Research Findings

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Sunflower Cultivation in Ukraine: Role of Fertilizers in Sunflower Seed Production

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Introduction

Sunflower is a strategically important oilseed crop in Ukraine, which plays a key role in the agricultural sector and accounts for 70 percent of all oilseed crops grown. In terms of world sunflower seed production, Ukraine holds first place at 25 percent, followed by Russia (22%) and Argentina (9%). In addition, around 57 percent of total world exports of sunflower oil come from Ukraine (State Statistics Service of Ukraine).

Sunflower sown area and productivity

Since the end of the 1990s, the land area devoted to sunflower cultivation in Ukraine has increased more than 2.5 fold from 2 million ha in 1995 to 5.1 million ha in 2012, which over the past four years has stabilized (Fig. 1). The main areas of production are located in the Kirovograd, Kharkov and Dnepropetrovsk regions, which account for over 30 percent of the sunflower area sown in the country or 10.8%, 10.5% and 9.5% for these regions,

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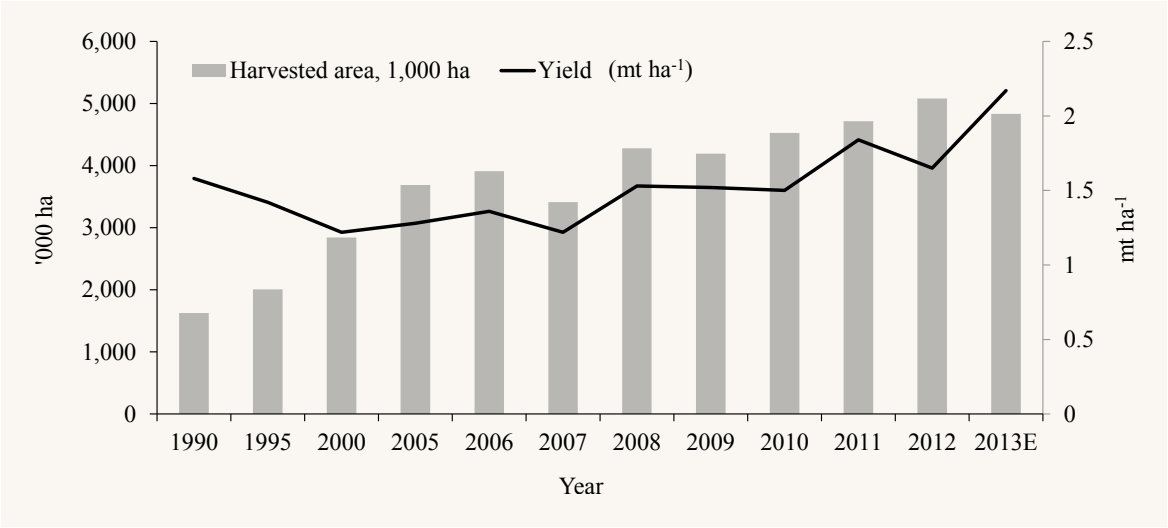

Fig. 1. Harvested area and yield of sunflower seeds in Ukraine from 1990 to 2013 (estimated for 2013).

respectively (State Statistics Committee of Ukraine). The most favorable conditions for sunflower establishment are in the forest-steppe and steppe zones, with the exception of the southern regions of the steppe zone (Kirichenko, 2010).

After the breakup of the Soviet Union, sunflower yield in Ukraine dropped significantly from 1.58 mt ha^{-1} in 1990 to 0.91 mt ha^{-1} in 1994, productivity being restored only in 2008 (1.53 mt ha^{-1}). Since then, yield has increased by 20 percent to 1.84 mt ha^{-1} in 2011. Despite this high increase, however, actual yields in Ukraine are below 50-60 percent of the biological potential of the crop (Kirichenko, 2010; Kirichenko, 2013) and many big enterprises use advanced technology to obtain yields of about 2.5-3.5 mt ha^{-1} (Kirichenko, 2010; Perepyatko, 2013). Modern hybrids have an even greater potential of 4.5-5 mt ha^{-1}. Currently, more than 350 hybrids are included in the Public Register.

The relatively low yield of sunflower in Ukraine can be accounted for by a number of factors:

- low fertilizer consumption, including potassium (K),
- failure to rotate crops and the need for improved farming technology,
- low seed quality,
- the spread of diseases (Sclerotinia head rot, Gray mold, *Phomopsis* and broomrape).

Although sunflower is a drought-resistant crop, its cultivation in the arid regions of the southern steppe has a restraining effect on crop growth (Kirichenko *et al.*, 2010; Andriyenko *et al.*, 2011).

Sunflower is the most profitable crop grown in Ukraine, the mean profitability (percent of net profit from total production costs) over the period of 1996-2012 being 51 percent (Fig. 2), and 20 percent in unfavorable seasons. As a consequence, sown areas have been increasing from year to year. One of the advantages of sunflower is that sunflower seed oil yield is much higher than that of other oilseed crops with an average of 750 kg ha^{-1} throughout the country (Denisenko, 2013).

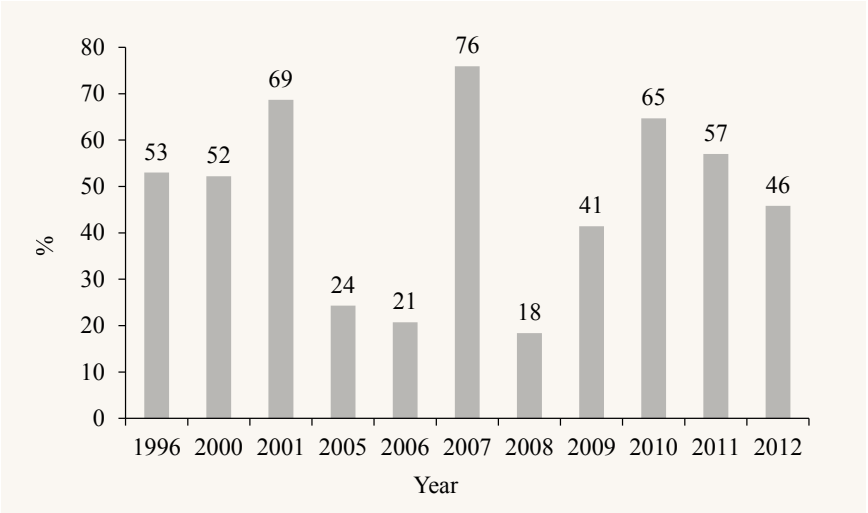

Fig. 2. The level of profitability of sunflower in Ukraine expressed as percent (%) for different years.

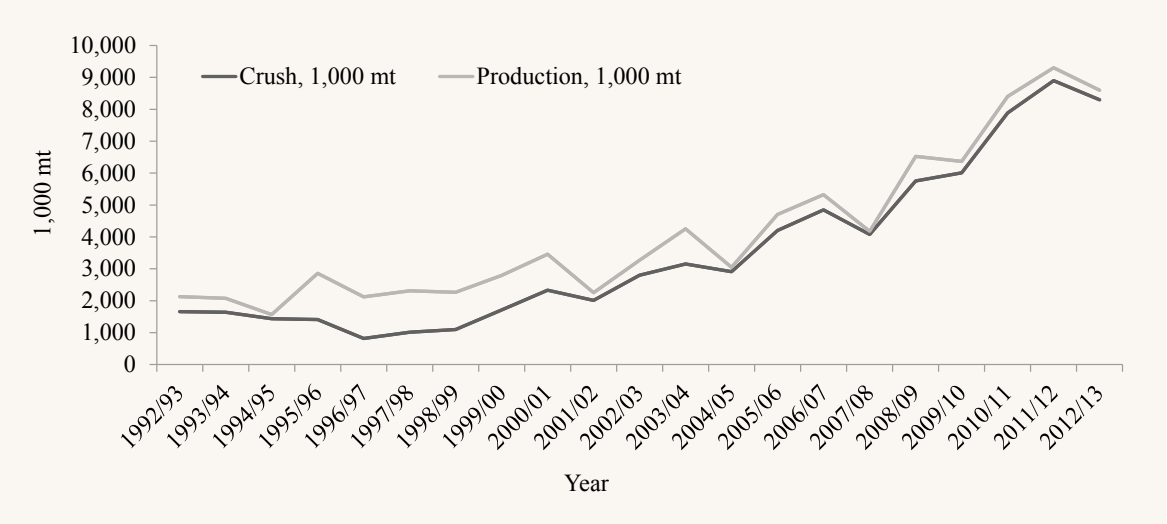

Fig. 3. Production and crush of sunflower seeds in Ukraine.

Sunflower production and crush in Ukraine

Ukraine is the world leader in sunflower production. Before 2000, sunflower production was below 3 million mt (Fig. 3). However, over the decade since 2000, production has increased threefold from 2.8 to 8.4 million mt in 2010. This has been achieved not only because of the expansion of sown areas, but also because of the increase in sunflower yields. Sunflower is cultivated mainly in the large agricultural enterprises of the country, which amounted to 84.1 percent of total production in 2011 (Perepyatko, 2013).

These agricultural agro-holdings have additional funding at their disposal to invest in the improvement of technology, which has greatly increased yields over the past few years allowing a record output of 9.3 million mt of sunflower seeds in 2011/2012. More than 95 percent of sunflower seeds produced are used in crushing plants.

The development of oilseed industry in Ukraine

Since 1990, crush capacity of Ukrainian plants has increased significantly, amounting to 13.3 million mt per year in 2012. According to The Ukroliyaprom Association (a voluntary association of oil sector enterprises), crush capacity is expected to reach around 15 million mt in 2015, close to the level of oilseed production in Ukraine (http://latifundist.com). Development in the sunflower oil industry in Ukraine has been stimulated by the introduction of export duties on seeds (currently standing at 10%), leading to a drop in exports of seeds from 1 million mt in 2000/2001 to 0.3 million mt in the last few years (USDA).

Due to the significant investment in modernization of crushing plants as of 2000, oil production in Ukraine significantly increased from about 1 million mt to 3.7-4.3 million mt in 2011-2012 (Table 1).

Domestic oil consumption, despite the slight increase, is about 590 mt on average, with the main production being exported. In 2000/2001, sunflower oil exports from Ukraine were 550,000 mt, but by 2012/2013 this value had risen to 3.3 million mt. Ukraine supplies sunflower oil to 88 countries, including India (27% of total exports), the EU (22%), Turkey (12%), Egypt (8%) and Russia (6%) (Maslak, 2012).

Fertilizer consumption in sunflower cultivation

Between 2003 and 2012 an enormous increase in mineral fertilizer use in sunflower cultivation took place rising from 35,000 mt of mineral fertilizers in 2003 to 169,200 mt of NPK by 2012 (Table 2). Before 2006, however, fertilizer utilization per ha did not change significantly, varying between 6-8 kg nitrogen (N), 4-6 kg of P_2O_5

Table 1. Production, consumption and export of sunflower oil in Ukraine ('000 mt).

Description	1995/96	2000/01	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
	---mt---									
Oil production	740	970	1,750	2,010	1,756	2,500	3,035	3,327	4,347	3,730
Oil export	219	550	1,200	1,826	1,326	2,098	2,645	2,652	3,263	3,300
Oil domestic consumption	426	417	540	375	395	365	395	470	540	585

Source: USDA, The State Statistics Service of Ukraine.

Table 2. The application of fertilizers in sunflower in Ukraine.

Year	Nutrient consumption						
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	Total NPK
	'000 mt			*kg ha^{-1}*			
2003	18.7	11.4	4.9	6	4	2	11
2004	14.5	11.0	5.4	6	4	2	12
2005	20.2	16.5	8.6	8	6	3	17
2006	23.6	18.1	9.9	8	6	3	18
2007	30.6	22.5	14.0	12	9	5	26
2008	46.9	27.3	18.4	15	9	6	29
2009	42.8	18.6	12.8	14	6	4	24
2010	63.3	30.2	19.5	18	9	6	33
2011	80.5	40.0	26.3	22	11	7	41
2012	95.4	44.7	29.1	24	11	7	42

Table 3. The effectiveness of K in the northern steppe.

Treatment	Yield	Increment		Agronomic efficiency	Oil yield
	mt ha^{-1}	*mt ha^{-1}*	*%*	*kg seeds per kg K_2O applied*	*mt ha^{-1}*
$N_{45}P_{45}$	2.65	-	-	-	1.29
$N_{45}P_{45} + K_{60}$	2.85	0.20	7.5	3.3	1.40
$N_{45}P_{45} + K_{90}$	3.02	0.37	13.9	4.1	1.49
$N_{45}P_{45} + K_{120}$	3.07	0.42	15.8	3.5	1.52
$N_{45}P_{45}$	2.65	-	-	-	1.29

and 2-3 kg K_2O. But, between 2007 and 2012, consumption of mineral fertilizer in sunflower production doubled, increasing from 12 to 24 kg per ha for N, from 6 to 11 kg per ha for P_2O_5, and from 3 to 7 kg for K_2O (Rybczynski 2013; State Statistics Service of Ukraine).

This level of fertilizer consumption, however, is not enough to obtain high yields of sunflower seeds. Sunflower takes up to 120 kg N, 50 kg P_2O_5 and 250 kg K_2O to produce 20 mt ha^{-1} of seeds together with the above ground biomass. Although sunflower has a poorer response to mineral fertilizer than cereals, it is necessary to provide enough N, phosphorus (P) and K fertilizer in sunflower production. The estimated rates of fertilizers are 60 kg N, 60 kg P_2O_5 and 40-60 kg K_2O per ha (Marchuk *et al.*, 2002).

Sunflower has large requirements for mineral nutrients and especially for K, compared to other nutrients. However, the effectiveness of K fertilization depends largely on the agro-ecological zone in which the crop is grown. Steppe soils, where the main cropping areas of sunflower are located, are heavy and have a high content of K, leading to low efficiency of fertilization with this nutrient. However, in some soils in the steppe zone in which there is a negative balance for K, the use of K fertilization for sunflower is recommended. In the forest-steppe zone, soils are poor in K and the benefit of K application increases by applying a complete mineral fertilizer at rates of N between 40 to 90, P_2O_5 between 40 to 60 and K_2O between 40 to 90 kg ha^{-1}.

In an experiment carried out under the northern forest-steppe zone conditions, the highest sunflower seed yield increase (0.42 mt ha^{-1} or 15.8% compared to $N_{45}P_{60}$ treatment) was obtained with 120 kg K_2O (Table 3), but the highest agronomic efficiency per kg K_2O resulted from 90 kg K_2O combined with N and P (Gorodniy, 1990).

Potassium applied together with N and P increased not only seed yield, but also oil yield. Sunflower oil yield from this Chernozem (black dirt) at $N_{45}P_{45}$ was 1.29 mt ha^{-1}. However, by additional application of K at 120 kg K_2O ha^{-1}, the highest oil yield of 1.52 mt ha^{-1} was obtained, representing a yield increment of 0.23 mt ha^{-1}, as compared to the N and P treatment only.

Summary

1. The failure of crop rotation in many regions leads to depletion in soil fertility and the spread of diseases. Sunflower already makes up about 20 percent of the land cultivated in Ukraine. As sunflower is a very profitable crop in Ukraine, the total current area of sunflower cultivation is predicted to be maintained, but its distribution is expected to change, falling in the south and increasing in the northern regions.

2. To improve sunflower yield, it is necessary to increase the use of modern high-yielding hybrids, plant protection products and fertilizers, including potash.

3. Increasing Ukrainian sunflower yield could lead to increased oil production and exports, helping meet the needs of the continuously increasing global demand for vegetable oil.

4. One of the possible limitations to increasing sunflower yield in the coming years is the cost of the growth of fertilizer consumption including K, particularly in the forest-steppe zone.

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The paper "Sunflower Cultivation in Ukraine: Role of Fertilizers in Sunflower Seed Production" also appears on the IPI website at:

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