TABLE 13
Consumption of mineral fertilizers under winter grain crops and green forage, 2004

Oblast	Area ('000 ha)	(kg/ha)	(%)
AR Crimea	316.7	15.2	82.7
Cherkaska	94.1	31.3	48.0
Chernivetska	25.2	20.4	60.6
Chernivetska	80.4	17.4	33.8
Dnipropetrovska	200.2	25.7	55.2
Donetska	189.5	27.0	64.6
Ivano-Frankivska	22.4	32.5	77.5
Kharkivska	135.0	13.3	36.5
Khersonska	75.4	8.8	32.4
Khmelnytska	137.6	22.8	52.8
Kirovohradska	98.4	14.7	34.5
Kyyivska	92.7	27.8	40.3
Luhanska	137.7	19.6	55.2
Lvivska	40.3	37.7	49.4
Mykolayivska	108.6	10.1	26.7
Odeska	189.6	17.2	32.1
Poltavska	80.9	13.2	29.1
Rivnenska	49.5	29.6	46.1
Sumska	85.5	17.8	40.3
Ternopilska	142.6	43.7	94.8
Vinnytska	96.9	18.1	33.9
Volynska	71.8	32.3	65.6
Zakarpatska	10.9	46.3	68.1
Zaporizka	173.1	18.8	48.8
Zhytomyrska	44.7	11.2	27.2
Total Ukraine	**2 699.7**	**19.6**	**45.5**

Source: SCS.

percent. The situation was better in the Khmelnitskiy area, where more than half of the cropped area was fertilized, while in Ivano-Frankovsk and Volynsk the fertilized areas amounted to 77.5 percent and 65.6 percent respectively. The proportions fertilized were in AR Crimea area at 82.7 percent and in Ternopil at 94.8 percent.

In Ukraine, on many farms fertilizers are applied according to recommendations based on the agrochemical mapping of fields and this is reflected in the yields obtained.

According to the Institute of Agronomy and Agrochemistry, the annual need of Ukraine for mineral fertilizers in the 2002 to 2005 period was 4.4 million tonnes (nitrogen 2.2 million tonnes; phosphates 1.2 million

TABLE 14
Increase of yield of maize grain from the application of manure

Manure	Yield without manure (tonnes/ha)	Yield increase with manure		Crop response to one tonne of manure	
		20 tonnes/ha	From 20 to 40 tonnes/ha	20 tonnes/ha	From 20 to 40 tonnes/ha
Without fertilizers	3.2	0.4	0.74	28.3 kg	25.2 kg
With fertilizers	4.1	0.28	0.51	20.3 kg	14.7 kg

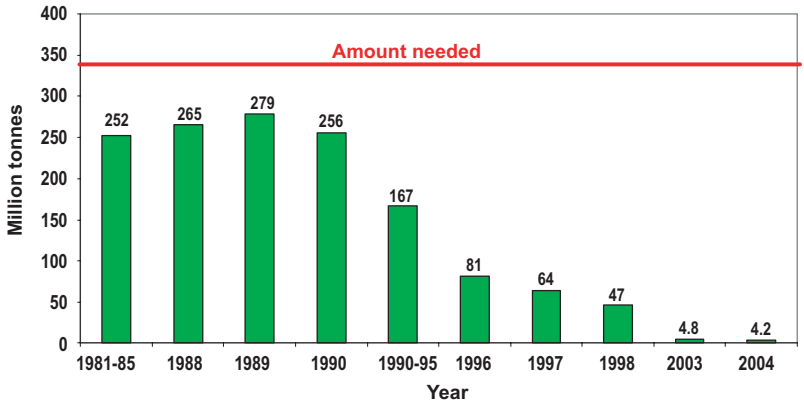
Source: Lisoval *et al*., 2002.

tonnes and potash 1 million tonnes). However, due to the low purchasing power of farmers, the total demand for all kinds of fertilizers is limited to 1.2 million tonnes. Most of the demand is in spring.

Apart from mineral fertilizers, organic manures are the main source of plant nutrients and serve to maintain the soil humus content. For this purpose it is necessary to apply annually on arable land not less than 340 million tonnes of organic manures; in Polissya 16 tonnes/ha, the Forest-Steppe 11 tonnes/ha and the Steppe 8 tonnes/ha.

Maize is particularly responsive to the application of organic manure (Table 14). It confers a better resistance to unfavourable soil-climatic conditions (decrease of temperature, deficit of trace substances). Growth and development are accelerated.

FIGURE 15
Consumption of manure



Source: SCS; UkrKhimProm.

With the disintegration of the large-scale cattle-breeding complexes and farms that existed under the Soviet economic system, the quantity of cattle and manure was sharply reduced (Figure 15).

In 2004, 3.6 percent of manure was used on a total cropped area of 6.4 million ha. The application of fertilizers varied between the different oblasts (Table 15). For example, in the Kherson area manure was applied on only one percent of the sown area, in Kirovograd 1.4 percent, in Zaporozhye and Cherkasy 1.7 percent, in Mykolaev 1.8 percent, in Zakarpattya 2 percent. The situation was better in Kharkiv, Zhytomyr and Chernivtsi areas at 5.3 to 6.3 percent and especially in AR Crimea area with 7.3 percent. The highest manured area was in Poltava at 9.9 percent.

TABLE 15
Consumption of organic manure on grain and green forage, winter

Oblast	Application ('000 tonnes)	Area ('000 ha)	Rate of application (tonnes/ha)	Proportion fertilized (%)
AR Crimea	165.3	28.0	0.4	7.3
Cherkaska	96.9	3.3	0.5	1.7
Chernivetska	62.7	2.6	1.5	6.3
Chernivetska	129.2	10.3	0.5	4.3
Dnipropetrovska	198.2	8.5	0.5	2.3
Donetska	336.3	9.8	1.1	3.3
Ivano-Frankivska	28.5	1.3	1.0	4.5
Kharkivska	768.1	19.7	2.1	5.3
Khersonska	16.9	2.3	0.1	1.0
Khmelnytska	220.8	15.9	0.8	6.1
Kirovohradska	124.4	3.9	0.4	1.4
Kyyivska	226.1	10.0	1.0	4.3
Luhanska	150.2	5.3	0.6	2.1
Lvivska	46.4	5.0	0.6	6.1
Mykolayivska	63.2	7.5	0.2	1.8
Odeska	174.3	11.1	0.3	1.9
Poltavska	602.2	27.5	2.2	9.9
Rivnenska	78.8	6.1	0.7	5.7
Sumska	152.5	8.2	0.7	3.9
Ternopilska	85.0	5.2	0.6	3.5
Vinnytska	116.3	5.7	0.4	2.0
Volynska	102.2	3.5	0.9	3.2
Zakarpatska	2.4	0.3	0.2	1.9
Zaporizka	144.1	6.2	0.4	1.7
Zhytomyrska	148.8	9.1	0.9	5.5
Total Ukraine	**4 239.8**	**216.3**	**0.7**	**3.6**

Chapter 5
Nutrient balance

In Ukraine the balance of nutrients is assessed by two methods. One approach is experimental and is based on laboratory and lysimetric research, micro-field and field trials with fertilizers, including experimental crop rotations and long-term trials. Research using the radio active elements ^{32}P, ^{15}N, ^{40}K is also relevant.

Another approach is farm-based, assessing the biological cycle of nutrients in agriculture and the biosphere. The objective in this case is to estimate the nutrient balance, at farm, regional, zonal and country levels. The problem with this type of research is to assess the nutrients removed in secondary production, roots and post-harvesting residues.

The farm level balance is the one most used. The quantities removed or lost are compared with nutrient supplies through the application of mineral and organic fertilizers, precipitation, seeds and symbiotic and non-symbiotic nitrogen fixation. Nutrients are removed by the crops and lost through water erosion, in drainage water, fixation by the soil etc.

On farms where a high level of the soil nutrient reserves was built up in previous years and where today organic and mineral fertilizers are applied adequately, the balance of the primary nutrients remains positive (Table 16). In this table, the balance of nutrients on a farm in the Cherkasy area is shown (data from the Department of Agrochemistry of the National Agricultural University).

Because of the sharp decline in the quantities of organic and mineral fertilizers applied on the majority of farms in Ukraine, the balance of nutrients has generally become negative. From Table 18 it can be seen that there has been a 5 to 13 fold decrease in the use of organic nutrients, mostly from manure, in the different zones of Ukraine. This has resulted in a sharp deterioration of the humus balance in the soil. Dehumification is of particular concern in Polissya, where during the last 10 to 15 years the humus deficit has increased five times.

TABLE 16
Farm nutrient balances

	N		P_2O_5		K_2O	
	(kg/ha)	(%)	(kg/ha)	(%)	(kg/ha)	(%)
Inputs						
Organic fertilizers	79	37	36	29	99	49
Mineral fertilizers	97	46	85	70	100	50
Seeds	4	2	1	1	2	1
Precipitation	5	2	-	-	-	-
Biological N fixation	25	12	-	-	-	-
Non-symbiotic N fixation	3	1	-	-	-	-
Total	**213**	**100**	**122**	**100**	**201**	**100**
Outputs						
Crop yields	155	90	65	100	144	100
Fertilizer losses	18	10	-	-	-	-
Total	**173**	**100**	**65**	**100**	**144**	**100**
Balance	40	-	57	-	57	-
Input/output ratio	124	-	189	-	141	-

Source: Lisovyj, 2002.

TABLE 17
Humus balances in cultivated soils (tonnes/ha)

Zone	No application*	Organic applications			Humus balances		
		1981–1990	1991–1995	2001	1981–1990	1991–1995	2001
Forest-Steppe	-0.68	9.4	6.2	2.1	-0.08	-0.25	-0.48
Polissya	-0.80	11.8	7.8	2.3	-0.10	-0.27	-0.60
Steppe	-0.59	6.6	4.4	0.5	-0.12	-0.24	-0.47
Ukraine	-0.66	8.6	5.7	1.8	-0.10	-0.25	-0.49

Source: Medvedev, Laktionova and Kanash, 2003.
* Average annual humus loss from soils receiving no application

In Ukraine as a whole, the balance of nutrients during the past decade has deteriorated sharply (Table 18). In particular, the balance of nitrogen has changed from -3.1 to -41.5 kg/ha, phosphorus (P_2O_5) from +24.9 up to -16.1 kg/ha and potassium (K_2O) from -0.5 to -56.4 kg/ha.

TABLE 18
Nutrient balances in Ukrainian agriculture (kg/ha)

	1986-1990			1996-2000			2001		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Application	90	56.1	103	26	10.4	15.3	21.5	5.9	9.2
Removal	93	31.2	103	56.5	18.2	53.7	63	22	65.6
Balance	-3.1	24.9	-0.5	-30.5	-7.8	-38.4	-41.5	-16.1	-56.4

Source: Medvedev, Laktionova and Kanash, 2003.

Chapter 6
Fertilizer use by crop

In Ukraine, four main methods are used for assessing the application rates of fertilizers required on agricultural crops. These are based on:

- the results of field experiments with fertilizers
- the calculation of the nutrient balances
- a complex method which takes into account the needs of plants for nutrients and other ecological factors
- an econometric method, which determines the application rates of fertilizers using multiple regression techniques.

Recommendations on fertilizer rates (Mosijuk *et al.*, 1989) were obtained until recently by calculating optimum rates based on the results of the field experiments in given agro-ecological zones. Long-term field experiments to determine the efficiency of different application rates of fertilizers were carried out by several research institutes that were representative of the different agro-ecological zones and according to the main types of soils. The results of the field experiments were processed mathematically, extrapolated and then translated into average recommendations for application rates of fertilizers. The advisers recommended fertilizer application rates, according to the soil-climatic conditions (Tables 22 to 32).

About 60 to 65 percent of farmers apply fertilizers. However, whether they apply the full recommendations or only part depends on their financial situation. The recommended application rates relate to specific yields: winter wheat 4.0 to 4.5 tonnes/ha, maize (grain) 4 to 6 tonnes/ha, maize (silage) 35 to 40 tonnes/ha, sugar beet 40 to 50 tonnes/ha, peas 3.0 to 3.5 tonnes/ha, spring wheat 3.0 to 3.5 tonnes/ha, sunflower 2.0 to 2.5 tonnes/ha. Agrochemical maps of the soils of the farm and a table for the correction of coefficients (Table 19) are used to arrive at the final recommendations.

From the farmer's point of view, it is important to know the quantity of nutrients necessary to obtain one tonne of a crop or an increment of one tonne, in order to assess the profitability. The standards are worked

TABLE 19
Correction coefficients applied to recommended application rates of fertilizers

Content of nutrients in the soil (mg/100 g soil)	Grain, sugar beet, potatoes, flax, grasses	Vegetables
Nitrogen fertilizers		
N content		
Very low	1.2	-
Low	1.1	1.2
Average	1.0	1.1
Increased	0.9	1.0
High	0.7	0.9
Very high	0.7	0.8
Phosphorus and potassium fertilizers		
P_2O_5 or K_2O content		
Very low	1.5	-
Low	1.2–1.3	1.5
Average	1.0	1.2–1.3
Increased	0.7–0.8	1.0
High	0.4–0.6	0.7–0.8
Very high	0.1–0.3	0.4–0.6

out on a zonal basis, type of crop and the main types and subtypes of soils of soil-climatic zones. These standards are worked out using short-term and long-term field experiments with fertilizers.

Recently in Ukraine calculations of the nutrient balances have been used to arrive at recommendations. There are some variants of this method of arriving at recommendations, based on:

- reserves of nutrients in the soil
- yield increase
- balance of nutrients in a crop rotation

Calculations according to the balance method do not fully conform with practical conditions, since the use of identical values of the cost of nutrients in the soil and in fertilizers does not correspond to the reality. More complex methods of determining fertilizer application rates allow for the quality of the soil and profitability of fertilization of the crop to be taken into account. However, they can be used only on farms where the quality of the soils is known.

In order to arrive at the recommended mineral fertilizer application rate, allowance is made for the application of manure to the crop and its

TABLE 20
Additional yields of crops resulting from the application of one tonne of manure

Crop	Farmyard manure (20 to 40 tonnes/ha)		Litterless manure (tonnes/ha)			
	Polissya	Forest-Steppe & Steppe	40	60	80	100
	kg					
Winter wheat	25	15	13	13	12	11
Sugar beet	396	265	85	96	88	69
Potatoes	328	176	96	76	68	48
Maize on:						
Seeds	25	23	14	14	13	13
Silage	376	205	118	82	71	65

Source: Lisoval *et al*., 2002.

impact on yield (Table 20). The ratios and quantities of the different kinds of mineral fertilizers are determined by one of the methods reviewed earlier.

Recently, econometric methods have been used to determine application rates of fertilizers. The estimation of application rates of fertilizers is based on a functional relationship between a crop at different levels of nutrients in the soil and the application rate of fertilizers (Mosijuk, 1989). These methods can be used only for those farms for which the experimental data needed by the mathematical model exist.

TABLE 21
Yield productivity of mineral fertilizers

Crop	N	P_2O_5	K_2O	Yield	Yield increase	Yield increase per kg NPK
	(kg/ha)			(tonnes/ha)		(kg)
Flax	45	75	79	0.8	0.2	1.1
Fodder roots	148	104	120	61.8	20.7	55.6
Hay	235	94	77	11.2	4.8	11.7
Maize grain	88	84	72	4.3	0.9	3.7
Maize, silage	77	72	65	29.9	6.4	29.9
Pastures	216	57	74	8.5	5.3	15.3
Potatoes	81	74	87	19.9	5.7	23.6
Spring cereals	62	60	43	3.2	0.8	4.7
Sugar beet	157	150	173	39.7	10.8	22.5
Sunflowers	55	66	44	2.1	0.3	1.9
Vegetables	112	112	76	52.8	14.5	48.3
Winter cereals	75	69	50	3.5	0.8	4.3

Source: Lisoval *et al.,* 2002 .

Today the profitability of fertilizer use rather than yield is normally the main criterion but in order to determine the economics of their use it is necessary to know the likely response (Table 21).

Recommended rates of use of fertilizers on different crops, according to the region and soil type, are given in the following Tables 22 to 32.

1. After fallow and permanent grass the rate of N is reduced by 20-30 kg/ha in Forest-Steppe Right-Bank.
2. After permanent grasses, the rate of N is reduced by 30-40 kg/ha and after fallow by 40 kg/ha, that of K_2O by 20 kg/ha. After maize the rate of N is increased by 20-30 kg/ha in Forest-Steppe Left-Bank.
3. The application of nitrogen (usually urea) is modified according to the results of foliar diagnosis.

TABLE 22
Winter wheat, recommended rates of fertilization (kg/ha)

Zone	Soil	Fertilizer rate			Notes
		N	P_2O_5	K_2O	
Polissya	Eutric Podzoluvisols and Haplic Greyzems	80–90	60	60	
Forest-Steppe Right-Bank	Haplic Greyzems	100	90–100	100	Yield target 4.5-5.0 tonnes/ha
	Haplic Chernozems	100	90	90	
Forest-Steppe Left-Bank	Haplic Greyzems	90	80	80	Yield target 4.5-5.0 tonnes/ha
	Haplic Chernozems	80	70	70	
Steppe	Haplic Chernozems	-	60	60	
	Haplic Chernozems	60	60	60	After fallow
	Luvic Kastanozems	90	60	-	After maize

Source: Lisoval *et al.,* 2002

TABLE 23
Barley, recommended rates of fertilization

Zone	Soil	N	P_2O_5	K_2O
			(kg/ha)	
Polissya & Carpathians	Eutric Podzoluvisols & Haplic Greyzems	60–90	45–60	45–60
	Rendzic Leptosols	60	60	60
Forest-Steppe	Haplic Greyzems	30	60	60
Steppe	Luvic Kastanozems	-	60	60

Source: Lisoval *et al*., 2002.

TABLE 24
Buckwheat, recommended rates of fertilization

Zone	Soil	N	P_2O_5	K_2O
			(kg/ha)	
Polissya & Carpathians	Eutric Podzoluvisols & Haplic Greyzems	30	60	60
Forest-Steppe	Haplic Greyzems	90	90	90
Steppe	Luvic Kastanozems	50	60	40

Source: Lisoval *et al*., 2002.

TABLE 25
Forage crops, recommended rates of fertilization

Zone	Soil	N	P_2O_5	K_2O
			(kg/ha)	
Polissya & Carpathians	Eutric Podzoluvisols & Haplic Greyzems	30	60	60
Forest-Steppe	Haplic Greyzems	30	60	60
Steppe	Luvic Kastanozems	-	60	60

Source: Lisoval *et al*., 2002.

TABLE 26
Sugar beet, recommended rates of fertilization

Zone	Soil	N	P_2O_5	K_2O
			(kg/ha)	
Polissya & Carpathians	Eutric Podzoluvisols	170	140	190
	Haplic Greyzems	150	160	180
	Haplic Chernozems	120	160	170
Forest-Steppe	Haplic Greyzems	170	160	180
	Haplic Chernozems	160	170	150
Steppe	Luvic Kastanozems	130	150	140

Source: Lisoval *et al*., 2002.

TABLE 27
Maize, recommended rates of fertilization

Zone	Soil	Fertilizer application rate (kg/ha)					
		Grain			Silage		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
Polissya and Forest-Steppe Western	Eutric Podzoluvisols and Haplic Greyzems	130	100	100	180	90	90
Forest Steppe	Haplic Greyzems and Haplic Chernozems	140	120	120	160	120	120
Forest-Steppe Right-Bank and Left-Bank	Haplic Greyzems and Haplic Chernozems	80–120	90–120	120	80–120	90–120	120
	Haplic Phaeozems	90	90	135	120	90	90
Steppe	Haplic Chernozems & Calcic Chernozems	90–120	60–90	20–40	90–120	60–90	20–40

Source: Lisoval *et al*., 2002.

TABLE 28
Sunflower, recommended rates of fertilization

Zone	Soil	N	P_2O_5	K_2O
		(kg/ha)		
Forest-Steppe	Haplic Greyzems	60	60	60
Steppe	Haplic Chernozems	60	60	40
	Calcic Chernozems	60	60	40
	Luvic Kastanozems	60	60	-

Source: Lisoval *et al*., 2002.

TABLE 29
Fruit crops (young orchards), recommended rates of fertilization

Age of trees	4 to 5 years				6 to 8 years			
	Manure	N	P_2O_5	K_2O	Manure	N	P_2O_5	K_2O
	(tonnes/ha)	(kg/ha)			(tonnes/ha)	(kg/ha)		
Polissya	30	60	45	60	30	90	45	90
Precarpathian Carpathian Transcarpathian	30	60	45	45	30	90	60	60
Forest Steppe & Steppe	25	60	45	45	25	90	60	90
Irrigated gardens	20	60	45	45	20	90	60	60

Source: Lisoval *et al*., 2002

TABLE 30

Fruit crops, (fruit bearing orchards), 160 to 200 trees/ha, recommended rates of fertilization (kg/ha)

Age of trees	9 to 15 years			Over 15 years		
kg/ha	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Polissya	60-90	45	90	60-90	60	120
Precarpathian Carpathian Transcarpathian	90	45	63	90	60	60
Forest Steppe	90–120	45–60	90–120	90–120	60	90–120
Steppe	60–120	45–60	45	120–150	60	60

Source: Lisoval *et al*., 2002.

TABLE 31

Fruit crops, (fruit bearing garden), 330 to 600 trees/ha, recommended rates of fertilization (kg/ha)

Age of trees	9 to 15 years			Over 15 years		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Polissya	90–120	160	120	120–150	60	120–150
Precarpathian Carpathian Transcarpathian	120	60	60	120	60	120
Forest Steppe	90–120	60	120	120–150	60	120
Steppe	90–150	60–90	60	90–120	60–90	60–90

Source: Lisoval *et al*., 2002.

TABLE 32

Tomatoes, recommended rates of mineral fertilizers (kg/ha)

Zone	Soil	Irrigation	Basal application			Top dressing		
			N	P_2O_5	K_2O	N	P_2O_5	K_2O
Forest Steppe Right Bank	Haplic Chernozems	No	60–90	120–140	90—20	-	-	-
	Haplic Greyzems	No	80–90	90–120	90–120	-	-	-
Forest Steppe Left Bank	Haplic Chernozems	No	45–60	60–90	45–60	-	-	-
		Yes	90–120	90–120	60–90	-	-	-
	Haplic Chernozems	No	45–60	60–75	30–60	-	-	-
		Yes	120–150	60–90	30–45	15–20	20–20	10–10

Source: Taran, 2004.

Chapter 7
Prices and profitability of fertilizers

PRICES OF MINERAL FERTILIZERS

The Ministry of Industrial Policy fixes maximum prices of domestically produced fertilizers, with a subsidy which, in the budget of 2004, amounted to 140 million UAH. The maximum prices applicable were 550 UAH/tonne for ammonium nitrate, urea (in bulk) (690 UAH/tonne), ammonium hydroxide (225 UAH/tonne), nitroammophoska (packed 995 UAH/tonne), (bulk 804 UAH/tonne), superphosphate (bulk) 490 UAH/tonne, kainite (bulk) 85 UAH/tonne.

The government of Ukraine approved subsidies to farmers from the state budget on ammonium nitrate (100 UAH/tonne), urea 130 UAH/tonne, ammonium hydroxide 70 UAH/tonne, nitroammophoska 270 UAH/tonne, complex mineral fertilizers 200 UAH/tonne, superphosphate 130 UAH/tonne and kainite 15 UAH/tonne.

In 2005, there were increases in the prices of mineral fertilizers (Table 33).

In February 2005, a memorandum was signed by the Ukrainian Union of Agricultural Corporations, the Association of the Farmers of Ukraine and fertilizer companies. The chemical firms undertook to supply farmers between February and July 2005 with 510 thousand tonnes of fertilizers at reduced prices. This quantity comprised 367 thousand tonnes of nitrogen, 91 thousand tonnes of phosphate and 52 thousand tonnes of potassium. The price of AN (packed) was fixed at 825 UAH/tonne, urea (packed) at 960 UAH/tonne, superphosphate (packed) at 580 UAH/tonne, nitroammophoska (packed) at 1 200 UAH/tonne and ammophos (bulk) at 1 540 UAH/tonne.

EFFICIENCY OF MINERAL FERTILIZERS

The efficiency of fertilizer use in the different agro-ecological zones is monitored. The highest efficiency is observed in the Carpathians,

TABLE 33
Average retail prices of the main mineral fertilizers

Fertilizer	Grade	Price (UAH/tonne)
NPK	10–26–26	1 400–1 450
NPK	14–14–14	1 200–1 260 (indicative)
NPK	15–15–15	1 250–1 300
NPK	16–16–16	1 210–1 280
NPK	13–19–19	1 190–1 500
DAP	16–48–0	2 100
Potassium nitrate		2 000–2 600
Urea		960–1 200
MAP		1 700
AS		460–960
Superphosphate (NP 3:16)		565–620
AN		825–950

Packed in bags or big bags, 1 January 2005
Source: Gordijchuk: http://www.agroperspectiva.com/.

in Polissya and in the western Forest-Steppe. Information on the efficiencies of mineral fertilizer use in different regions permits a rational determination of application rate of fertilizers and the preparation of yield indices for winter wheat in different districts, areas or regions of the country.

The yield increase to be expected from fertilizer use depends on the climate, soil fertility and the level of fertilizer application. According to the different agro-ecological conditions, the higher the application rate, the lower the yield increase per unit of fertilizer (Table 34). These are the results of field experiments carried out in the geographical trial network.

The use of advanced technologies for the cultivation of crops, in particular fertilization, does not provide a high yield level in the Ukraine. In the case of grain, the average yield increase per kg of NPK is 4.3 to 4.7 kg of a grain (Table 35). The best result is 6.7 to 7.0 kg. The yield obtained from the application of one kg of nitrogen in Western European countries (expressed in kg of grain) is as follows: Spain 16.2 kg, Italy 18.1 kg, Germany 20.3 kg, France 21.2 kg, England 24.3 kg. In Ukraine this index does not exceed 10.8 to 12.0 kg of grain.

Sunflower was the most profitable crop in 2003 (Table 36). With a combination of high price, relatively low production cost and traditionally

TABLE 34
Yield increase of winter wheat through mineral fertilization

NPK application (kg/ha)	Yield increase (tonnes/ha)			Grain yield increase per one 1 kg of NPK (kg of grain)		
	Eutric Podzoluvisols	Haplic Greyzems	Haplic Chernozems	Eutric Podzoluvisols	Haplic Greyzems	Haplic Chernozems
90	0.8	0.5	0.6	8.44	5.1	6.32
120	0.6	0.6	0.5	5.21	5.28	4.35
140	0.8	0.7	0.6	5.63	4.68	4.07
150	0.7	0.7	0.6	4.92	4.78	4.1
160	0.9	0.7	0.6	5.42	4.56	4.03
180	0.9	0.7	0.7	4.76	4.13	3.81
210	0.8	0.7	0.7	4.03	3.48	3.35
240	0.9	0.8	0.7	3.86	3.4	3.1
270	0.9	0.9	0.8	3.41	3.26	2.95
300	1.0	0.9	0.8	3.43	3.16	2.71
330	1.0	0.9	0.8	3.13	2.68	2.54
360	1.1	1.0	0.7	2.97	2.87	2.04
390	1.3	-	0.8	3.25	-	2.08

Source: Nosko *et al.*, 1994.

TABLE 35
Yield increase from the application of mineral fertilization

Crops	Application rate of mineral fertilizers			Yield	Yield increase	Yield increase per kg NPK,
	N	P_2O_5	K_2O			
	(kg/ha)			(tonnes/ha)		(kg)
Fodder root crops	148	104	120	61.8	20.7	55.6
Flax	45	75	79	0.8	0.2	1.1
Haymaking	235	94	77	11.2	4.8	11.7
Maize (seed)	88	84	72	4.3	0.9	3.7
Maize (silage)	77	72	65	29.9	6.4	29.9
Pastures	216	57	74	8.5	5.3	15.3
Potatoes	81	74	87	19.9	5.7	23.6
Spring grains	62	60	43	3.2	0.8	4.7
Sugar beet	157	150	173	39.7	10.8	22.5
Sunflowers	55	66	44	2.1	0.3	1.9
Vegetables	112	112	76	52.8	14.5	48.3
Winter grains	75	69	50	3.5	0.8	4.3

Source: Lisoval *et al.*, 2002.

high demand, sunflower has become one of the most consistently profitable crops. Its high profitability has encouraged a significant expansion in the planted area, beginning in the late 1990s.

TABLE 36
Percentage rate of return on investment

	2000	2001	2002	2003
		(%)		
Grains	65	44	20	19
Sunflower	57	70	78	81
Sugar beet	7	1	-7	9

Source: Agricultural Policy for Human Development Project in Ukraine, *Agrarnyi Sector Ekonomiky Ukrainy*, 2004.

Chapter 8
Agrochemical services in Ukraine

The production of fertilizers, agrochemical services and the application of fertilizers are integral components of a single system that promotes the productivity of agriculture.

In the Ukraine, before the breakup of the Soviet Union, all the agrochemical services were implemented by the state-owned organization *Ukragrokhim*. This was the main institution for coordinating fertilizer and plant protection supplies. *Ukragrokhim* comprised regional and district manufacturing associations, zonal agrochemical laboratories and plant protection services. Regional agrochemical associations were subordinate to regional agricultural boards and to the Ministry of Agriculture (which has now become the Ministry of Agrarian Policy). In the districts, the agrochemical services were under the authority of district agricultural boards and regional agrochemical associations.

This fertilizer supply system existed until 1996 but the system gradually disintegrated since the authorities were unable to finance capital intensive projects. However, all later arrangements were based on the general principles of the same system or simply imitated it, still being based on the centralized allocation of fertilizers.

The main challenges of the agrochemical service in Ukraine are:

- to monitor arable land
- to compile field plans
- to carry out the mass analysis of soils and fertilizers
- to prepare the guidelines on application of fertilizers

The agrochemical service is run by state and commercial firms. The main activities of the State Technological Center for the Preservation of Soil Fertility of the Ministry of Agrarian Policy are:

- preparation of proposals and implementation of technology concerning the preservation of soil fertility
- scientific methods for organizing the monitoring of soils and the agrochemical certification of land

- measures concerning the maintenance, recovery and preservation of soil fertility
- definition of quality and safety of crop production

The agrochemical laboratories of the research and educational institutions and the bodies responsible for the preservation of soil fertility and the quality of crop production are under the authority of the State Technological Center of Preservation of Soil Fertility.

The agrochemical service has worked out a series of measures and services concerning fertilizers, amendments, engineering and technologies concerning these products. The agrochemical service is provided by the national association *Ukrsilgospkhimia* (OSC), *Agrokhimcentr*, and district formations *Silgospkhimia*. These bodies ensure the supply of fertilizers and points of sale. Services are carried out on a contractual basis.

The state has a protectionist policy for agriculture. In 1996, the supply of fertilizers to farmers was covered by Ukraine's Cabinet of Ministers regulation No.562 dated May 25 1996. This act provided for the production and supply of over 352 000 tonnes of nutrient fertilizers to the Ministry for Agriculture and Food, i.e. 217 000 tonnes of nitrogenous fertilizers, 107 000 tonnes of phosphate fertilizers and 28 000 tonnes of potassium fertilizers. The Ministry of Industry was made responsible for the production and supply of these fertilizers.

As the representative of the Ministry of Agriculture and Food, *Ukragrokhim* was responsible for the allocation and distribution of fertilizers. This company, jointly with the Ministry of Industry, determined the output volumes and the product mix of the fertilizers to be produced, and selected the regional suppliers of the fertilizers. The fertilizers were supplied to farmers with the security of regional and district agricultural boards and against crop collateral.

The Cabinet's regulation No.977 of September 3 1997 concerned the selection of wholesale suppliers of fertilizers. The candidates included both Ukrainian and foreign companies. The four successful bidders were the Ukrainian Gas Company, Ukrgazsbut, Intergaz, and Itera Ukraine.

In 1999, the authorities terminated the tender for natural gas suppliers and fertilizers were supplied as they were in 1997. This time, in compliance with the Cabinet's regulation No.1953 dated December 10 1998, national joint-stock company Naftogaz Ukrainy dealt with supplies of natural gas

to chemical companies. Naftogaz Ukrainy made contracts with chemical companies and the state owned enterprise *Ukrzovnishkhimprom* for supply of 1 275 million m^3 of natural gas needed to manufacture 500 000 tonnes of fertilizer nutrients, of which 420 000 tonnes were to be supplied to agricultural producers and 80 000 tonnes exported. It was planned that the export revenues should be used for the acquisition of raw materials necessary to make phosphate fertilizers.

As before, the public joint stock company *Agrokhimtsentr* was responsible for the distribution of the fertilizers to agricultural producers. This time the chemical companies owned the fertilizers during the manufacturing stage, but agricultural companies acquired ownership title after receipt of the fertilizers via the *Agrokhim* system.

As in previous years, the state programme for providing fertilizer supplies to agriculture failed partially and was not executed on time. By October 1999, agricultural producers had obtained 355 000 tonnes of fertilizers out of the scheduled 420 000 tonnes.

Although the centralized system of fertilizer supplies to agriculture appears to have advantages for agricultural companies, e.g. the opportunity to obtain fertilizers in advance, this system has been detrimental to Ukrainian agriculture. Since the fertilizer manufacturers received no payment for the fertilizers supplied, they tried to avoid the domestic market and search for foreign markets.

Regulation No.340 of 17 February 2000, "On the mechanism for supplying mineral fertilizers to agricultural producers in 2000" stipulates a supply of 300 000 tonnes of fertilizer nutrients per year, the remainder to be supplied on the basis of direct and regional contracts. The indications are that the fertilizer companies favour direct contracts.

Chapter 9
Concluding remarks

The soils of Ukraine are mainly fertile Chernozems and have considerable production potential. For many years the economic well-being of Ukraine was determined by grain production. Ukrainian grain occupied a prominent place in the world market and supported the competitiveness of the remainder of Ukrainian agriculture. In 1913, the Ukrainian grain production amounted to 25 million tonnes, a larger quantity than that produced by Germany in the 1980s. Immediately before World War II, total Ukrainian grain production reached that of the United States (Saiko, 1995). The highest average annual production (47.4 million tonnes or almost 1 000 kg/capita) was achieved during the 1986 to 1990 period. In spite of this, when total grain production reached more than 51 million tonnes in 1989 only 62 percent of the national livestock need for fodder grains could be provided internally.

However, because of excessive cultivation, a negative nutrient balance, erosion and other types of degradation, insufficient moisture at critical periods of development of the crop and, what is most important, non-observance of proper crop production technology, crop productivity is not very high. Moreover, in recent years, when the country's economy has been changing accompanied by an economic crisis, soil fertility has declined. The production of the main crops fell to almost half that of 1990. There was a seven-fold decrease in the quantity of mineral fertilizers used.

Today, much is being done in Ukraine to correct the situation. Modern soil protection concepts and the preliminary national and regional soil protection programmes have been worked out. They are now realized in part. A new law concerning the protection of soil fertility by land owners has been prepared. Work on the monitoring of soil cover, supported by a Governmental decree concerning the certification of land, is in hand.

The transition of Ukraine's agricultural sector from a centrally planned economy to a more market oriented system has introduced the element

of financial responsibility and farm managers are striving to make their enterprises as efficient as possible. Decisions on crop selection, fertilizer application, method of harvesting, grain storage and all other aspects of farm management are being made with a view to boosting farm profit. Ukraine agriculture is going through a sorting out process whereby unprofitable, usually smaller farms will either collapse or be integrated with more successful farms.

In Ukraine, there is a highly developed chemical industry for the production of mineral fertilizers. The raw materials are available and the engineering staff highly qualified.

It can be expected that the economic problems will be resolved progressively during the next 10 to 15 years. This should permit a rehabilitation of production from Ukraine's rich Chernozem soils.

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