 | 16.40 | 41.07 |
| | $N_{150}$ | 87.3 | 7.60 | 16.53 | 40.67 |
| | $N_{200}$ | 88.0 | 8.03 | 17.47 | 44.27 |
| $P_{80}$ | $N_0$ | 80.3 | 6.97 | 15.20 | 36.53 |
| | $N_{50}$ | 83.3 | 7.23 | 16.00 | 40.46 |
| | $N_{100}$ | 86.7 | 7.67 | 16.67 | 43.00 |
| | $N_{150}$ | 89.7 | 8.03 | 16.73 | 44.46 |
| | $N_{200}$ | 90.7 | 8.10 | 17.00 | 44.60 |
| $P_{120}$ | $N_0$ | 78.0 | 7.06 | 15.67 | 38.13 |
| | $N_{50}$ | 84.0 | 7.40 | 16.07 | 40.93 |
| | $N_{100}$ | 86.0 | 7.80 | 16.47 | 43.33 |
| | $N_{150}$ | 88.7 | 7.83 | 16.47 | 43.66 |
| | $N_{200}$ | 89.7 | 7.93 | 17.00 | 43.80 |

1.2. The influence of nitrogen – phosphorus interaction on the mass of 100 liters and on the mass of one thousand grains

The nutritive value of wheat grains can either be evaluated by its content and quality of nutrients as well as by some physical indicators as: color, the mass of 100 liters, the mass of one thousand grains; these elements have, also, a trade value (PETRA, 2001).

The mass of 100 liters of grains varies, usually, in function of crop variety, grains purity, the moisture of the grains yet, especially in function of the technology used, e.g. fertilization. A high mass of 100 liters of grains give a good image of milling quality of the wheat and has a high importance on the storage (HERA, 2002).

The mass of one thousands grains is one of the physical features of grains that can be used to asses the drought resistance of a certain crop variety, the resistance to several diseases as rust, the reaction of varieties to technology measures as fertilization; crop varieties that have a high mass of a thousand grains express a higher yielding capacity (ALLAND, 1991, WELLINGTON, 1970).

The applying of both nitrogen and phosphorus has had a direct influence on the mass of 100 liters of grains as well as on the mass of one thousand grains (table 2).

*Table 2*

The influence of the nitrogen – phosphorus interaction on the mass of 100 liters of grains and on the mass of one thousand grains of the winter wheat cropped at ARDS Caracal (average 2008-2011)

| Experimental factors | | Mass of 100 liters of grains | Mass of 1,000 grains |
|---|---|---|---|
| Phosphorus rate Kg a.i./ha | Nitrogen rate Kg a.i./ha | | |
| P0 | N 0 | 73.76 | 36.74 |
| | N 50 | 74.03 | 38.49 |
| | N 100 | 73.55 | 39.52 |
| | N 150 | 74.22 | 39.86 |
| | N 200 | 74.10 | 39.44 |
| P40 | N 0 | 73.64 | 38.62 |
| | N 50 | 74.45 | 40.14 |
| | N 100 | 74.42 | 41.08 |
| | N 150 | 74.38 | 41.60 |
| | N 200 | 73.75 | 40.80 |
| P80 | N 0 | 73.67 | 38.64 |
| | N 50 | 74.55 | 40.56 |
| | N 100 | 74.33 | 40.80 |
| | N 150 | 73.65 | 41.90 |
| | N 200 | 73.38 | 40.60 |
| P120 | N 0 | 74.10 | 39.06 |
| | N 50 | 74.71 | 40.22 |
| | N 100 | 74.14 | 40.46 |
| | N 150 | 73.70 | 40.23 |
| | N 200 | 73.17 | 39.85 |

The analysis of the results of these two indicators in function of the nitrogen rates, phosphorus rates and their interaction show that both fertilizers have mainly influenced the mass of one thousand grains and less the mass of 100 liters of grains. This manner, with the not fertilized control treatment, the mass of 100 liters of grains have been 73.76 kg/hl and it increased to 74.10 – 74.22 as a result of fertilization with rates of N 150 – N 200 as well as a result of phosphorus application by P 120, it was 74.10 kg/hl. The interaction between nitrogen and phosphorus has had a favorable influence on the mass of 100 liters of grains at moderate values of these rates, N 50 P 40 – 74.45 kg/hl and N 50 P 120 – 74.79 kg/hl.

High rates of nitrogen and phosphorus, of N 150 – N 200 on P 80 – P 120 has determined the decreasing of the mass of 100 liters of grains to 73.17 – 73.38 kg/hl; this result has been, also, sown up by ALLISON, 1995.

The mass of 1,000 grains has been favorably influenced by the nitrogen and phosphorus applied as well as by their interaction. This, way, with the not fertilized control treatment, the mass of 1,000 grains has been 36.74 g and it progressively increased along with nitrogen rates from N 50 to N 200 at values of 38.62 g and 39.06 g.

The interaction between nitrogen and phosphorus has determined the increasing of this indicator to 41.60 – 41.90 g with fertilizer rates of N 150 P 40 and n 150 P 80.

2. The Influence of several fertilizer rates on yield (average 2008-2011)

Fertilizers are the main factor for wheat yield increasing and without them, the crop variety potential could not be capitalized (NICOLESCU, 2005).

Yield outputs as a result of applying one kg of active ingredient fertilizer are 10-15 kg grains and they can overpass 25 kg in certain conditions, on low supplied soils by nutrients. Taking account that one kilo of a.i. fertilizer (including spreading) costs 4-6 kg of grains it is clear that the fertilizers are economically beneficial (MIHĂILĂ, 2008).

At ARDS Caracal conditions, fertilizers have had good economical efficiency due to high yield outputs. The highest efficiency has been given by nitrogen fertilizers. With not fertilized control treatment the yield has been of 3,210 kg/ha and the yield has increased along with fertilizer rates to 4,240 kg/ha with N 50, to 4,826 kg/ha with N 100, to 5,485 kg/ha with N 200 while with P 0 – P 120 the yield ranged from 4,562 to 4,943 kg/ha.

*Table 3*

The influence of nitrogen fertilizers on winter wheat yield

| C factor Nitrogen fertilization kg/ha s.a | | Average yield 2009-2011 kg/ha | Difference | | Signiffication | Yield output kg/kg s.a |
|---|---|---|---|---|---|---|
| | | | Kg/ha | % | | |
| $C_1$ | $N_0$ | 3210 | Mt. | 100 | - | - |
| $C_2$ | $N_{50}$ | 4240 | 1030 | 132.3 | XXX | 20.64 |
| $C_3$ | $N_{100}$ | 4826 | 1616 | 150.3 | XXX | 16.15 |
| $C_4$ | $N_{150}$ | 5224 | 2014 | 162.7 | XXX | 13.42 |
| $C_5$ | $N_{200}$ | 5485 | 2275 | 170.8 | XXX | 11.37 |

DL 5%=871,3; DL1%=1157,6; DL0,1%=1492,0

There can be noticed that the yield outputs per kg of active ingredient have ranged from 11.37 kg wheat with the highest nitrogen rate to 20.69 kg wheat with the lowest rate, of N 50.

The interaction between nitrogen and phosphorus has had a more accentuated effect than unilateral applying of nitrogen or phosphorus fertilizers. This way, from data of fourth table there can be noticed that with not fertilized control treatment the yield was much reduced, of 2,774 kg/ha.

The applying of several nitrogen rates, of N 50 – N 200 on P 40 background has determined yields of 4,243 – 5,455 kg/ha, the yield outputs being of 52.6 – 96.3%. The yield output per kg of active ingredient fertilizer is high, of 11.05 – 16.21 kg wheat.

On P 80 background there are obtained yields of 4,413 – 5,854 kg/ha. Yield differences over P0 are high, of 854 – 1,080 kg/ha yet, over P 40 they are lowered, of 250-401 kg/ha that are economically correct.

The yield outputs are between 1,714 – 3,075 kg/ha and percent ones of 61.7-210.6% and they show that the yield doubles as a result of applying P 80 N 150 and P 80 N 200.

The applying of several nitrogen rates on P 120 background has limited the yield as compared with P 80 background at the same level of nitrogen or at the same level with P 120 N 200 rate, of 5,854 kg/ha (table 4).

## CONCLUSIONS

1. Nitrogen fertilizers determine the highest increase in winter wheat yield yet the highest nitrogen rate, N 200 has limited the yield;

2. Nitrogen – phosphorus interaction is favorable to winter wheat crop when the yield ranges between 4,243 – 5,455 kg/ha and 4,493 – 5,854 kg/ha; the highest phosphorus background, P 120 has limited the yields and it is not feasible economically;

3. Productivity elements: plants height at harvest, the length of the ear, the number of ear branches and the number of grains in an ear have been favorable influenced by nitrogen and phosphorus rates yet the best results were given by the interaction between two fertilizers;

4. The mass of 1,000 grains has been correlated with the yield, being higher were the yields were bigger: P 80 K 80 N 150 yet, especially, N 150 – N 200 P 80.

5. The mass of 100 liters of grains has decreased or stayed at the same level as a result of different phosphorus rates, has increased after potassium application and has decreased after nitrogen rates application; this parameter has increased as a result of interaction between nitrogen and phosphorus and, especially with nitrogen – potassium;

6. On the basis of researches carried out at ARDS Caracal within 2008-2011 period there can be recommended on the chernozem soil of the zone, in climatically favorable years, the following rate: N100-150 P 80; in less favorable years regarding rainfall: N 50-100 P 80.

*Table 4*

The influence of nitrogen-phosphorus interaction on wheat yield, average 2009-2011

| Factors | | Average yield 2009-2011 kg/ha | Difference | | Signification | Yield output kg/kg s.a |
|---|---|---|---|---|---|---|
| P rate | N rate | | Kg/ha | % | | |
| $P_0$ | $N_0$ | 2779 | Mt. | 100 | - | - |
| | $N_{50}$ | 3639 | 860 | 130,9 | XX | 17,20 |
| | $N_{100}$ | 4105 | 1326 | 147,7 | XXX | 13,26 |
| | $N_{150}$ | 4426 | 1646 | 159,2 | XXX | 10,97 |
| | $N_{200}$ | 4774 | 1995 | 171,7 | XXX | 7,97 |
| $P_{40}$ | $N_0$ | 3196 | 417 | 115,0 | - | 10,62 |
| | $N_{50}$ | 4243 | 1464 | 152,6 | XXX | 16,21 |
| | $N_{100}$ | 4785 | 2006 | 172,1 | XXX | 14,32 |
| | $N_{150}$ | 5127 | 2348 | 184,5 | XXX | 12,35 |
| | $N_{200}$ | 5455 | 2676 | 196,3 | XXX | 11,15 |
| $P_{80}$ | $N_0$ | 3423 | 644 | 123,2 | X | 8,05 |
| $P_{80}$ | $N_{50}$ | 4493 | 1714 | 161,7 | XXX | 13,18 |
| | $N_{100}$ | 5217 | 2428 | 187,7 | XXX | 13,54 |
| | $N_{150}$ | 5707 | 2928 | 205,3 | XXX | 12,73 |
| | $N_{200}$ | 5854 | 3075 | 210,6 | XXX | 10,98 |
| $P_{120}$ | $N_0$ | 3442 | 663 | 123,8 | X | 5,52 |
| | $N_{50}$ | 4586 | 1807 | 164,4 | XXX | 10,62 |
| | $N_{100}$ | 5198 | 2419 | 187,0 | XXX | 10,99 |
| | $N_{150}$ | 5634 | 2855 | 202,7 | XXX | 10,57 |
| | $N_{200}$ | 5854 | 3075 | 210,6 | XXX | 9,60 |

DL 5%=580.0; DL1%=770.6; DL 0,1%=993.6

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