Research article

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Management approaches for sustainable growth in Moldova's Sunflower Sector

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Abstract: Moldova is one of the 15 largest sunflower growing countries. In the past decades, significant changes have been implemented in Moldovan farming due to the liberalization of the agricultural economy after its independence in 1991 and the transition to a market economy, as well as uncontrolled land use. The impact of such changes on production remains mostly unexplored. To determine which factors impede the attainment of higher yields and whether this problem can be solved by conducting further research to improve and manage the sunflower cultivation or by improving the efficiency of farmers' support systems, the current situation of sunflower production in Moldovan farms was investigated. In this context, the databases of the National Bureau of Statistics of Moldova and the Food and Agriculture Organization were analyzed and farmers' surveys in different locations across the Republic of Moldova were conducted. The data related to the dynamics of sunflower production, yield and the surface of sunflower growing area, as well as of applied agricultural practices have been accumulated. It has been established the significant expansion of sunflower cultivated area which was leading to (i) considerable exploitation of land where sunflower is cultivated; (ii) failure of crop rotations; (iii) the accumulation of various pathogens. Some solutions to redress the situation have been proposed.

Keywords: agricultural practices; management; phytosanitary situation; production; sunflower crop; yield.

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Introduction

Sunflower (*Helianthus annuus* L.) is a crop of global importance. Sunflower seed oil, with a lower concentration of saturated fats and greater percentages of mono- and polyunsaturated fatty acids, is the preferred fluid oil for food uses within the European Union. Furthermore, sunflower oil also can be used as a source of biodiesel – a biodegradable, non-toxic and environment-friendly fuel (Boumesbah et al. 2015).

Sunflower is grown on about 25 million hectares, with an annual production of around 45 million metric tons, making this oilseed crop the third-largest in the world, preceded only by soybean and rapeseed (Pilorgé 2020). In the last few years, sunflower production increased from 54.97 million tons in 2019, to an estimated 56.69 million in 2020/2021, according to the predictions of the United States Department of Agriculture (World Agricultural Production 2020, http://www.worldagriculturalproduction.com). Sunflower production is concentrated mainly in Europe, with 70.4% of the cultivated areas, followed by Asia and America with 12.5 and 9.2%, respectively (FAOSTAT).

About 85% of the sunflower seeds imported in Europe are a result of trade within Europe, Moldova being one of the main suppliers. For example, in 2017, Moldova was the developing country supplying the largest share to Europe: close to 10%, or 330 thousand tons of sunflower seeds (CBE 2019). The Moldovan sunflower production was doubled over the last years from 548.0 thousand tonnes in 2014 to 811.0 thousand tonnes in 2019 (Nuseed 2017). During the same period, the areas where sunflowers are grown increased by 12% and, according to some forecasts, it will be extended by 25% by 2022 (Ulinici and Savga 2019). Despite its small size, Moldova is in the top 15 largest sunflower growing countries. In 2018, for example, the surface occupied by sunflower in Moldova represented 1.36% of the world production area, ranking the country in 8th and 13th place, respectively, in Europe and the world (based on acreage and productivity) (FAOSTAT). Whilst the average yield has increased over the last nine years compared to the period of 1991–2010, it is still less than the average values in 1981–1990. Therefore, production efficiency could be improved further (NBS).

Long-term systemic research has shown that sunflowers can be grown successfully if the correct crop rotation systems are implemented, alternating with wheat (or other cereals) and corn as the optimal predecessors and allowing a minimum of six years between successive sunflower crops. To ensure this system works, in Moldova, sunflower growing areas must not exceed 170 thousand ha of the country's arable land (Vronschih et al. 2002).

In the past three decades, significant changes have been implemented in farming due to the shifts in the socio-economic and institutional environment in Moldova. The rapid liberalization of the Moldovan agricultural economy after its independence in 1991 and the transition to a market economy, as well as uncontrolled land use, has created a more uncertain environment for farmers and the private sector. Thus, as a result of privatization, the collective and state farms have been restructured in small individual plots of around 1.4 ha each, which are not controlled by the government. Considering that production of some crops including sunflower dependents on scale and mechanization, it is difficult to use these plots efficiently. Also, limited knowledge, finance, as well as lack of technical skills in crop production among farmers constrain crop production. In these circumstances, a part of landowners leased their land to operators (so-called leaders), who founded corporate farms mostly organized as joint-stock companies, limited liability companies, agricultural cooperatives. Current the major part of the agricultural land is cultivated by agricultural farms that hold more than 100 ha of land. An important part of the land (around 40%) is cultivated by households and small farms with less than 10 ha (Moroz et al. 2014).

In the last years, the sunflower occupied surface increased continuously (NBS). This was also driven by the growing demand for sunflower seeds, combined with the high crop tolerance to drought, which made sunflower the more predictable and less risky crop choice for farmers looking to maintain a stable annual income. Naturally, this led to the failure of the crop rotation system, the soil degraded, increasing the frequency and aggressiveness of various pathogens. Moreover, the inefficiency of long term strategies in managing insects, diseases and weeds, decreased even further the soil's physical properties (Kondakov et al. 2012).

All of these circumstances raised major challenges for the Moldovan sunflower agricultural sector and mobilized further research aiming at the sustainability of the growing production of sunflower in the twenty-first century. Sunflower research is essential in designing public policies focused on fostering greater efficiency in agricultural production.

To determine which factors impede the attainment of higher yields and whether this problem can be solved by conducting further research to improve and manage the sunflower cultivation or by improving the efficiency of farmers' support systems (providing policies, an extension of subsidies etc.) information on the situation in the field are needed. In this context, the research undertaken for this paper investigated the dynamic of sunflower production, yield and the surface of sunflower growing area and the current situation of sunflower production in Moldovan farms.

Materials and methods

Data available in the database of the National Bureau of Statistics of the Republic of Moldova (NBS) and the Food and Agriculture Organization (FAO) were analyzed to evaluate the dynamics of sunflower production, yield and the surface of sunflower growing area. Also, surveys were conducted in 2014 and 2020 in different locations across the Republic of Moldova. Farmers were interviewed face-to-face or by telephone about their practices around crop rotation, the type of pathogens present on their field and their incidence, the type of hybrids they grow, the most common measures of crop protection and pathogens control. In 2014, 78 localities were analyzed, including 20 localities in seven districts of *the northern region*, 22 localities in eight districts of *the southern region* and 36 localities, 11 districts of *the central region*. In 2020, 49 agricultural households were evaluated, from 19 districts in different areas of the country, as follows: *northern region* – five districts, with 16 households from 15 localities; *central region*, represented by nine districts, with 25 households from 20 localities and the *southern area* – with eight agricultural households from seven localities, from six districts, respectively.

The survey participants represented small (19.7% of respondents), medium (8.6%) and large-scale (71.7%) farms (Figure 1).

Results and discussions

During the last few decades, the area planted with sunflower increased substantially both at a global and regional level. At the beginning of the twenty-first century, the worldwide harvested area was about 21.2 million hectares; in 2018, it represented around 26.7 million hectares, an increase of 25.9%. In Europe, sunflower acreage increased by 66.4%, from 11.3 million hectares in 2000 to 18.8 million hectares in 2018 (FAOSTAT). It is estimated that the areas cultivated with this oilseed crop will continue to grow, but not as considerably as in the past. To

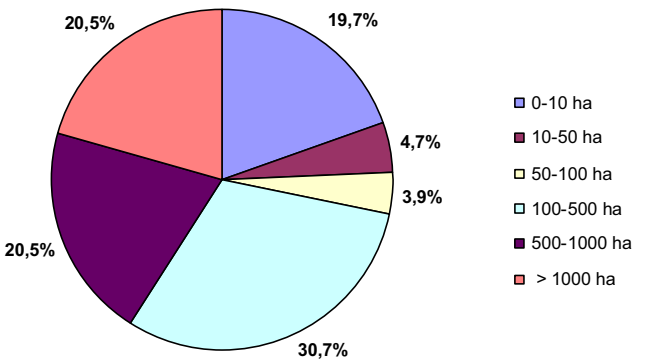

Figure 1: Breakdown of the surveyed farmers according to the farm size.

increase production without expanding agricultural land according to actual tendencies (Edgerton 2009), current recommendations focus on stabilizing and increasing productivity by obtaining high yielding hybrids resistant to biotic and abiotic factors, as well as performing and implementation of effective control measures of pathogens.

In the Republic of Moldova, sunflower has been cultivated from the first half of the 20th century. The first document attesting its presence dates back to 1845 (NARM). In 1863 it was mentioned as a field crop widely spread across individual farms (Gordienco 1959). Since the late 1940s, the harvested areas have been expanded gradually, reaching around 135.0 thousand hectares at the beginning of the 1980s. During the next four decades, the surface occupied by sunflower increased considerably, accumulating 327.1 thousand hectares in 2019 (NBS). Sunflower production is concentrated in the North and South part of the country (Figure 2).

Contrary to sunflower acreage, the average total sown area in Moldova has decreased by 16.3%, from 1795.4 thousand ha in 1981–1990 to 1503.4 thousand ha in 2011–2019 (Figure 3). This reduction was due to the change in the use of parts of the cultivated area after the land reform, as well as the lack of good management and adequate policies. As a result of the land reform, the structure of agriculture land use has changed.

The area where sunflower was cultivated increased from 7.4% in the 1980s to 17.1% in the early 2000s, out of the total area harvested in the country. In 2019 the quota of *H. annuus* was 21.8%: the third most cultivated crop after wheat and corn.

The largest area dedicated to sunflower was in 2017 (385.0 thousand ha), increasing the share of this crop to 25.1% out of the total cultivated area, which is almost 2.5 times higher than the recommended limit (170.0 thousand ha) (Vronschih et al. 2002). Up until the 2000s the producers have respected the recommendations for sunflower cultivation. However, in the last 20 years, they completely ignored it and the sunflower quota increased each year. This led to the degradation of the land and the depletion of groundwater (Ursu 2011). As more phytopathogens have been accumulating, the intensive use of various chemical fertilizers, pesticides and insecticides further degraded the quality of the soil (M. Duca, personal communication).

Total production of sunflower has increased with each decade, except between 1991 and 2000. The biggest increases occurred in the last nine years. Thus, in 1981–1990 the average sunflower seeds' production was estimated at 249.7 thousand tons, in 1991–2000 it was 191.7 thousand tons, and in the next two decades, it represented 320.3 and 593.2 thousand tons respectively (Figure 4).

The increase in the total sunflower seeds production can be mostly attributed to the extension of the planted area rather than any yield improvements, which

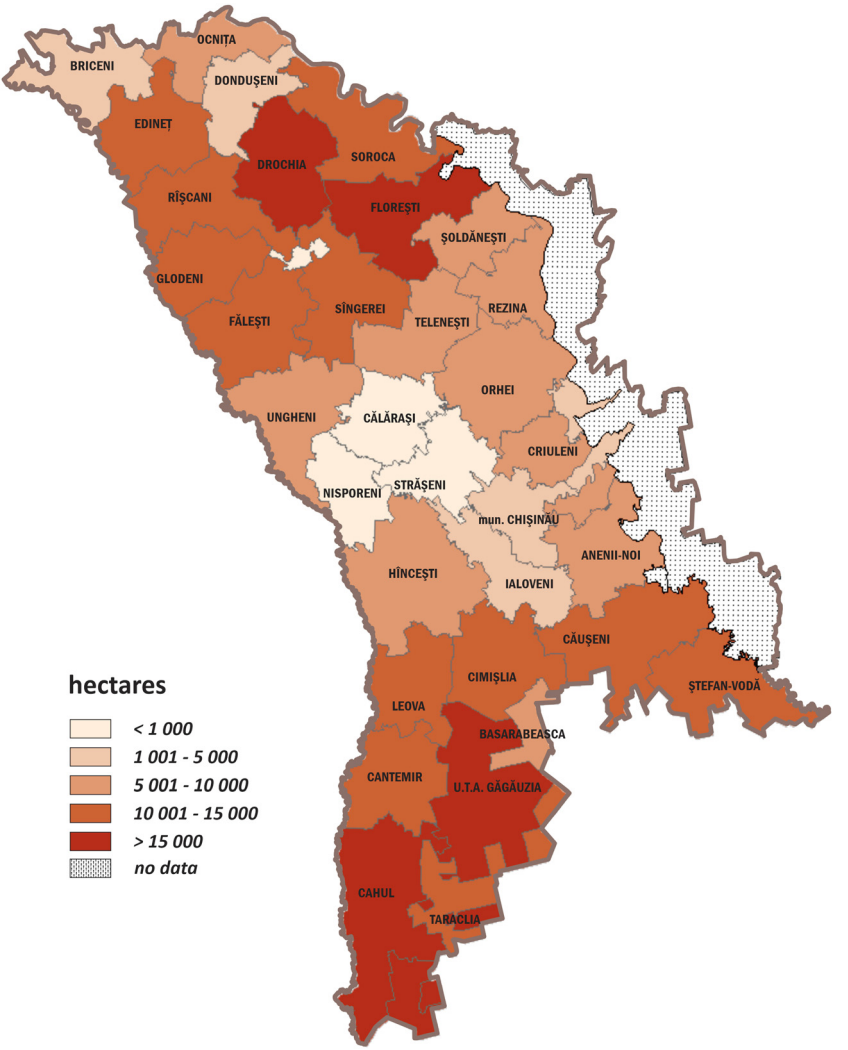

Figure 2: Map showing sunflower production regions in the Republic of Moldova, 2019 (Data source: National Bureau of Statistics of the Republic of Moldova).

was lower in 1991–2010 than in the previous decade. Analysis of yield data shows that the average value calculated per decade has fluctuated from 1.9 t/ha in 1981–1990 to 1.2 t/ha in 1991–2000 and 2001–2010 and 1.8 t/ha in 2011–2019. The Moldovan average yields in the last two decades are lower than the values of most top 10 sunflower producing countries, which range between 1.3 and 2.3 t/ha in 2001–2010 and 1.7 to 2.7 t/ha in 2011–2018 (Figure 5). The lowest seed yields

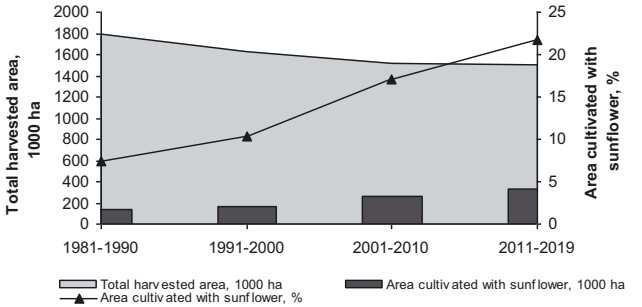

Figure 3: The total cultivated area in the Republic of Moldova and the share of sunflower crop, 1981–2019 (Data source: National Bureau of Statistics of the Republic of Moldova) * values are 10-year averages.

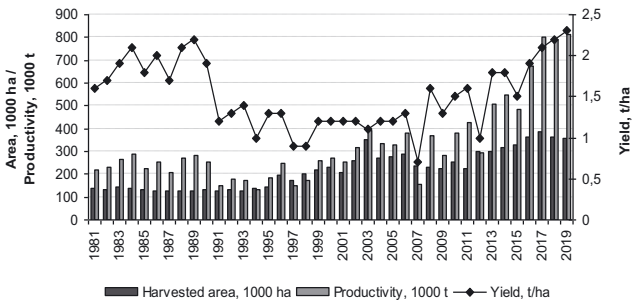

Figure 4: Dynamics of the surface (thousand hectares), production (thousand tons) and yield (t/ha) of sunflower in the Republic of Moldova, 1981–2019 (Data source: National Bureau of Statistics of the Republic of Moldova).

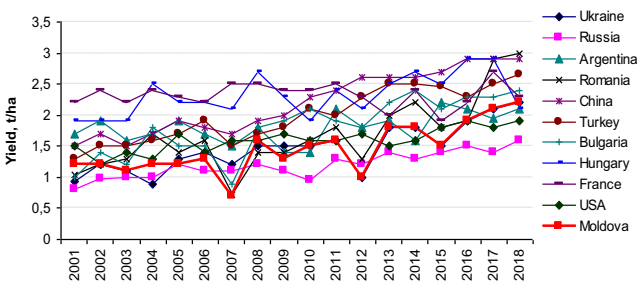

Figure 5: The evolution of sunflower seeds yield (t/ha) in the Republic of Moldova and the main producing countries, 2001–2018 (Data source: FAOSTAT).

(0.7 and 1.0 t/ha, respectively) were recorded in 2007 and 2012, characterized by prolonged and severe droughts. Sunflower crop was also significantly affected by the 2015 extreme drought (Tudorache 2015).

Nevertheless, the yield trended upwards. Similar to countries such as Ukraine, Romania, China, Turkey, Bulgaria, where the average yield was 43–63% higher between 2011 and 2018 compared with 2001–2010, in Moldova this value increased by 50%. The surge in the yield is more considerable in the last three years when the average value of 2.06 t/ha was higher than the world and European averages of 1.85 and 1.95 t/ha respectively (FAOSTAT). This tendency could be explained probably by the preferential use of modern high-yielding resistant hybrids.

Following an on-location survey conducted in different districts from northern, southern and central regions of the country showed that the majority of hybrids grown in Moldovan sunflower fields are produced by Pioneer, Saaten Union, Syngenta, Euralis semences, NARDI Fundulea, Institute of Field and Vegetable Crops, Novi Sad etc. Private companies (AMG-Agroselect Comert LTD, Novasem, AgroS-Sem LTD etc.) and public institutions (Research Institute of Field Crops "Selectia") in the Republic of Moldova also carry out sunflower breeding programs. As a result, around 15 local hybrids are homologated annually and registered in the Register of Plant Varieties of the Republic of Moldova. However, foreign sunflower hybrids, including genes for resistance to different pathogens, as well as Clearfield hybrids tolerant to imidazolinone herbicides, are more preferable for farmers. According to the surveys, the most cultivated hybrids were SY Subtil (in 20.8% of analyzed farms) and Opera (10.9%) in 2014 and P64LE25 (29.0%) and P64LE99 (16.1%) in 2020. Only around 5% of the hybrids sown in the studied fields are of local provenance (Figure 6).

The recommended six-year rotation between successive sunflower crops was respected in only 11 and 6% of farms analyzed in 2014 and 2020, respectively (Figure 7A). In half the cases (approx. 50%), the sunflower was cultivated in four to five-year rotation; and in 37% (2014) and 48% (2020) of the farms surveyed, the crop returned to the same field only after a one to the three-year rotation. The share of households where the crop rotation was respected decreased from over 10% in 2014 to under 10% in 2020. Thus, whereas in 2014 sunflower returned to the same fields after five or more years in 37% of the surveyed households, in 2020 this percentage decreased to 23%.

The sequence of the crops in the recommended rotation are generally respected (Figure 7B) within most of the farms (around 96% in 2014 and 88% in 2020), sunflower being preceded by wheat, barley, other cereals (59 and 45%, respectively) and corn (37 and 43%).

Analysis of crop-rotation organization in farms with different size showed that in large farms sunflower returned to the same plots after four or more years in 67%

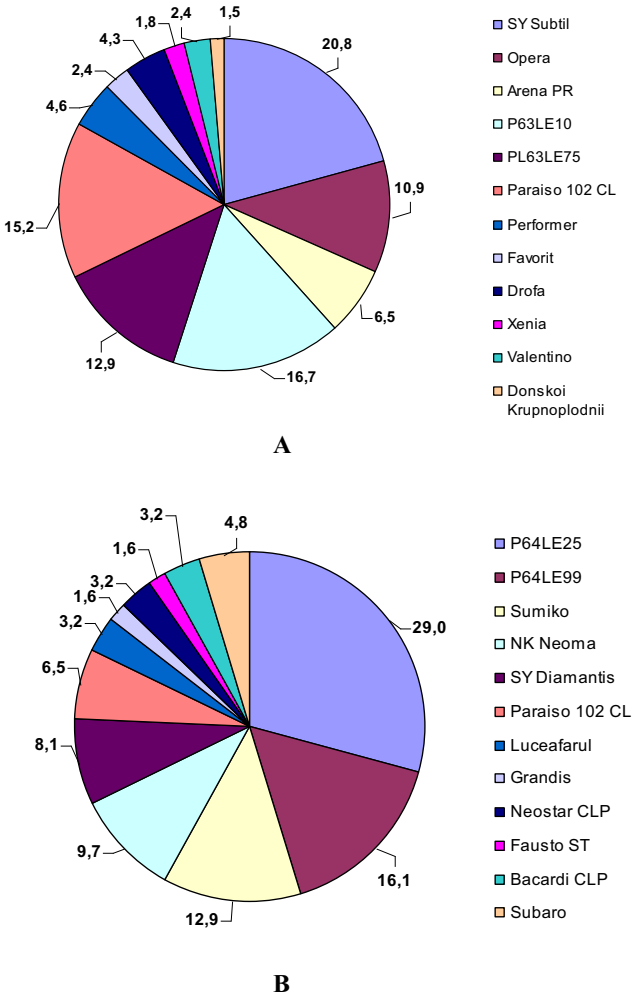

Figure 6: Share of sunflower hybrids cultivated in Moldovan farms (A – in 2014; B – in 2020).

of cases, while in small and medium-size farms this percentage constituted 44 and 18.2%, respectively. The small size and the disaggregated nature of planting plots restrict the ability to respect the correct crop rotations. Thus, according to our data in small and medium-size farms sunflower is cultivated in the same fields after one to three years (66 and 81.8%) (Figure 8).

The analysis of the phytosanitary situation in Moldovan sunflower fields represents another objective of our study. Based on the collected data, it was found that farmers periodically must deal with various diseases caused by mycelial fungi,

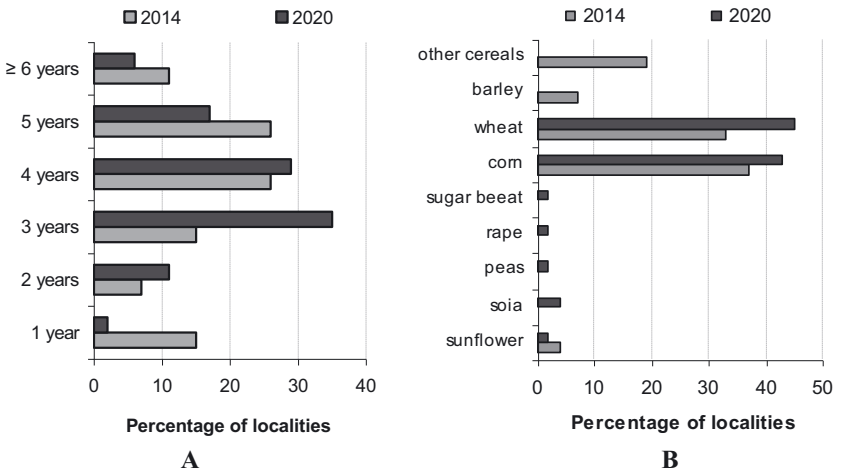

Figure 7: Rotation of sunflower in farms of Moldova (A – Period of sunflower return to the same field; B – Predecessors of sunflower).

such as *Plasmopara halstedii*, *Pucinia helianthi*, *Phomopsis* sp., *Sclerotinia sclerotiorum*, *Septoria helianthi*, *Alternaria helianthi*. The presence of pathogens in the field was reported by 27 farmers. The most widespread pathogen was *P. halstedii*, which causes the downy mildew; its presence being noticed especially in the rainy years, in 15 of the 49 households analyzed in 2020 (Figure 9).

The second most common pathogen was the rust (*P. helianthi*), which was present in 13 households, mostly located in the central part of Moldova. Phomopsis, white mould, septoria and alternariosis have been reported sporadically in two or three households, mainly in the north. In contrast to the data collected during the expeditions conducted in 2014, when the broomrape was detected in

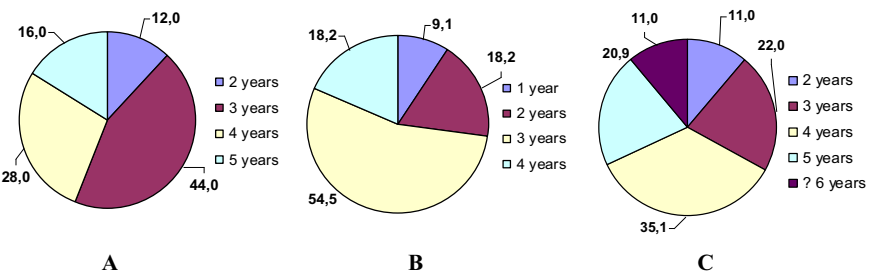

Figure 8: Period of sunflower return to the same field in the farms with different size (A – small; B – medium; C – large).

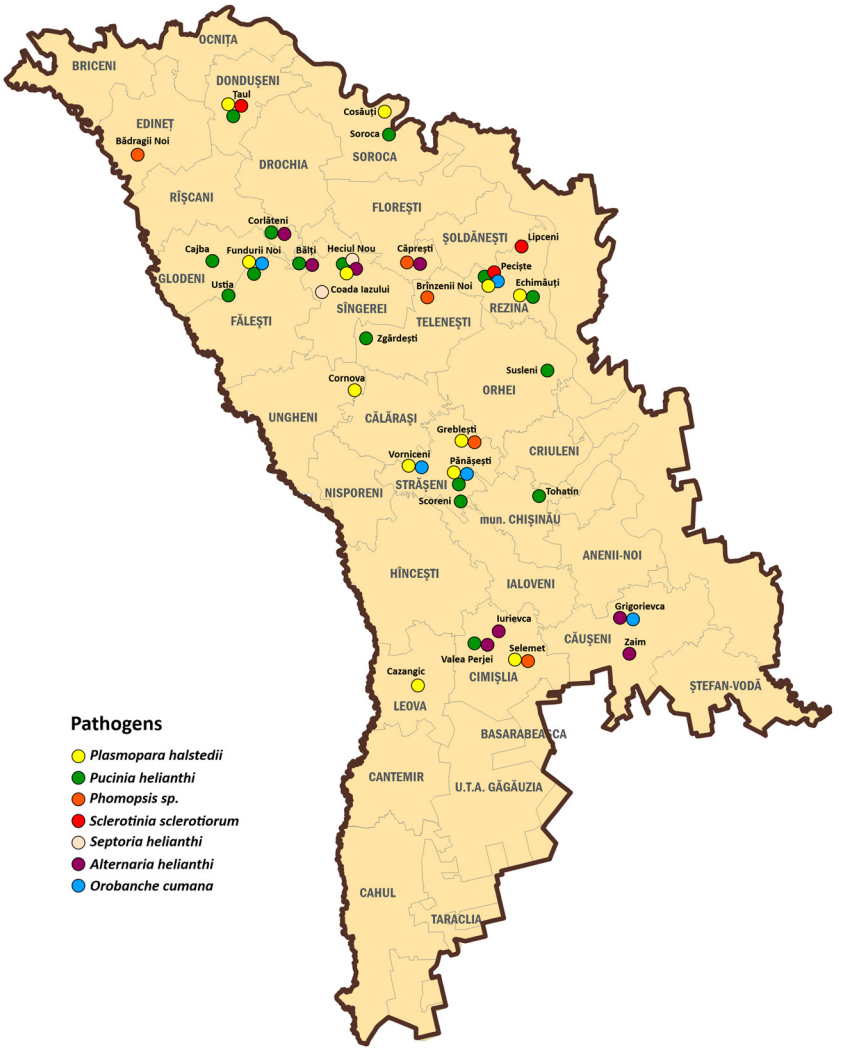

Figure 9: Map showing the distribution of sunflower specific pathogens in the analyzed households of the Republic of Moldova (according to data collected from the survey in 2020) *the locations of pathogens are shown with markers of different colours.

63% of analyzed localities from the south, 47 and 18% of localities from the central and northern regions, respectively (M. Duca, personal communication), in the 2020 survey, *Orobanche cumana* Wallr. was mentioned only by 10% of farmers, mainly in the central part of the country.

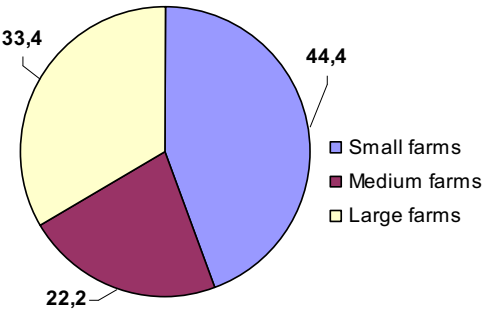

Figure 10: Breakdown of the farms where the pathogens were reported according to their size.

The presence of pathogens was reported especially by farmers representing small (44.4%) farms (Figure 10). This may be because in large size farms the long-term crop rotation is especially organized. Also, in the large farms, there are more financial and technical possibilities to ensure crop efficiency and to avoid pathogens.

It should be mentioned that about 40% of farmers indicated the presence of aphids as an important problem in sunflower cultivation, especially this year. According to farmers' observations, the main factors (reported by 23 respondents) that determine the increased incidence of pathogens in sunflower fields include the cultivation of sensible hybrids and non-compliance with crop rotations (return in the same field over one to three years) and, to a lesser extent, cultivation in soils with high humidity and mineral deficiency.

The cultivation of resistant hybrids and crop rotation were mentioned as basic measures of pathogen control and crop protection by 67 and 49% of the respondents, even when part of them didn't respect these rules. Around 30 of the interviewed farmers in 2020 noted the application of herbicides, the most common being Express (by 10 farmers), followed by Pulsar and several other herbicides, such as Pantera four EC or Granstar. Also, 13 and, respectively, 12 respondents mentioned that occasionally (if needed), they use insecticides and fungicides.

Periodic on-location analysis can reveal the impact of the chosen technology, the type of hybrids, the methods implemented for controlling pathogens etc. This helps researchers and policymakers understand the challenges and real drivers for the productivity of the crops, which is essential in designing public policies focused on fostering greater efficiency in agricultural production. The outputs of this or similar studies can also inform and help educate farmers on how to improve the efficiency and profitability of their activity.

Conclusions

The current study reveals that within the Republic of Moldova, sunflower has consistent planting areas, but exceeds the admissible limits of this crop for carrying out correct rotations. This significant expansion is leading to (i) considerable exploitation of land where sunflower is cultivated; (ii) failure of crop rotations; (iii) the accumulation of various pathogens. The situation is more difficult on small size farms and state authorities should pay more attention to them.

For this reason, sunflower research should further focus on the identification of variable and invariable components of sunflower productivity, based on integrated studies, which identify the factors that inhibit the realization of the yield potential of hybrids (pathogens, agricultural practices, inadequate utilization of fertilizers, climate change etc.). Also, periodic on-location analysis is needed to assess the effect of management decisions on-farm efficiency and profitability and to deliver corresponding information and recommendations to farmers. Decision-makers responsible for the development, future strategies and investments in the sunflower industry need to address the balance between basic sunflower research programs (genetics, breeding etc.) and technological management (agro techniques, nutrition, protection etc.), to develop and promote the corresponding regulations.

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