

## INFLUENCE OF CHEMICAL FERTILIZERS APPLICATION ON AUTUMN WHEAT YIELD IN LONG-TERM EXPERIENCES AT AGRICULTURAL RESEARCH AND DEVELOPMENT SECUIENI, NEAMȚ COUNTY, ROMANIA

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**ABSTRACT.** The current paper intends to interpret from a technical point of view the data and yield functions which resulted from applying different fertilizer doses with nitrogen and phosphorus. The analyzed parameters (yield, yield increase, marginal increase) represent basic elements with determining role in establishing the doses and approximating the economic efficiency when applying fertilizers. The data comes from a long time experience with chemical fertilizers at Agricultural Research and Development Station (A.R.D.S.) Secuieni, Neamț county, Romania, since 1975 and examines the results obtained between 2010-2012. As a result of nitrogen and phosphorus chemical fertilizers application (compared to the unfertilized version  $N_0P_0$ ), were achieved yield increases of 5-56%, representing 234-2342 kg/ha. The resulted yield have been influenced by the fertilizer's type but also by the weather conditions in the research period. The use of phosphorus fertilizers in doses of  $P_{40}-P_{160}$  brought medium yield increases compared to the unfertilized version  $P_0$  of 5-13%

representing 256-681 kg/ha, and those with  $N_{40}-N_{160}$  nitrogen brought medium increases (compared to the unfertilized version  $N_0$ ) of 15 -35% representing 599-1584 kg/ha. The production increases were directly correlated with the doses used, establishing highly significant correlations. The yield increases achieved by applying 1 kg of fertilizer active matter had medium values of 4.25-8.82 kg wheat/kg active matter  $P_2O_5$  at phosphorus fertilizers and 9.9-14.97 kg wheat/kg active matter N at nitrogen fertilizers. These increases were indirectly correlated with the applied doses.

**Key words:** Wheat; Phosphorus; Nitrogen; Yields;

**REZUMAT.** Influența îngrășămintelor chimice asupra producției la cultura grâului de toamnă în experiențele de lungă durată la S.C.D.A. Secuieni, județul Neamț. Lucrarea își propune să interpreteze, din punct de vedere tehnic, datele și funcțiile de producție, rezultate ca urmare a aplicării diferitelor doze de

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îngrășăminte cu azot și fosfor. Parametrii analizați (producția, sporul de producție, sporul marginal) constituie elemente de bază, cu rol determinant în stabilirea dozelor și în aprecierea eficienței economice la aplicarea îngrășămintelor. Datele provin dintr-o experiență de lungă durată cu îngrășăminte chimice, organizată la S.C.D.A. Secuieni-Neamț din anul 1975, și analizează rezultatele obținute în perioada 2010-2012. Prin aplicarea îngrășămintelor chimice cu azot și fosfor (față de varianta nefertilizată  $N_0P_0$ ) s-au obținut sporuri de producție de 5-56%, reprezentând 234-2342 kg/ha. Producțiile obținute au fost influențate de tipul îngrășământului și de condițiile climatice din perioada de cercetare. Utilizarea îngrășămintelor cu fosfor în doze de  $P_{40}$ - $P_{160}$  a adus sporuri de producție medii, față de varianta nefertilizată  $P_0$ , de 5-13%, reprezentând 265-681 kg/ha, iar cele cu azot de  $N_{40}$ - $N_{160}$ , sporuri medii (față de varianta nefertilizată  $N_0$ ) de 15-35%, reprezentând 599-1584 kg/ha. Sporurile de producție au fost corelate direct cu dozele folosite, stabilindu-se corelații foarte semnificative. Sporurile de producție realizate prin aplicarea a 1 kg de îngrășământ s.a. au avut valori medii de 4,25-8,82 kg grâu/kg s.a.  $P_2O_5$  la îngrășămintele cu fosfor și de 9,9-14,97 kg grâu/kg s.a. N la îngrășămintele cu azot. Aceste sporuri au fost corelate indirect cu dozele aplicate.

**Cuvinte cheie:** grâu; fosfor; azot; producții.

## INTRODUCTION

Within plant cultivation technologies, the importance of fertilization is undeniable, and the results obtained by the agricultural research and practice have highlighted the influence of this technological link

on the quantitative, qualitative and economical side of resulted crops.

The autumn wheat is a pretentious plant when applying mineral fertilizers because its poor developed radicular system extends over a reduced volume of soil and has a small capacity of solubilisation and absorption nutritive elements reserves from the soil, and the maximum consumption of these takes place in a short period of time, starting from the elongation of the straw until maturity, period in which the plants absorb about 80% of the necessary nitrogen and over 80% of the phosphorus (Bălțeanu, 1998; Burlacu and Popescu, 2007; Hera and Borlan, 1980; Lupu, 2007; Mihăilă *et al.*, 1996; Petcu *et al.*, 2003; Oancea, 1998).

The multitude of factors that influence the fertilizers' efficiency creates difficulties in determining the dosage, even more as some factors are difficult to control or to be taken into account (weather conditions and valorization prices of yield).

The current paper aims to interpret from a technical point of view the data and yield functions resulting from the application of different fertilizer doses with nitrogen and phosphorus. The analyzed parameters (yield, yield increase, the yield increase achieved by applying 1kg of fertilizer active matter) represent basic elements in interpreting the functions of yield from economical point of view, with determining role in establishing the doses and approximating the

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economic efficiency when applying fertilizers.

### MATERIAL AND METHOD

The data comes from the long-term experience located at A.R.D.S. Secuieni, Neamț county (1975), in a 3-year rotation wheat-corn-bean, organized according to the method of subdivided plots into five repetitions.

Analyzed factors: A – phosphorus fertilizers:  $a_1\text{-P}_0$ ;  $a_2\text{-P}_{40}$ ;  $a_3\text{-P}_{80}$ ;  $a_4\text{-P}_{120}$ ;  $a_5\text{-P}_{160}$ ; B – nitrogen fertilizers:  $b_1\text{-N}_0$ ;  $b_2\text{-N}_{40}$ ;  $b_3\text{-N}_{80}$ ;  $b_4\text{-N}_{120}$ ;  $b_5\text{-N}_{160}$ .

The cultivated variety was Crina. Data processing was made using the method of variance, correlations and regressions analysis (Ceapoiu, 1968).

Climatic conditions during the research period (2010-2012) influenced the production and production increases obtained (Figs. 1 and 2). From the climatic point of view, out of the 3 years considered in the study, 2 were more favorable to the wheat crop (2011 and 2012) and one less favorable (2010). The limiting factor for the 2010 year was the excess of humidity recorded in May, June, July, which negatively influenced the phytosanitary condition of the field.

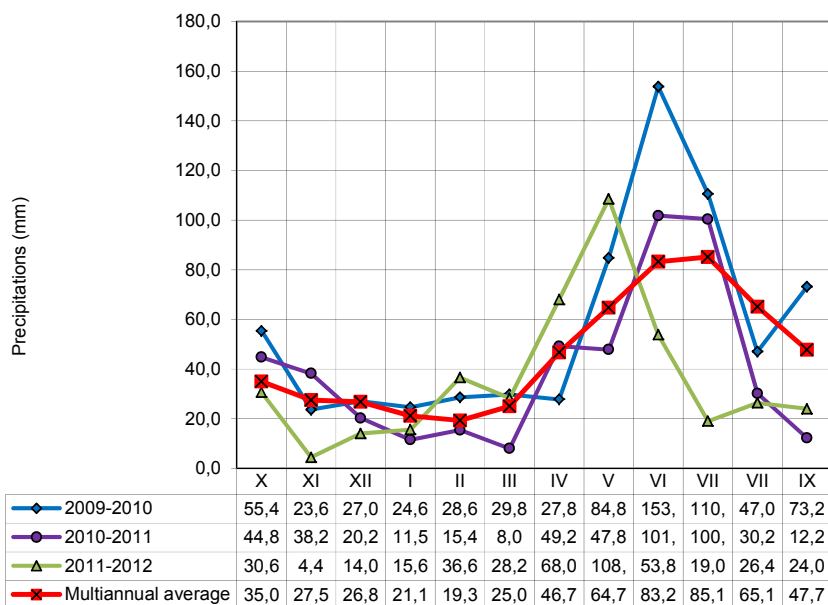
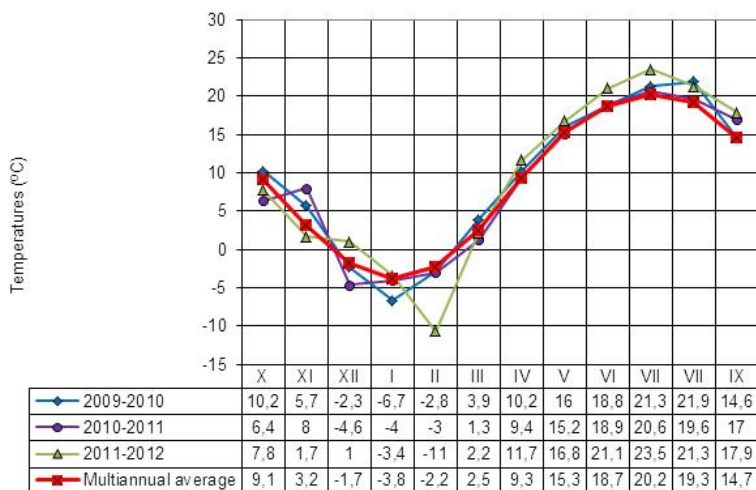


Figure 1 – Monthly and annual precipitations at A.R.D.S. Secuieni-Neamț during 2010 - 2012

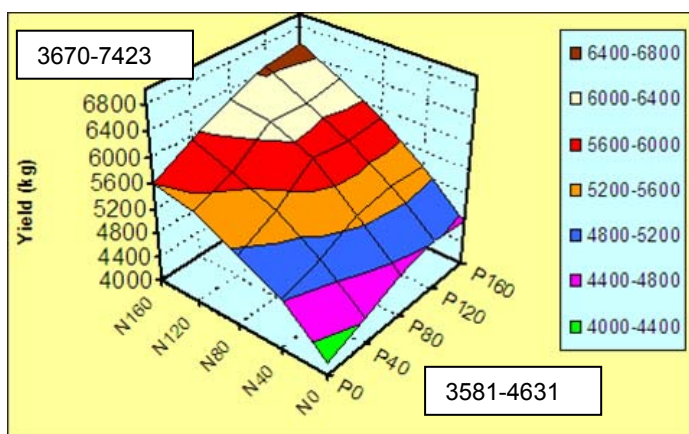


**Figure 2 – Monthly and annual average temperatures at A.R.D.S. Secuieni-Neamț (2010-2012)**

## RESULTS AND DISCUSSION

Wheat yields obtained in the studied period have encountered variations as a result of applied fertilizer doses and different weather conditions (*Fig. 3, Table 1*).

In the case of the unfertilized version ( $N_0P_0$ ), yields ranged between 3581 and 4631 kg/ha, and by applying nitrogen and phosphorus fertilizers between 3670 and 7611 kg/ha.



**Figure 3 – Influence of nitrogen and phosphorus fertilizer on wheat production at A.R.D.S. Secuieni-Neamț (2010 - 2012)**

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**Table 1 – Influence of nitrogen and phosphorus fertilizers on autumn wheat yield - Crina variety (Secuieni, Neamț, 2010-2012)**

| Fertilizer dose<br>kg/ha |                  | Yield<br>kg/ha |      |      | Average<br>2010 - 2012 |     |                |                |
|--------------------------|------------------|----------------|------|------|------------------------|-----|----------------|----------------|
| P                        | N                | 2010           | 2011 | 2012 | Production             |     | Diff.<br>kg/ha | Diff.<br>semn. |
|                          |                  |                |      |      | kg/ha                  | %   |                |                |
| P <sub>0</sub>           | N <sub>0</sub>   | 3581           | 4631 | 4379 | 4197                   | 100 | MT             | -              |
|                          | N <sub>40</sub>  | 3879           | 5512 | 5036 | 4809                   | 114 | 612            | ***            |
|                          | N <sub>80</sub>  | 4066           | 5982 | 5390 | 5146                   | 122 | 949            | ***            |
|                          | N <sub>120</sub> | 4179           | 6482 | 5800 | 5487                   | 131 | 1290           | ***            |
|                          | N <sub>160</sub> | 4272           | 6517 | 6000 | 5596                   | 133 | 1339           | ***            |
| P <sub>40</sub>          | N <sub>0</sub>   | 3670           | 5030 | 4592 | 4431                   | 105 | 234            | -              |
|                          | N <sub>40</sub>  | 4084           | 5583 | 5383 | 5017                   | 119 | 820            | ***            |
|                          | N <sub>80</sub>  | 4372           | 6180 | 5757 | 5436                   | 129 | 1239           | ***            |
|                          | N <sub>120</sub> | 4416           | 6473 | 6280 | 5723                   | 136 | 1526           | ***            |
|                          | N <sub>160</sub> | 4516           | 6854 | 6457 | 5942                   | 141 | 1745           | ***            |
| P <sub>80</sub>          | N <sub>0</sub>   | 3856           | 5167 | 4995 | 4673                   | 111 | 476            | **             |
|                          | N <sub>40</sub>  | 4198           | 5837 | 5882 | 5306                   | 126 | 1109           | ***            |
|                          | N <sub>80</sub>  | 4448           | 6444 | 6776 | 5889                   | 140 | 1692           | ***            |
|                          | N <sub>120</sub> | 4564           | 6861 | 7050 | 6158                   | 147 | 1961           | ***            |
|                          | N <sub>160</sub> | 4635           | 7364 | 6721 | 6240                   | 148 | 2043           | ***            |
| P <sub>120</sub>         | N <sub>0</sub>   | 3860           | 5358 | 5251 | 4823                   | 115 | 626            | ***            |
|                          | N <sub>40</sub>  | 4220           | 6071 | 5856 | 5382                   | 128 | 1185           | ***            |
|                          | N <sub>80</sub>  | 4437           | 6619 | 6377 | 5811                   | 138 | 1614           | ***            |
|                          | N <sub>120</sub> | 4516           | 7070 | 6771 | 6119                   | 146 | 1922           | ***            |
|                          | N <sub>160</sub> | 4591           | 7391 | 7381 | 6454                   | 154 | 2257           | ***            |
| P <sub>160</sub>         | N <sub>0</sub>   | 3831           | 5301 | 5042 | 4725                   | 112 | 528            | ***            |
|                          | N <sub>40</sub>  | 4194           | 5880 | 5923 | 5332                   | 127 | 1135           | ***            |
|                          | N <sub>80</sub>  | 4305           | 6645 | 6565 | 5838                   | 139 | 1641           | ***            |
|                          | N <sub>120</sub> | 4622           | 7026 | 6974 | 6207                   | 149 | 2010           | ***            |
|                          | N <sub>160</sub> | 4582           | 7423 | 7611 | 6539                   | 156 | 2342           | ***            |
| DL P x N (kg/ha)         |                  |                |      |      |                        |     |                |                |
| 5%                       | 380              | 155            | 379  |      |                        | 285 |                |                |
| 1%                       | 427              | 208            | 506  |      |                        | 506 |                |                |
| 0,1%                     | 557              | 273            | 662  |      |                        | 662 |                |                |

The yields variation has been influenced by the combination of fertilizers used, the size of the dose and the weather conditions in the year of experimentation. The medium yields of the unfertilized version in the 2010-2012 period has been of 4195 kg/ha, and by applying nitrogen and phosphorus fertilizers the medium

values ranged between 4431 and 6539 kg/ha (*Table 1*).

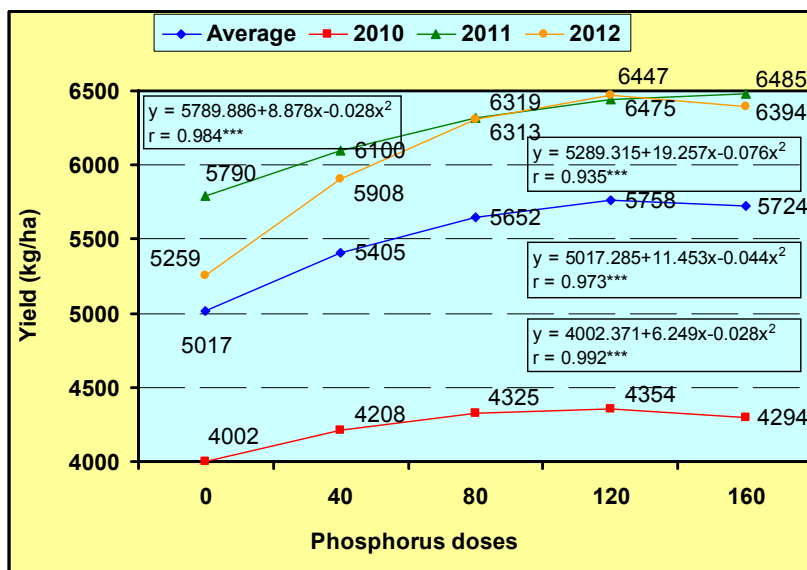
The application of phosphorus fertilizers (considering the averages of the five nitrogen fertilizers graduations) has determined medium productions between 4218 and 6585 kg/ha in the 2010-2012 period (*Table 2*). The average of the version without

phosphorus (2010-2012) has been of 5047 kg/ha, and by applying doses of 40-160 kg P<sub>2</sub>O<sub>5</sub>/ha the medium yields ranged between 5312 and 5753 kg/ha.

Between the phosphorus doses applied and the obtained yield has been set a very close positive correlation (Fig. 4).

**Table 2 – Influence of phosphorus fertilizer on autumn wheat yield**

| Fertilizer dose<br>kg/ha | Yield<br>kg/ha |      |      | Average<br>2010 - 2012 |                |     |                     |
|--------------------------|----------------|------|------|------------------------|----------------|-----|---------------------|
|                          | P              | 2010 | 2011 | 2012                   | Yield<br>kg/ha | %   | Difference<br>kg/ha |
|                          |                |      |      |                        |                |     | Difference<br>semn. |
|                          | 0              | 3995 | 5825 | 5321                   | 5047           | 100 | mt                  |
|                          | 40             | 4218 | 6024 | 5694                   | 5312           | 105 | 265                 |
|                          | 80             | 4340 | 6335 | 6585                   | 5753           | 114 | 706                 |
|                          | 120            | 4325 | 6501 | 6327                   | 5717           | 113 | 670                 |
|                          | 160            | 4307 | 6455 | 6423                   | 5728           | 113 | 681                 |
| DL (kg/ha)               |                |      |      |                        |                |     |                     |
| 5%                       |                | 68   | 78   | 172                    |                |     | 126                 |
| 1%                       |                | 94   | 107  | 237                    |                |     | 174                 |
| 0,1%                     |                | 130  | 148  | 326                    |                |     | 239                 |

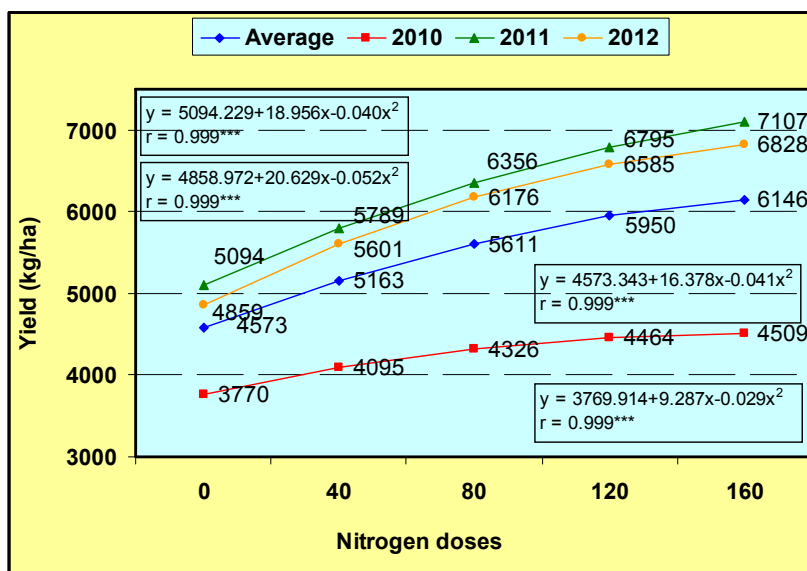


**Figure 4 – The correlation between doses of phosphorus and production of wheat at A.R.D.S. Secuieni-Neamț (2010-2012)**

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**Table 3 – Influence of nitrogen fertilizer on autumn wheat yield**

| Fertilizer dose<br>kg/ha | Yield<br>kg/ha |      |      | Average<br>2010 - 2012 |     |                     |                      |
|--------------------------|----------------|------|------|------------------------|-----|---------------------|----------------------|
| N                        | 2010           | 2011 | 2012 | Yield<br>kg/ha         | %   | Difference<br>kg/ha | Difference<br>seemn. |
| 0                        | 3760           | 5097 | 4852 | 4570                   | 100 | mt                  | -                    |
| 40                       | 4115           | 5777 | 5616 | 5169                   | 113 | 599                 | ***                  |
| 80                       | 4325           | 6374 | 6173 | 5624                   | 123 | 1054                | ***                  |
| 120                      | 4466           | 6782 | 6575 | 5941                   | 130 | 1371                | ***                  |
| 160                      | 4519           | 7110 | 6834 | 6154                   | 135 | 1584                | ***                  |
| DL (kg/ha)               |                |      |      |                        |     |                     |                      |
| 5%                       | 77             | 67   | 169  |                        |     | 127                 |                      |
| 1%                       | 102            | 89   | 224  |                        |     | 169                 |                      |
| 0,1%                     | 132            | 115  | 289  |                        |     | 216                 |                      |



**Figure 5 – The correlation between doses of nitrogen and production of wheat A.R.D.S. Secuieni-Neamț (2010 - 2012)**

The application of nitrogen fertilizers in the 2010-2012 period (considering the averages of the five phosphorus fertilizers graduations) has determined productions ranging between 4115 and 7110 kg/ha (Table 3). The nitrogen unfertilized version

registered productions between 3760-5097 kg/ha in the research period, and the average of the 2010-2012 period has been 4570 kg/ha.

Between the nitrogen doses applied and the obtained yields has

been set a very close positive correlation (*Fig. 5*).

The average gains of yield registered by applying nitrogen and phosphorus fertilizers, comparing to the unfertilized version, were 5-56% (234-2342 kg/ha). They were directly correlated with the type and doses of the applied fertilizers. The lower yield increases have been registered in the versions which have been unilaterally fertilized with phosphorus fertilizer (5-15%, representing 234-626 kg/ha) and lower nitrogen  $N_{40}$  doses (14-28%, representing 612-1185 kg/ha).

The application of increasing nitrogen  $N_{40}$ - $N_{160}$  doses achieved yield gains of 14-33% (612-1399 kg/ha) on the  $P_0$  agrofond, gains of 19-41% (820-1745 kg/ha) on the  $P_{40}$  agrofond, gains of 26-48% (1109-2043 kg/ha) on the  $P_{80}$  agrofond, gains of 28-54% (1185-2257 kg/ha) on the  $P_{120}$  agrofond and production gains of 27-56% (1135-2342 kg/ha) on the  $P_{160}$  agrofond (*Table 1*).

The yield increases obtained by applying phosphorus fertilizers (considering the averages of the five nitrogen fertilizers graduations) compared to the phosphorus unfertilized version have been of 5-14% (265-706 kg/ha). The gains have been increasing on applying  $P_{40}$ - $P_{80}$  doses (5-14%) and they maintained constant (13%) on applying  $P_{120}$ - $P_{160}$  doses (*Table 2*).

The yield gains obtained by applying nitrogen fertilizers (considering the averages of the five phosphorus fertilizers graduations) compared to the nitrogen unfertilized

version have been of 13-35% (599-1584 kg/ha) and have been proportional with the applied nitrogen dose (*Table 3*).

Between the applied fertilizer doses and the obtained yield gains were established highly significant direct correlations (*Figs. 6 and 7*).

In the 2010-2012 period the variation of yield gain on applying nitrogen fertilizers ranged as following: 355-764 kg/ha on  $N_{40}$  dose, 565-1321 kg/ha on  $N_{80}$  dose, 706-1723 kg/ha on  $N_{120}$  dose and 759-2013 kg/ha on  $N_{160}$  dose.

The yield gains on applying phosphorus fertilizers in the research period have registered the following values: 204-373 kg/ha on  $P_{40}$  dose, 345-1264 kg/ha on  $P_{80}$  dose, 330-1006 kg/ha on  $P_{120}$  dose and 312-1102 kg/ha on  $P_{160}$  dose (*Table 4*). The yield increase obtained by applying 1 kg of fertilizer with  $P_2O_5$  during the studied period has values of: 5.10 - 9.32 kg wheat/kg  $P_2O_5$  (average 6.62 kg wheat/kg  $P_2O_5$ ) on the  $P_{40}$  dose, 4.31-15.8 kg wheat/kg  $P_2O_5$  (average 8.82 kg wheat/kg  $P_2O_5$ ) on the  $P_{80}$  dose, 2.75-8.38 kg wheat/kg  $P_2O_5$  (average 5.58 kg wheat/kg  $P_2O_5$ ) on the  $P_{120}$  dose and 1.95-6.94 kg wheat/kg  $P_2O_5$  (average 4.25 kg wheat/kg  $P_2O_5$ ) on the  $P_{160}$  dose.

After using nitrogen fertilizer in the 2010 -2012 period (considering the averages of the five phosphorus fertilizers graduations), the marginal increases obtained by applying 1 kg of nitrogen fertilizer active matter registered values of: 8.87-19.10 kg wheat/kg N active matter (average

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14.97 kg wheat/kg N active matter) on the N<sub>40</sub> dose, 7.06 -16.5 kg wheat/kg N active matter (average 13.17 kg wheat/kg N active matter) on the N<sub>80</sub> dose, 5.88-14.35 kg wheat/kg N active

matter (average 11.42 kg wheat/kg N active matter) on the N<sub>120</sub> dose and 4.74-12.58 kg wheat/kg N active matter (average 9.90 kg wheat/kg N active matter) on the N<sub>160</sub> dose.

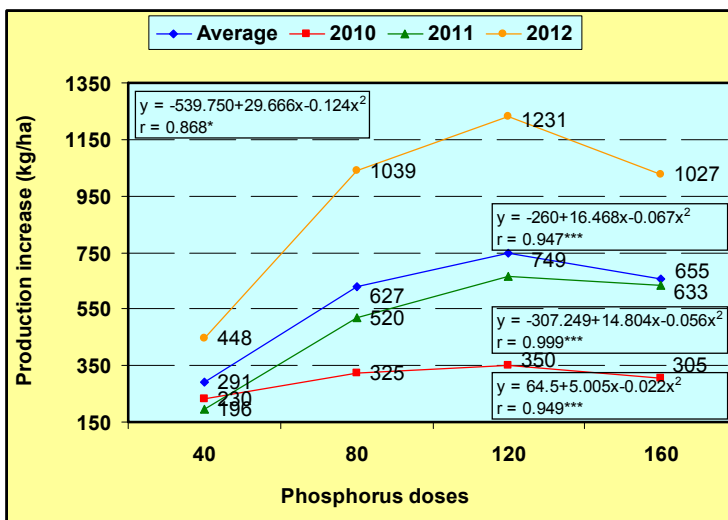


Figure 6 – The correlation between doses of phosphorus and production increase obtained by applying phosphorus fertilizers at A.R.D.S. Secuieni-Neamț (2010-2012)

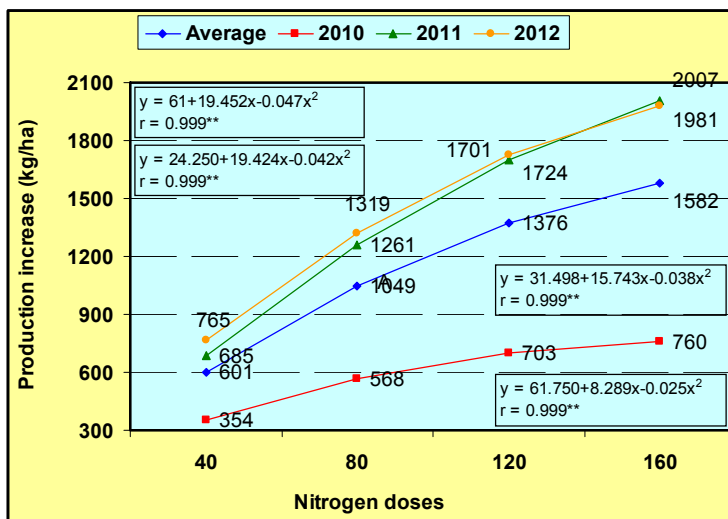


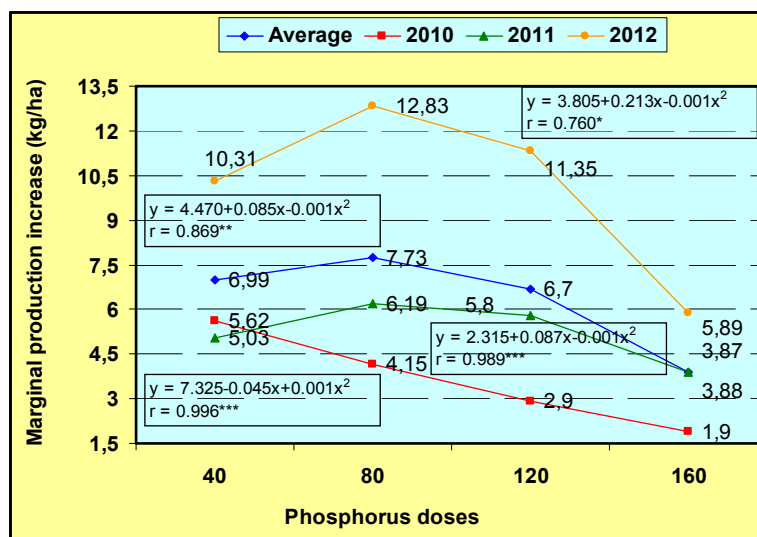
Figure 7 – The correlation between doses of nitrogen and production increase obtained by applying nitrogen fertilizers at A.R.D.S. Secuieni-Neamț (2010-2012)

The marginal average gains have been influenced by the type and dose of the fertilizer used and they presented annual variations, being influenced by the weather conditions. Therefore, they were lower when applying phosphorus fertilizers (4.25-

8.82 kg wheat/kg  $P_2O_5$  active matter) and higher in those with nitrogen (9.90-14.97 kg /kg N active matter) and they were directly correlated with the obtained fertilizer gains and indirectly with the applied dose (Table 4, Figs. 8 and 9).

**Table 4 – The variation of the yield increase and the marginal increase by applying NP fertilizers on autumn wheat yield at the conditions of A.R.D.S. Secuieni-Neamț (2010 - 2012)**

| Fertilizer dose kg/ha | Yield increase kg/ha |                   | Yield increase kg wheat/kg a.m. fertilizer |                   |
|-----------------------|----------------------|-------------------|--------------------------------------------|-------------------|
|                       | variation limits     | average 2010-2012 | variation limits                           | average 2010-2012 |
| P40                   | 204-373              | 265               | 5,10-9,32                                  | 6,62              |
| P80                   | 345-1264             | 706               | 4,31-15,8                                  | 8,82              |
| P120                  | 330-1006             | 670               | 2,75-8,38                                  | 5,58              |
| P160                  | 312-1102             | 681               | 1,95-6,94                                  | 4,25              |
| N40                   | 355-764              | 599               | 8,87-19,10                                 | 14,97             |
| N80                   | 565-1321             | 1054              | 7,06-16,5                                  | 13,17             |
| N120                  | 706-1723             | 1371              | 5,88-14,35                                 | 11,42             |
| N160                  | 759-2013             | 1584              | 4,74-12,58                                 | 9,9               |



**Figure 8 – The correlation between doses of phosphorus and marginal production increase at A.R.D.S. Secuieni-Neamț (2010-2012)**

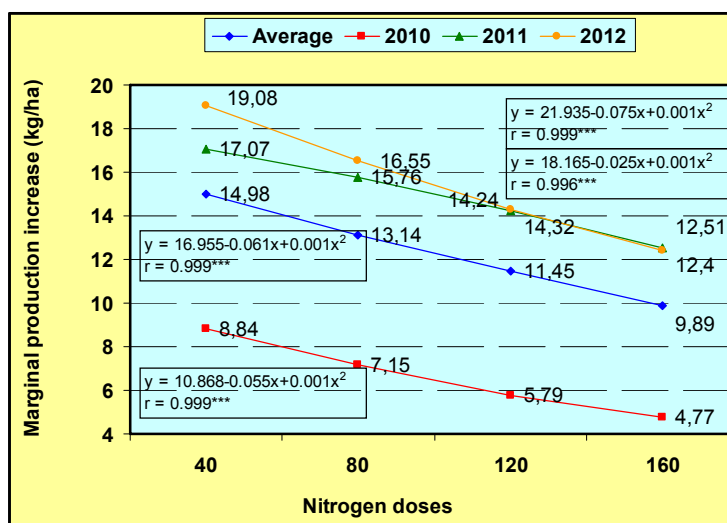


Figure 9 – The correlation between doses of nitrogen and marginal production increase at A.R.D.S. Secuieni-Neamț (2010-2012)

## CONCLUSIONS

The wheat productions obtained by applying phosphorus and nitrogen fertilizers ranged according to the doses used and the weather conditions of the experimentation year. Between applied doses of fertilizer and the acquired yields have been established positive correlations.

Compared to the unfertilized version  $N_0P_0$ , the application of chemical fertilizers on autumn wheat ( $N_{40}$ - $N_{160}$  and  $P_{40}$ - $P_{160}$ ) achieved yield gains of 5-56% (234-2342 kg/ha). The obtained yield gains have been very close correlated with the fertilizer's type and dose, but also with the weather conditions recorded in the research period.

The nitrogen fertilizers achieved medium increases higher than the yield (15-35% representing 599-1584

kg/ha), compared to those with phosphorus, in which case the average yield gains were lower (5-13% representing 265-681 kg/ha).

The yield increases achieved by applying 1 kg of fertilizer active matter have had average values of 4.25-8.82 kg wheat/kg active matter  $P_2O_5$  related to phosphorus fertilizers and 9.90-14.97 kg wheat/kg active matter N related to nitrogen fertilizers and were indirectly correlated with the applied doses.

The best results in wheat yield were obtained by combined application of nitrogen and phosphorus fertilizers.

The optimal dose is that on which the value of achieved yield increase is higher than the acquisition and applying fertilizers costs. For the similar conditions with the experimental ones, it is recommended

to use the doses of 120 kg/ha nitrogen and 80 kg/ha phosphorus in order to obtain a yield increase of 46%, representing 1922 kg/ha.

## REFERENCES

**Bâlțeanu Gh., 1998** - Fitotehnie (Plant growing). Edit. Ceres, București.

**Burlacu Gh., Popescu Ana, 2007** - Rezultate ale cercetărilor în domeniul folosirii raționale a îngrășămintelor (Research results in rational fertilizers use domain). Analele INCDA Fundulea, Vol. LXXV, București.

**Ceapoiu N., 1968** - Metode statistice aplicate în experiențele agricole și biologice (The statistical methods applied in agricultural and biological experiences). Edit. Agrosilvica, București.

**Hera Cristian, Borlan Zenovia, 1980** - Ghid pentru alcătuirea planurilor de fertilizare (Guide for making fertilizer plans). Edit. Ceres, București.

**Lupu Cornelia, 2007** - Influența îngrășămintelor cu azot și fosfor asupra producției de grâu la S.C.D.A. Secuieni, Neamț - 45 de

ani de activitate științifică (The influence of nitrogen and phosphorus fertilizers on wheat crop production at A.R.D.S. Secuieni, Neamț county - 45 years of scientific activity). Edit. Ion Ionescu de la Brad, Iași.

**Mihăilă V., Burlacu Gh., Hera Cristian, 1996** - Rezultate obținute în experiențele de lungă durată cu îngrășămintele pe cernoziomul cambic de la Fundulea (Achieved results in long time experiences with fertilizers at Fundulea on cambic chernozem). Analele INCDA Fundulea, Vol. LXIII, București.

**Petcu Gh., Sin Gh., Ioniță S., 2003** - Evoluția producțiilor de grâu și porumb în experiențele de lungă durată sub influența rotației și fertilizării (Evolution of wheat and maize crop productions in long time experiences by the influence of rotation and fertilization). Analele INCDA Fundulea, Vol. LXX, București.

**Oancea I., 1998** - Tratat de terminologii agricole (Treatise of agricultural terminologies). Edit. Ceres, București.