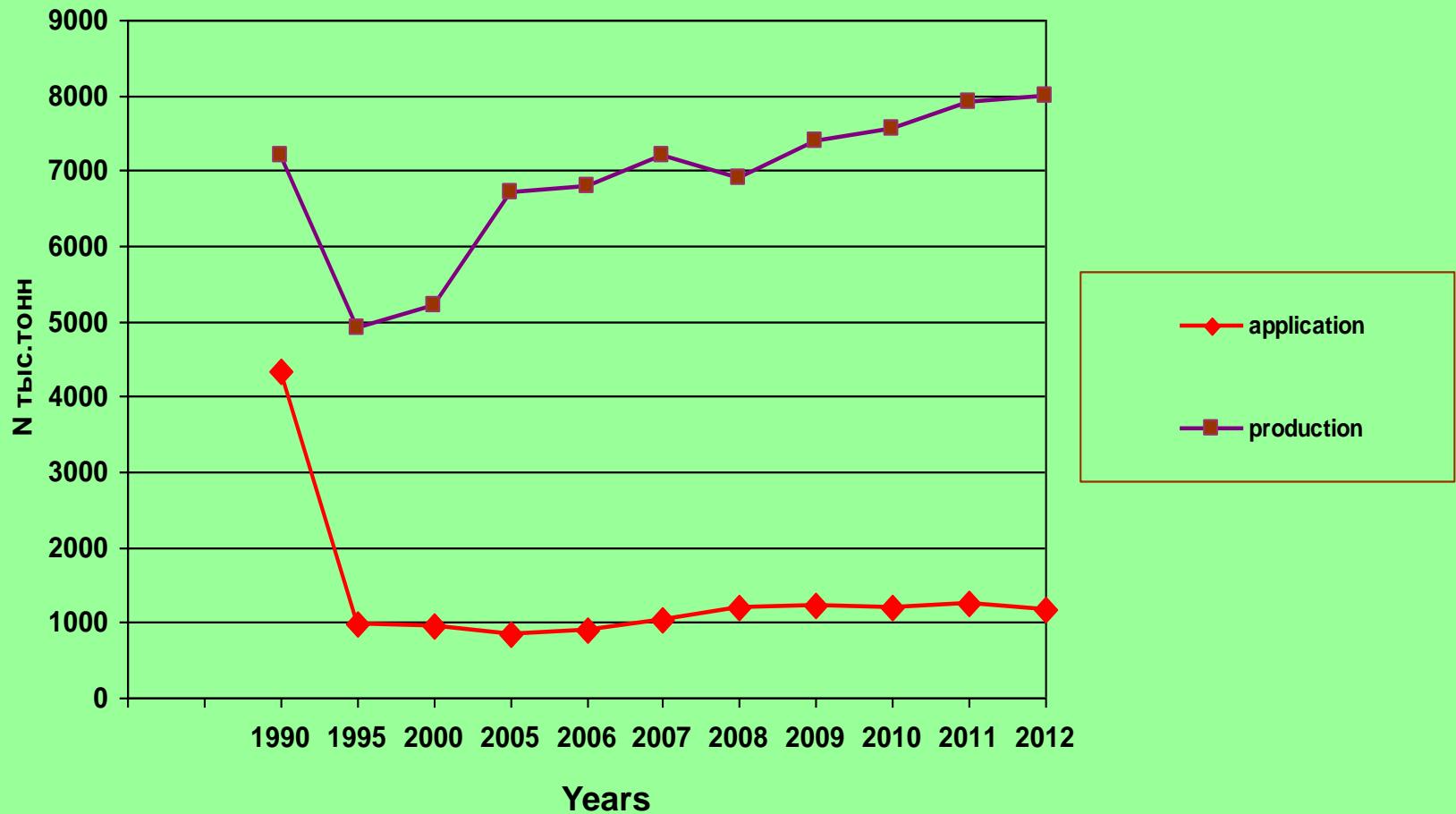




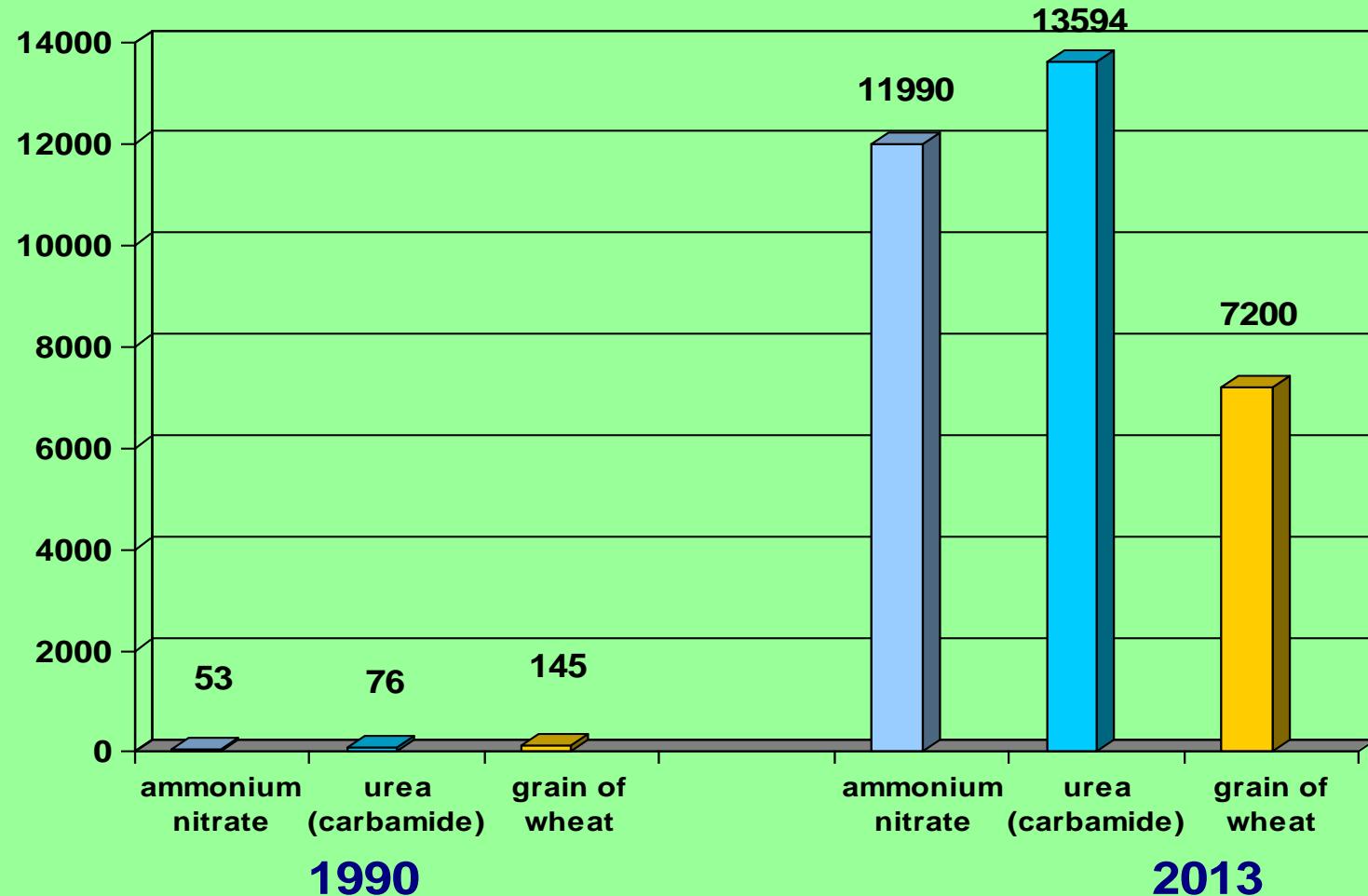
N BALANCE FOR AGRICULTURAL LANDS WITH FERTILISER AND MANURE APPLICATION. A RUSSIAN CASE STUDY

State Research Institution All-Russian Research Institute of organic fertilizers and peat , Vladimir Region, Russia
Sergei M. Lukin, Dr. Sc.

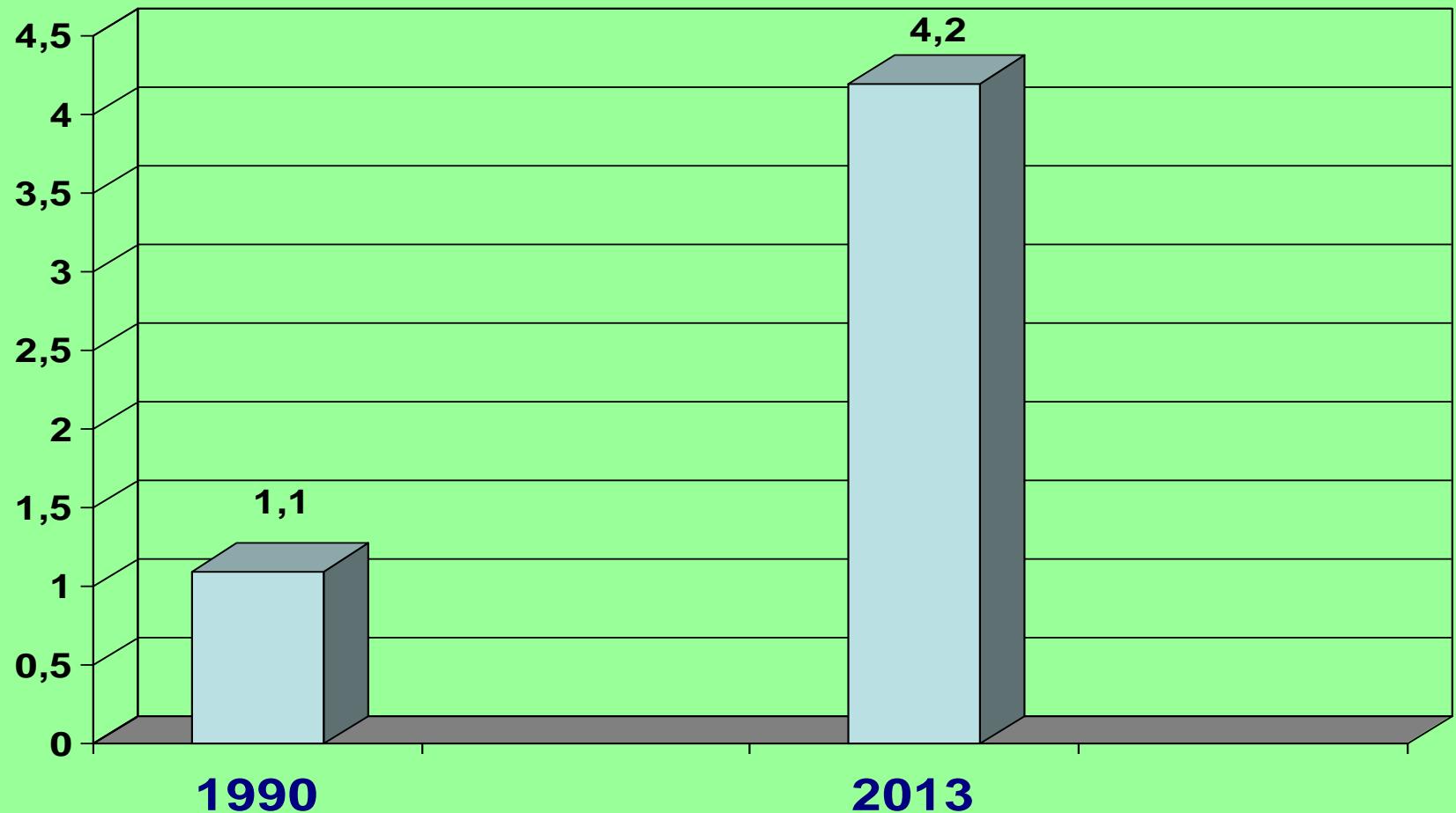
Production and application of nitrogen fertilizers in Russia, N thousand tons



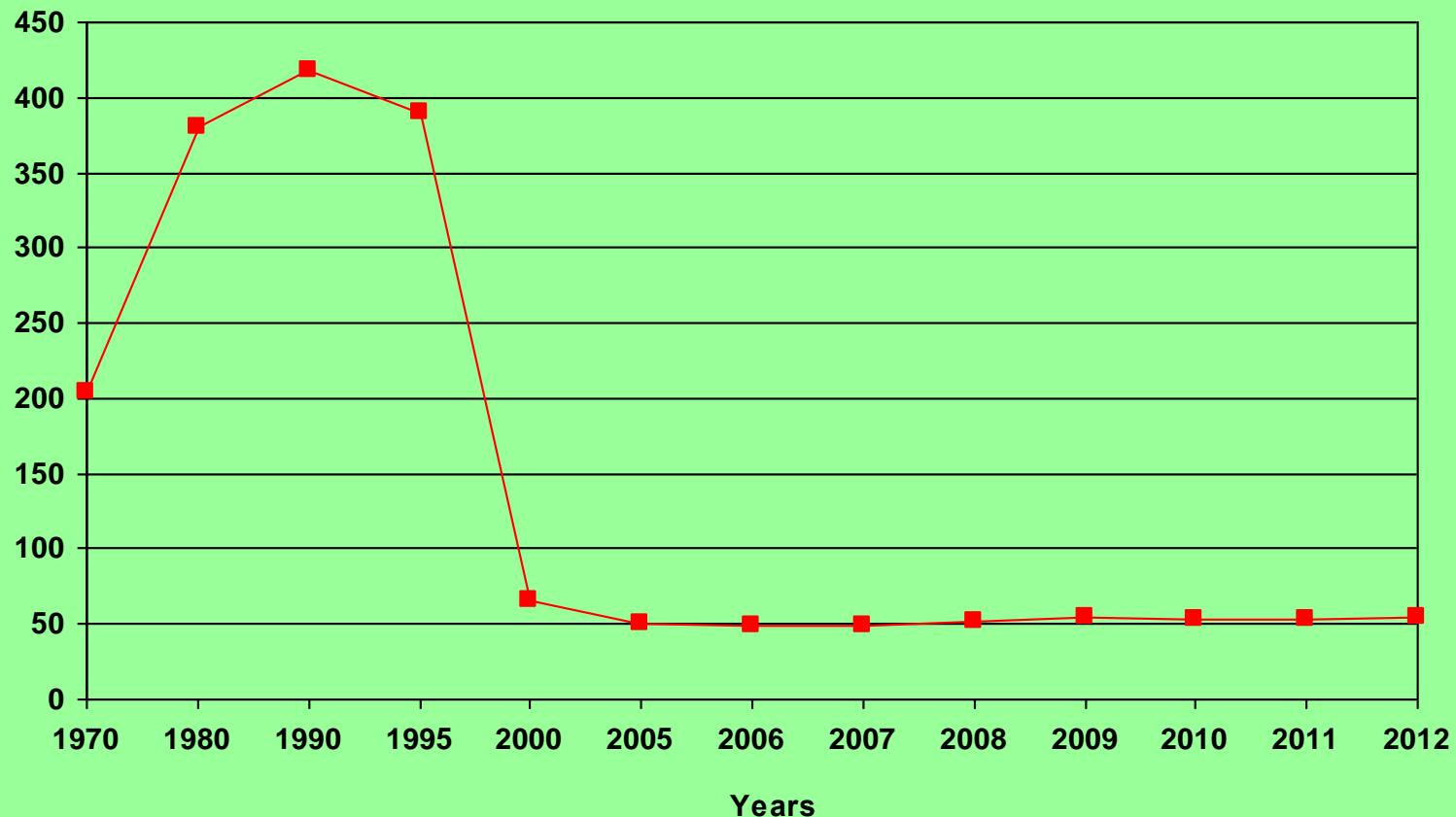
Cost of 1 t of nitrogen fertilizer and winter wheat grain, rub.



Cost ratio of 1 kg N and 1 kg of grain



DYNAMICS OF USE OF ORGANIC FERTILIZERS IN AGRICULTURE OF THE RUSSIAN FEDERATION, million t



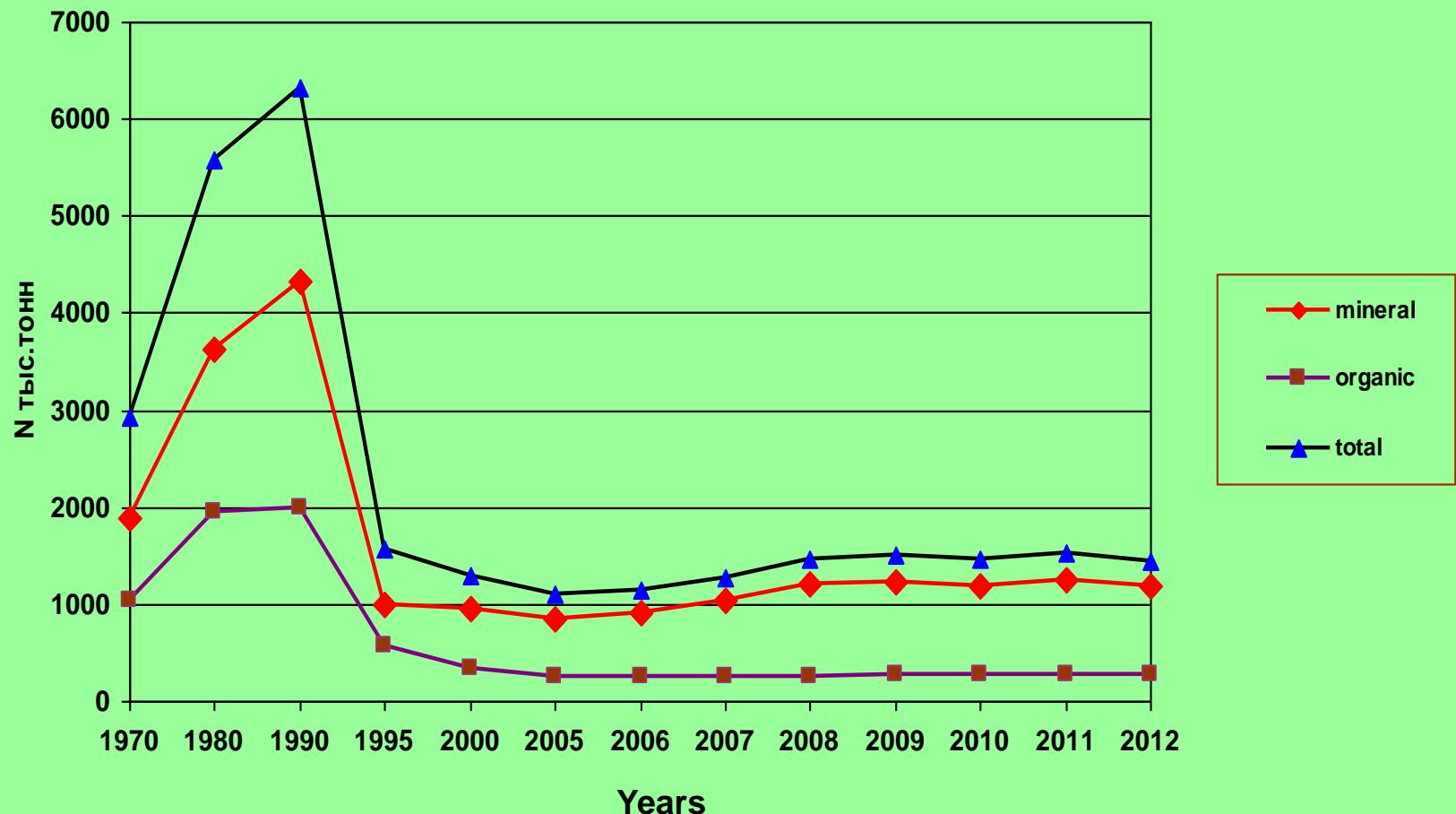
Dynamics of a livestock in the Russian Federation in 1990-2012, million goals

| Years | Cattle cows | | Pigs | Sheep and goats, horses, poultry | horses | poultry | Total UE goals | UE goals /ha |
|-------|-------------|------|------|----------------------------------|--------|---------|----------------|--------------|
| | total | cows | | | | | | |
| 1990 | 57,0 | 20,5 | 38,3 | 58,2 | 2,6 | 660 | 75,5 | 0,64 |
| 1995 | 39,7 | 17,4 | 22,6 | 28,0 | 2,4 | 425 | 51,3 | 0,54 |
| 2000 | 27,5 | 12,7 | 15,8 | 15,0 | 1,6 | 343 | 36,0 | 0,42 |
| 2005 | 21,6 | 9,5 | 13,8 | 18,6 | 1,3 | 357 | 31,2 | 0,41 |
| 2006 | 21,6 | 9,4 | 16,2 | 20,2 | 1,3 | 375 | 32,4 | 0,43 |
| 2007 | 21,5 | 9,3 | 16,3 | 21,5 | 1,3 | 389 | 32,7 | 0,44 |
| 2008 | 21,0 | 9,1 | 16,2 | 21,7 | 1,4 | 405 | 32,8 | 0,43 |
| 2010 | 20,1 | 8,9 | 17,3 | 22,4 | 1,4 | 471 | 32,8 | 0,43 |
| 2011 | 20.1 | 9.0 | 17.3 | 22.8 | 1.4 | 473 | 32.9 | 0.42 |
| 2012 | 20.0 | 8.9 | 18.8 | 24.2 | 1.4 | 496 | 33.8 | 0.44 |

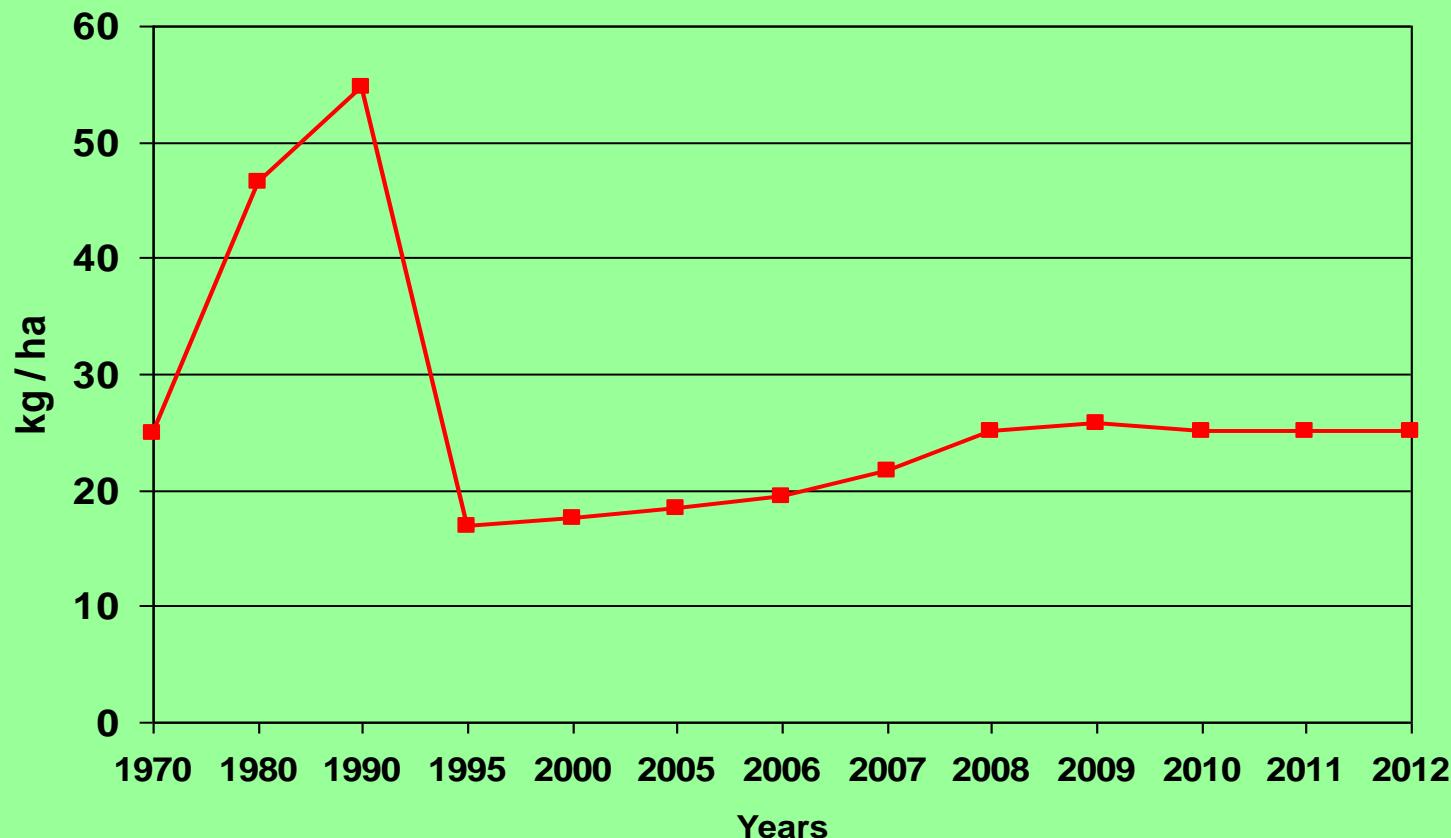
**Resources of manure in the agricultural organisations and personal part-time farms
in Russian Federations, 2008 г, million t**

| Livestock manure | Total | including | |
|---|--------------|---------------------------------|---------------------------------|
| | | Agriculture Organization | personal part-time farms |
| solid manure | 125,2 | 32,0 | 93,2 |
| semi-solid manure | 40,1 | 40,1 | - |
| liquid | 56,1 | 56,1 | - |
| slurry | 34,3 | 34,3 | - |
| compost | 38,6 | 38,6 | - |
| total:physical mass in terms of solid manure | 294,3 | 201,1 | 93,2 |
| | 211,0 | 108,0 | 103,0 |
| NPK, million tons | 2,90 | 1,53 | 1,37 |
| including N, million t | 1,08 | 0,55 | 0,53 |

Receipt of nitrogen with mineral and organic fertilizers in the agricultural organisations of Russia, thousand tons



Receipt of nitrogen with mineral and organic fertilizers in the agricultural organisations of Russia, kg/ ha



Imports of food in RUSSIA, thousand tons

| Food | 1992 | 2000 | 2005 | 2010 | 2011 | 2012 (assessment) |
|---|-------------|-------------|-------------|-------------|-------------|------------------------------|
| Beef and pork | 288 | 517 | 1340 | 1614 | 1429 | 1380 |
| poultry | 46 | 694 | 1329 | 688 | 493 | 555 |
| Fish | 41 | 328 | 787 | 792 | 705 | 672 |
| milk | 46 | 77 | 314 | 238 | 179 | 140 |
| butter | 25 | 71 | 133 | 134 | 135 | 110 |
| sunflower oil | 181 | 150 | 131 | 114 | 94 | 17 |
| sugar | 4848 | 5014 | 3518 | 2371 | 2579 | 475 |
| grain | 28867 | 4677 | 1449 | 444 | 690 | 880 |
| breadstuffs | 1440 | 175 | 74 | 120 | 65 | 70 |
| apples | | 367 | 730 | 1206 | 1191 | 1270 |
| Imports total, billion dollars | 9.6 | 7.4 | 17.4 | 36.4 | 42.5 | 40.0 |

РОССИЙСКАЯ АКАДЕМИЯ СЕЛЬСКОХОЗЯЙСТВЕННЫХ НАУК
МИНИСТЕРСТВО СЕЛЬСКОГО ХОЗЯЙСТВА И ПРОДОВОЛЬСТВИЯ РФ
ЦЕНТРАЛЬНЫЙ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ИНСТИТУТ
АГРОХИМИЧЕСКОГО ОБСЛУЖИВАНИЯ СЕЛЬСКОГО ХОЗЯЙСТВА
(ЦИНАО)

Сигнал

УТВЕРЖДАЮ

Заместитель Министра сельского
хозяйства и продовольствия
Российской Федерации

В.И. Алгинин

" 07 " апреля

2000 г.

МЕТОДИЧЕСКИЕ УКАЗАНИЯ
ПО ОПРЕДЕЛЕНИЮ БАЛАНСА
ПИТАТЕЛЬНЫХ ВЕЩЕСТВ
АЗОТА, ФОСФОРА, КАЛИЯ,
ГУМУСА, КАЛЬЦИЯ

Минсельхоз

Агрохимцентр

Москва - 2000

Guidelines for the calculation Balance of NPK, humus and calcium , 2000

The main elements in the nitrogen balance calculation in Russia

Nitrogen inputs:A

- Fertilisers
- Livestock manure
- Nitrogen supply with seeds (2-5 kg/ha)
- Symbiotic nitrogen fixation (10- 20 kg/ha)
- Non-symbiotic nitrogen fixation (3-10 kg/ha)
- Atmospheric deposition (2-5 kg/ha)

Nitrogen outputs: B

- Removed N Crops and Grass (30-40 kg/ha)
- Removed N Weeds (10-15 kg/ha)
- Emission to the Atmosphere (6-10 kg/ha)
- Emission to ground and surface waters (25- 30 kg/ha)

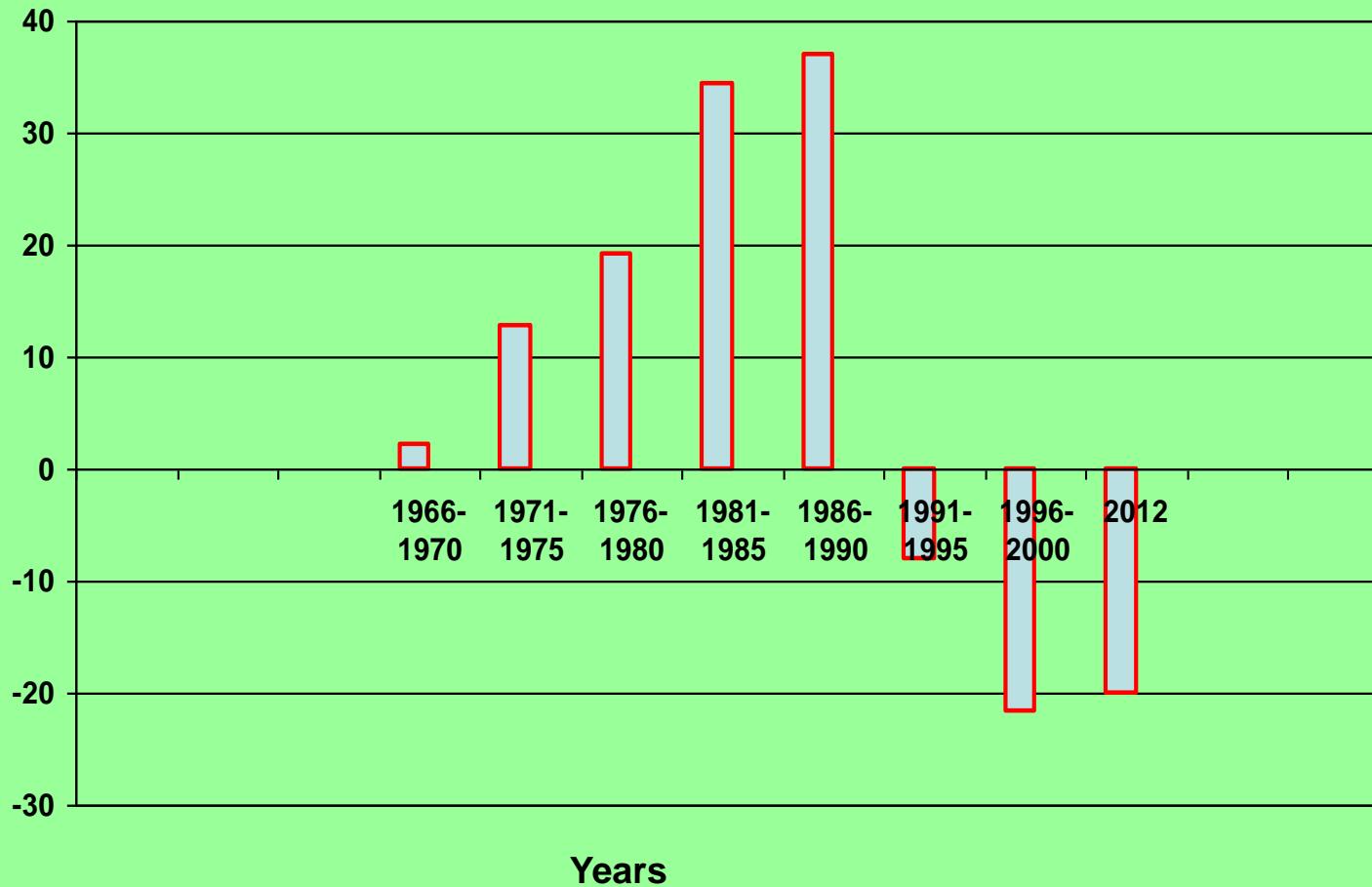
$$A - B = N \text{ balance}$$

Approximate evaluation the nitrogen balance of the Russian Federation in crop production (Zawalin A.A.,2012)

- Fertilisers 1,31 mln. t
- Livestock manure 0,27 mln. t
- Biological nitrogen fixation 0,71 mln. t
- Removed N Crops and Grass 3,02 mln. T

Farm Nitrogen balance – 0,73 mln. t

Gross Nitrogen balance in the Russian AGRICULTURE, kg/ha



Assortment N fertilizers for the planned harvest area with 85 mln.ha

(grain – 120 mln t, sugar beets – 35 mln t, sunflowers – 6 mln t, potatoes -40 mln t, fodder crops – 50 mln t, vegetables and fruit – 20 mln t

| No № | N fertilizers | Mln. t N | % |
|------|------------------------|----------|------|
| 1. | Ammonium nitrat | 0.7 | 16.7 |
| 2. | Urea | 1.3 | 31.0 |
| 3. | Ammonia | 0.4 | 9.5 |
| 4. | Ammonium nitrat + urea | 0.8 | 19.0 |
| 5. | Ammonium sulfate | 0.02 | 0.5 |
| 6. | Complex fertilizers | 0.92 | 21.9 |
| 7. | Other | 0.06 | 1.4 |
| | Total mln. tonn | 4.2 | 100 |
| | Kg N /ha | 49.4 | |



Long-term Field Experiments of VNIIOU



Long-term Field Experiment 1 : Lupine- Winter wheat - Potatoes - Barley





Experiment 1. «Effect of long-term fertilisation systems application for productivity of grain-row crop rotation, production quality and soddy podsolic soil fertility»

(Included in EuroSOMNET database)

Foundation year

1968

Treatments

- 1. Nil inputs
- 2. P50K60
- 3. N50P50
- 4. N50K60
- 5. N50P50K60
- 6. FYM 10 t/ha
- 7. FYM 20 t/ha
- 8. N50P25K60
- 9. N50P50K90
- 10. FYM 5 t/ha+N25P12K30
- 11. FYM 10 t/ha+N50P25K60+straw
- 12. FYM 10 t/ha+N50P25K60 +straw+green manure
- 13. FYM 10 t/ha+N50P25K60
- 14. N100P50K120
- 15. N50P25K60+straw
- 16. FYM 10 t/ha+N100P50K120

Long-term Field Experiment 2 : Crop rotation -

- 1. cereals - row crops**
- 2. cereals - row crops- annual grasses**
- 3. cereals - row crops- lupine**
- 4. cereals - row crops-leguminous grasses**
- 5. cereals - leguminous grasses**



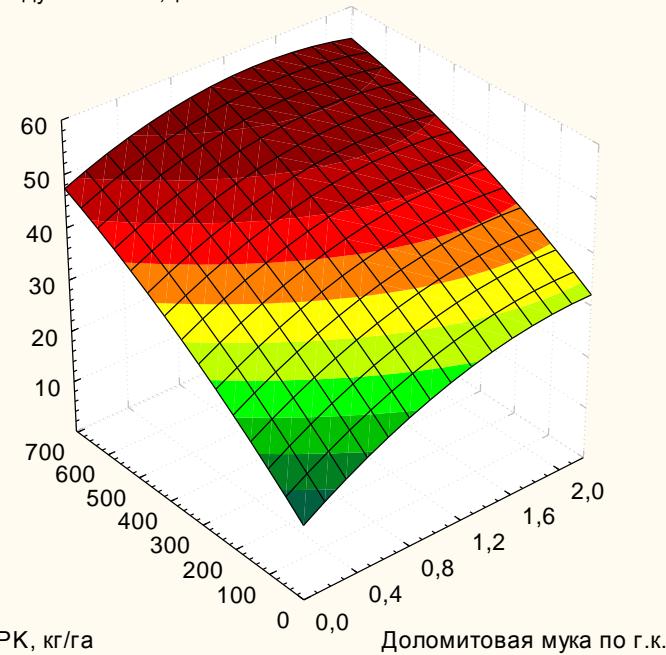
Long-term Field Experiment 3:

Crop rotation: sunflower - winter wheat - maize- barley

dose of fertilizer: N 0-180, P 0-180 K 0-180, manure 0-15 t/ha, and lime



Продуктивность, ц з.е./га



$$Y = 17,50 + 0,695P0,5 + 2,670H0,5 + 12,511Ca0,5 + 0,038(NP)0,5 + 0,752(NCa)0,5 + 0,023(PK)0,5 - 0,782(PCA) - 1,638(HCa)0,5, \quad R = 0,971, R^2 = 0,943, \text{ где } N, P, K - \text{kg/ha};$$

H – manure, t/ha; Ca – lime on units hydrolytic acidity .



Long-term Field Experiment 1

Effect of different fertilization systems on crop yield (average from 7 rotations)

| Treatment | Crops, dt/ha | | | | Average yield, dt/ha G.U. | Yield Increase dt/ha G.U. |
|---------------------------|--------------|--------------|-----------|--------|---------------------------|---------------------------|
| | Lupin | Winter wheat | Pota-toes | Barley | | |
| Nil inputs | 222 | 18,0 | 115 | 13,0 | 23,9 | - |
| FYM 10 t/ha | 243 | 23,9 | 174 | 18,6 | 32,1 | 8,2 |
| FYM 10 t/ha + N25P12K30 | 249 | 26,3 | 183 | 23,5 | 35,3 | 11,4 |
| N50P25K60 | 250 | 25,7 | 178 | 26,6 | 35,6 | 11,7 |
| FYM 20 t/ha | 250 | 26,3 | 200 | 22,0 | 35,6 | 11,7 |
| FYM 10 t/ha + N50P25K60 | 254 | 27,1 | 217 | 29,4 | 39,8 | 15,9 |
| N100P50K120 | 255 | 26,1 | 198 | 29,1 | 38,3 | 14,4 |
| FYM 10 t/ha + N100P50K120 | 268 | 27,3 | 219 | 30,4 | 40,8 | 16,9 |

LSD 0,95 (fertilization systems), dt/ha 9,2 0,9 8,2 1,2 1,4

HCP 0,95 (years), dt/ha 10,2 0,9 8,5 1,3 1,5

Long-term Field Experiment 1
Balance of nitrogen in a crop rotation of use of fertilizerssystems ,
kg/hectares

| Variant | Input N | | removal | Balance | | Intensity of balance% | Efficiency N, % | The content of total nitrogen in soil, % |
|---------------------------------|---------|---------------|---------|---------|--------|-----------------------|-----------------|--|
| | total | The symbiotic | | total | annual | | | |
| Without fertilizers | 1036 | 728 | 1351 | -315 | -11,3 | 77 | - | 0,075 |
| 10 t/ha of Manure | 2471 | 763 | 1772 | 699 | 25,0 | 139 | 30 | 0,095 |
| 10 t/ha of Manure + N25P12K30 | 2483 | 765 | 1936 | 537 | 19,2 | 128 | 42 | 0,086 |
| N50P25K60 | 2467 | 759 | 2084 | 383 | 13,7 | 118 | 52 | 0,075 |
| 20 t/ha of Manure | 3872 | 764 | 1913 | 1959 | 70,0 | 202 | 20 | 0,102 |
| 10 t/ha of Manure + N50P25K60 | 3879 | 771 | 2207 | 1672 | 59,7 | 176 | 31 | 0,084 |
| N100P50K120 | 3865 | 757 | 2221 | 1644 | 58,7 | 174 | 31 | 0,077 |
| 10 t/ha of Manure + N100P50K120 | 5311 | 803 | 2346 | 2965 | 105,9 | 179 | 24 | 0,090 23 |

Long-term Field Experiment 1
Biological utilization (assimilation) and loss of nitrogen in the crop rotation using different systems of fertilizers

| Variant | Input N, kg/ha | Assimilated by plants, kg / ha | Increase content in soil, kg/ha | Total, kg/ha | Loss,kg/ha | | The coefficient of nitrogen assimilation % , % | The ratio of nitrogen assimilation by the plant to the increase of its content in the soil |
|---------------------------------|----------------|--------------------------------|---------------------------------|--------------|------------|---------|--|--|
| | | | | | total | An-nual | | |
| 10 t/ha of Manure | 1400 | 421 | 638 | 1029 | 341 | 12,2 | 76 | 0,7 |
| 10 t/ha of Manure + N25P12K30 | 1400 | 585 | 375 | 960 | 440 | 15,7 | 69 | 1,6 |
| N50P25K60 | 1400 | 733 | 67 | 800 | 600 | 21,4 | 57 | 11,0 |
| 20 t/ha of Manure | 2800 | 562 | 885 | 1447 | 1353 | 48,3 | 52 | 0,6 |
| 10 t/ha of Manure + N50P25K60 | 2800 | 856 | 365 | 1221 | 1579 | 56,4 | 44 | 2,3 |
| N100P50K120 | 2800 | 870 | 195 | 1065 | 1735 | 62,0 | 38 | 4,5 |
| 10 t/ha of Manure + N100P50K120 | 4200 | 995 | 623 | 1618 | 2582 | 92,2 | 39 | 1,6 |

Long-term Field Experiment 1
Changes of mineral nitrogen reserves
in autumn-winter-spring period in soil layer 0-60 cm (n = 19)

| Вариант | Nmin reserves in soil, kg / ha | | Change in autumn-winter period | |
|----------------------------------|--------------------------------|--------|--------------------------------|--------------|
| | autumn | spring | kg / ha | % of initial |
| Lupine - Winter wheat | | | | |
| Nil inputs | 53,4 | 43,5 | -9,9 | -19 |
| FYM 20 t/ha | 61,6 | 57,7 | -3,9 | -6 |
| FYM 10 t/ha+N50P25K60 | 56,3 | 51,0 | -5,3 | -9 |
| N100P50K120 | 67,6 | 42,8 | -24,8 | -37 |
| Winter wheat - Potatoes | | | | |
| Nil inputs | 37,9 | 29,0 | -8,9 | -23 |
| FYM 20 t/ha | 45,9 | 46,2 | +0,3 | +1 |
| FYM 10 t/ha+N50P25K60 | 39,1 | 34,0 | -5,1 | -13 |
| N100P50K120 | 54,7 | 30,1 | -24,6 | -45 |
| Potatoes – Barley | | | | |
| Nil inputs | 42,2 | 24,6 | -17,6 | -42 |
| FYM 20 t/ha | 59,1 | 42,7 | -16,4 | -28 |
| FYM 10 t/ha+N50P25K60 | 61,7 | 32,8 | -28,9 | -47 |
| N100P50K120 | 58,0 | 22,3 | -35,7 | -62 |
| Barley –Lupine | | | | |
| Nil inputs | 38,4 | 24,9 | -16,2 | -42 |
| FYM 20 t/ha | 38,3 | 22,1 | -16,2 | -42 |
| FYM 10 t/ha+N50P25K60 | 49,0 | 22,5 | -26,5 | -54 |
| N100P50K120 | 77,0 | 24,2 | -52,8 | -68 |
| On average, crop rotation | | | | |
| Nil inputs | 43,0 | 30,5 | -12,5 | -29 |
| FYM 20 t/ha | 60,7 | 42,2 | -18,5 | -30 |
| FYM 10 t/ha+N50P25K60 | 51,6 | 35,1 | -16,5 | -32 |
| N100P50K120 | 64,3 | 29,8 | -34,5 | -54 |



The content of nitrate nitrogen in the soil and underlying moraine after potatoes

| Depth, см Глубина отбора образцов, см | Nil inputs Без удобрений | FYM 20 t/ha Навоз 20 т/га | FYM 10 t/ha + N25P12K30 Навоз 10т/га+ N50P25K60 | N100P50K120 | FYM 10 t/ha + N100P50K120 Навоз 10т/га+ N100P50K120 |
|---|--------------------------------|------------------------------|---|-------------|--|
| 0-20 | 4,2 | 7,9 | 4,6 | 4,2 | 10,0 |
| 20-40 | 2,2 | 6,3 | 3,6 | 2,8 | 12,6 |
| 40-60 | 1,2 | 2,8 | 2,8 | 2,8 | 2,8 |
| 60-80 | 1,1 | 2,8 | 2,5 | 2,8 | 2,2 |
| 80-100 | 1,1 | 2,8 | 2,5 | 3,5 | 3,5 |
| 100-120 | 1,1 | 2,2 | 2,5 | 2,8 | 4,2 |
| 120-140 | 1,2 | 2,2 | 2,8 | 2,8 | 3,5 |
| 140-160 | 1,2 | 2,2 | 2,8 | 2,8 | 3,5 |
| 160-180 | 1,7 | 2,2 | 2,8 | 2,8 | 3,5 |
| 180-200 | 1,2 | 2,1 | 2,8 | 2,2 | 4,2 |
| 200-220 | 1,2 | 2,2 | 3,2 | 2,2 | 3,5 |
| 220-240 | 1,7 | 2,1 | 3,2 | 2,2 | 4,2 |
| 240-260 | 1,2 | 2,2 | 3,3 | 2,2 | 4,2 |
| 260-280 | 1,7 | 2,2 | 3,3 | 2,7 | 3,5 |
| 280-300 | 1,7 | 2,2 | 3,6 | 2,7 | 4,2 |

Long-term Field Experiment 2
Nitrogen balance in crop rotations with different specialization without
fertilizers, kg / ha per year

| Crop rotation | percen- tage of legu- mes | Input N | | | Remo- val | Balanc- ce | Inten- sity of balan- ce % |
|--|---------------------------------------|---|---------------------------|-------|--------------|---------------|-------------------------------------|
| | | with precipi- ta- tion and seeds | Nitro- gen fixation | total | | | |
| cereals - row crops | 0 | 10,5 | 0 | 10,5 | 40,0 | -29,5 | 26 |
| cereals - row crops- annual grasses | 12 | 10,3 | 10,4 | 20,7 | 46,3 | -25,6 | 45 |
| cereals - row crops- lupine | 25 | 11,0 | 26,0 | 37,0 | 48,3 | -11,3 | 77 |
| cereals - row crops- leguminous grasses | 33 | 9,7 | 37,8 | 47,5 | 63,7 | -16,2 | 75 |
| cereals - leguminous grasses | 33 | 9,2 | 89,7 | 98,9 | 103,7 | -4,8 | 95 |

**Input of nitrogen through non symbiotic fixation in long-term stationary experiments,
kg / ha per year**

| Variant | pH | Input of N | | nitrogen losses | | Removal of nitrogen | Balanc- | change in gross reserves of nitrogen in the soil, average annual | Non symbiotic nitrogen fixation | | | | | |
|---|------|------------------------------|--|-----------------|------------------------|---------------------|---------|--|---------------------------------|--|--|--|--|--|
| | | with precipitation and seeds | <u>on account of symbiotic nitrogen fixation</u> | denitrification | with subsurface runoff | | | | | | | | | |
| Long-term Field Experiment 1 | | | | | | | | | | | | | | |
| Crop rotation: annual lupine - winter wheat - potato - barley | | | | | | | | | | | | | | |
| without fertilizers | 5,85 | 11,0 | 26,2 | 16,1* | 14,6* | 48,2 | 41,7 | -7,5 | 34,2 | | | | | |
| P50K60 | 5,86 | 11,0 | 28,4 | 16,1* | 14,6* | 55,7 | 47,0 | -8,6 | 38,4 | | | | | |
| Long-term Field Experiment 3 | | | | | | | | | | | | | | |
| Crop rotation: sunflower - winter wheat -maize - barley | | | | | | | | | | | | | | |
| Without fertilizer and lime | 4,20 | 10,5 | - | 7,4* | 14,6* | 25,7 | -37,2 | 14,3 | 22,9 | | | | | |
| Dolomite lime, 1 hydrolytic acidity | 5,49 | 10,5 | - | 19,5* | 14,6* | 40,0 | -63,6 | -22,6 | 41,0 | | | | | |

Nitrogen losses due to denitrification and subsurface runoff determined in laboratory and lysimetric experiments

Proposals for research areas to reduce environmental pollution by nitrogen compounds

1. Assessment of the size of nitrogen losses from manure in Chains – farm – manure - storage - field ;
2. Determine changes agrochemical, physico-chemical and biological properties of soils under long-term use of different types of fertilizers system;
3. Study flow of N and C (soil nitrogen and carbon, fertilizers nitrogen) , (NO₂, NH₃, CH₄, CO₂), (Studies with¹⁵N);
4. Assessment of the quality of plant products using of organic and mineral fertilizers .

СПАСИБО ЗА ВНИМАНИЕ!

THANKS YOU FOR ATTENTION

Предложения по направлениям исследований по сокращению загрязнения окружающей среды соединениями азота

- Выявление размеров газообразных потерь азота из навоза в цепи: ферма-навозохранилище-поле;
- Определение изменений агрохимических, физико-химических и биологических свойств почв при длительном применении различных видов навоза;
- Изучение потоков азота (азот почвы, азот удобрений), включая газообразные потери (NO_2 , NH_3 , CH_4 , CO_2), использование растениями, закрепление в почве, вымывание с дренажными водами и степени устойчивости агроэкосистем при использовании навоза (исследования с ^{15}N);
- Оценка качества растениеводческой продукции, получаемой при внесении различных видов органических удобрений.