Sciences. Austria. 2022., Vol. 9-10. pages. 36-40. https://doi.org/10.29013/AJT-22-9.10-36-40. (№23 Scientific journal impact factor).

10. Aliyeva M. T. “Apis Mellifera xitozan asosida modifikatsiyalangan vermikulitning fizik-kimyoviy xossalarini tahlil qilish. Development of Science ilmiy jurnali. 2024. V. 1,(1). №6, P.81-89. ISSN 3030-3907. (https://oak.uz/pages/4802).

RESIDUES OF PLANT PROTECTION PRODUCTS IN SOILS OF THREE FARMING SYSTEMS AT THE SPNA KOLLUMERWAARD EXPERIMENTAL FARM IN THE NETHERLANDS

Information about the authors;
Jelmer Buijs;
works for and owns Buijs Agro-Services in Bennekom,
e-mail: jelmerbuijs@gmail.com
Geert-Jan van der Burgt;
works for and owns Burgt Agrarische Diensten,
e-mail: gjvanderburgt@gmail.com

Subtitle. Differences in pesticide residues in soils after 19 years of different management in three farming systems.

Abstract. Residues of pesticides can accumulate in the soils of conventional arable farms. In 2000, conventional cultivation was partly replaced by organic cultivation on two sections of a trial farm, without further use of pesticides. After 19 years, soil samples from conventional and from the two organic sections were analyzed for 664 pesticides. Of an adjacent nature reserve a soil sample was taken as comparison without any agricultural use.

Key words: soil, pesticides, farming systems, environment, ecosystem services, experimental farms, accumulation, organic production



Figure 1. Onions harvested in rows in the conventional farming system of the SPNA experimental farm (31 October 2019)

Introduction

SPNA Experimental Farm “Kollumerwaard” is located on the northern marine clay soil on the border of two Dutch provinces Friesland and Groningen, located in the Lauwersmeer area. Here, three farm sections of SPNA with different agricultural farming systems are located. Until 1969, the land had an identical history. Adjacent to those three farming systems is a nature reserve on similar (reclaimed) soil. This makes it an ideal location for research into the presence of crop protection product residues in the soil.

Until 1969, the land was seabed (Lauwerszee) and, after a dam was closed and the entire area was desalinated, it was converted into arable land and a part was reserved as a nature conservation area. From 1990 to 2000, the SPNA experimental farm Kollumerwaard practised conventional arable farming here on an area of 132 hectares [12]. The soil varies from light sandy loam (near the Lauwersmeer nature reserve) to light clay (near the dyke). The crop rotation included (and in the conventional farming system still includes) seed potatoes, sugar beets, onions and grain, mostly winter wheat and winter barley. Fertilisation on the conventional plots consists partly of liquid animal manure, partly of artificial fertilizer. Compost and solid animal manure are also used. In the second system, being organic arable farming, organic manure is purchased and the crop rotation consists of fodder crops, vegetables and cereals. The third system, called "Planty Organic", has no manure input. Several leguminous crops cover the nitrogen needs of the rotation. Vegetables are grown as high income crops.

Material and methods

On 31 October 2019, four soil samples were taken from the topsoil (0-20 cm):

- Conventional farming system on plot 4 (with onion cultivation as the previous crop)
- the adjacent organic plot 2 (with cauliflower as the previous crop) under organic management
- the "Planty Organic" trial field with six sub-fields (with the six crops from the crop rotation in the previous season)
- Nature reserve managed by the State Forestry Department (SBB)



Figure 2. Satellite image of SPNA experimental farm.

The blue line indicates the conventional farming system and the yellow line the boundary of the organic farming systems. Inside the yellow line the orange line indicates the "Planty Organic" farming system, and the red line indicates plot 2 of the organic farming system. The purple line indicates the location within the nature reserve of the State Forestry Department where the sampling was done.

Twenty soil samples were taken from each plot in a zigzag pattern, spread across the entire plot ("Planty Organic": the six subfields). The soil samples were analysed by the Eurofins laboratory in the Netherlands (https://www.eurofins.nl/en/), using a multi-analysis package for the presence of 661 plant protection products and their metabolites using both liquid and gas chromatography (LC & GC). The Limit of Quantification (lower measurement threshold that met the reliability requirements) for the 661 substances measured was 1.5 µg/kg fresh weight of soil. In addition to the multi-analysis, a single residue analysis was also performed to measure glyphosate, AMPA and glufosinate. The Limit of Quantification for this measurement was 0.5 µg/kg fresh weight of soil. In total, 661+3=664 different residues were measured using two different methods.

Results

The results of the measurements are summarized in Table 1. The substances found are classified according to their intended use. Fungicides are used to combat fungal diseases, herbicides to combat weeds, and insecticides to combat insects. In the past, the repellent anthraquinone was added to seeds to prevent them from being eaten by birds.

Table 1.

Number of substances found, total content and numbers of fungicides, herbicides, insecticides and repellents identified on the four plots

Farming system	Total number of compounds	Summed concentration of pesticides µg/kg dry matter	Number of fungicides	Number of herbicides	Number of insecticides	Number of repellents
Conventional	33	600,7	16	11	5	1
Organic	4	29,1	2	1	0	1
"Planty Organic"	5	37,9	2	1	1	1
Nature conservation area SBB	4	22,4	2	1	1	0

To provide a clearer picture of the types of substances found in the soil, Table 2 lists the total concentrations of the various categories of pesticides.

Table 2.

Total levels (µg/kg DM) of fungicides, herbicides, insecticides and repellents in the three farming systems and in the adjacent nature reserve

	Fungicides	Herbicides	Insecticides	Repellents	Total
Conventional	467,5	96,5	23,7	13,0	600,7
Organic	16,2	0,9	0	12,0	29,1
"Planty Organic"	16,4	1,0	12,5	8,0	37,9
Nature conservation area SBB	12,8	0,8	3,0	5,8	22,4

Table 2 shows that approximately 78% of the pesticides found in the soil of the conventional plot are fungicides.

Finally, Table 3 lists all pesticides found in the surface soil of the three farming systems and of the nature reserve.

Table 3.

Residues of plant protection products in the soil (in micrograms per kg dry matter) from three SPNA farming systems and from the nearby plot managed by the State Forestry Depart-ment (SBB)

		Conventional	Organic	"Planty Organic"	Nature conservation area SBB
Type of pesticide	**Name of pesticide**	**µg/kg dry matter**	**µg/kg dry matter**	**µg/kg dry matter**	**µg/kg dry matter**
herbicide	AMPA (metabolite glyphosate)	44,1	1,1	-	-
repellent	Antraquinon[1]	13,0	12,0	8,0	5,8
fungicide	Azoxystrobin	59,0	-	-	-
fungicide	Bixafen	34,2	-	-	-
fungicide	Boscalid	33,5	-	-	-
herbicide	Chlorpropham	1,0	-	-	0,8
insecticide	Clothianidin	10,0	-	-	-
fungicide	Cyproconazole	1,0	-	-	-
fungicide	Diphenyl[1]	14,3	12,2	12,2	12,8
insecticide	Diphenylamine[1]	-	-	12,5	3,0
herbicide	Diflufenican	5,7	-	-	-
fungicide	Epoxiconazole	56,0	-	-	-
herbicide	Ethofumesate	2,0	-	1,0	-
fungicide	Fluopicolide	51,5	-	-	-
fungicide	Fluopyram	116,9	-	-	-
fungicide	Fluoxastrobin	27,4	-	-	-
herbicide	Glyphosate	5,5	-	-	-
insecticide	Imidacloprid	7,1	-	-	-
fungicide	Isopyrazam	10,4	-	-	-
herbicide	Isoxaben	4,9	-	-	-
herbicide	Linuron	11,1	-	-	-
fungicide	Mandipropamid	18,0	-	-	-
fungicide	Metalaxyl	6,0	-	-	-
herbicide	Metamitron	5,6	-	-	-
herbicide	Metolachlor-s	6,0	-	-	-
herbicide	Pendimethalin	12,0	-	-	-
insecticide	Pirimicarb	3,2	-	-	-
fungicide	Prochloraz desimidazole-amino	12,3	4,0	4,2	-
herbicide	Prosulfocarb	8,0	-	-	-
fungicide	Prothioconazole-desthio	3,0	-	-	-
fungicide	Pyrimethanil	11,0	-	-	-
fungicide	Tebuconazole	13,0	-	-	-
insecticide	Thiamethoxam	3,5	-	-	-
	Summed concentration of all detected substances	**610,2**	**29,3**	**37,9**	**22,4**
	Number of detected substances	**32**	**4**	**5**	**4**

[1]These substances do not originate solely from agriculture.

The total summed concentration of pesticides in the soil from Table 3 are shown in figure 3;

Figure 3. The total summed concentration of all soil pesticides in three farming systems of SPNA experimental farm and in the adjacent nature conservation area

Conventional farming system

Thirty-two active substances from plant protection products were found in the soil of the conventional onion plot of the conventional farming system. Three of these substances (anthraquinone, diphenyl and diphenylamine) are unlikely to originate only from agriculture. Fungicides formed the largest group of pesticides. The largest individual contribution (25%) to the fungicide content of the conventional farming system was made by the substance fluopyram. The second largest contribution (more than 12%) was made by the fungicide azoxystrobin. Of the herbicides, the majority (84%) of the substances found consisted of AMPA (a metabolite of glyphosate), glyphosate, linuron, pendimethalin and prosulfocarb. AMPA and glyphosate alone accounted for 51% of the measured concentration of herbicides. The substance with the highest concentration (116.9 µg/kg DM) of the conventional farming system was the fungicide fluopyram, which belongs to the well-known PFAS (Per- and polyfluoroalkyl substances) compounds. Another substance with a high concentration was azoxystrobin. This fungicide is authorised for use on potatoes, for example, where it may be applied a maximum of once per year at a rate of 75 grams per hectare. The fourth highest concentration was that of the fungicide fluopicolide, which also belongs to the PFAS compounds.

Organic farming system

It is striking that only a very small concentration of the glyphosate metabolite AMPA was found in the soil of the organic plot and that no insecticide residues were present in the soil. Anthraquinone, diphenyl and diphenylamine are most likely not of agricultural origin, but the prochloraz metabolite is. Therefore, only two residues of plant protection products were identified that are clearly of agricultural origin. Anthraquinone, diphenyl and

diphenylamine can also originate from industrial sources or exhaust gases.

"Planty Organic" farming system

The soil of the "Planty Organic" field contained only two residues of plant protection products: ethofumesate and the prochloraz metabolite, although it should be noted that the latter was also present in the soil of the organic plot, as well as in the conventional system. The other three substances in Table 5 are most likely not of agricultural origin.

Nature reserve managed by the State Forestry Department (SBB)

Three substances were found in the soil of the SBB plot that were unlikely to have originated from agriculture. Only the seed treatment agent chlorpropham clearly originated from conventional arable farming.

Discussion

Many more different residues were found in the soil of the conventional farming system than in the soil of the two organic farming systems. The soil of the nature reserve contained a comparable number of pesticides as the two organic farming systems. The total quantity of pesticide residues in the conventional farming system was much larger. Most of the substances found are used exclusively in agriculture. Only the origin of anthraquinone, diphenyl and diphenylamine is possibly outside agriculture [1]. The conventional rotation with the usual crop protection system appears to have led to much higher soil contamination (by a factor of 20 and 16 for organic and "Planty Organic" respectively) with residues. Very few residues were found in the "Planty Organic" and organic farming systems, despite the fact that conventional arable farming was practiced on this soil from 1990 to 2000. Apparently, from 2000 to 2019, the residues largely disappeared or were converted into substances (metabolites) that we did not measure. If the three substances that are unlikely to originate from agriculture are subtracted for the three farming systems, the difference between conventional, organic and "Planty Organic" is as much as a factor of 114 and 112 respectively. In the soil of the nearby State Forestry Department (SBB) nature reserve, only chlorpropamide (agriculture-related) was found. Therefore, the difference in (agricultural-related) residues between the conventional plot and this nature reserve was a factor of 727.

The modest concentration of AMPA detected in the organic farming system may be the result of residues present in the organic fertilizer applied. Prochloraz-desimidazole-amino was found in the soil of all three farming systems, so it is possible that this residue originated from crops grown before 2000. The low concentration of chlorpropham in the nature reserve of the State Forestry Department was practically the same as the level found in the conventional farming system. The substance was not detected in the organic and "Planty Organic" systems; this can possibly be explained by the fact that the measured value is very low, close to the detection limit. The substance chlorpropham is extremely volatile and is often found at greater distances from agricultural plots [2,3]. This potato sprout inhibitor has not been authorised since 2019. It was also authorised as herbicide in potatoes but given the low concentration in the soil of the conventional plot, it is unlikely to have been used here in the recent past.

Given the fact that only 15 active ingredients of plant protection products were applied to onions in 2019 and 32 substances were found (30 of which originated from arable farming), it is evident that at least 15 of the plant protection products found in 2019 must have originated from previous crops and have apparently remained in the soil. Many of the substances can attach themselves to organic matter or clay minerals and thus remain in the soil for years or decades. The insecticide imidacloprid had not been used for several years, yet it was still present in the

soil in 2019. For some of the substances found in the highest concentrations on the conventional plot, we will discuss whether accumulation has occurred.

Fluopyram

In onions, the recommended dose is 200 g/ha, which translates to 66 µg/kg soil for the entire topsoil if 100% of the product ends up in the top soil from 0-20 cm. Fluopyram is not volatile, with a vapor pressure of 1.2 x 10-3mPa at 20 degrees Celsius [11]. After application, there will undoubtedly be drift, followed by some evaporation and runoff with the crop, so the concentration of 116.9 µg found clearly indicates that the product has accumulated in the soil over a number of years. The product was applied to the onions on 12/7/2019. The product has been authorised in the EU since 2009.

Azoxystrobin

In potatoes grown on SPNA, a maximum of one spray per year may be carried out with this product at 75 g/ha of active substance. Divided through the topsoil, the applied dose is therefore 25 µg/kg DM in the soil. The concentration of 59 µg/kg soil found therefore shows that this substance has also accumulated in the soil.

Epoxiconazole

The concentration of this substance found was 56 µg/kg DM in the soil. Until 2020, the product was permitted to be applied at a dose of 1 liter per hectare and a concentration of 125 grams per liter. This equates to an application of 41 µg/kg soil in the topsoil. This substance, which is now banned, also appears to have accumulated. The substance is not very volatile and contains both fluorine-carbon and chlorine-carbon bonds.

Ecosystem services

It is well known that in conventional cultivation systems, the occupancy of crop plant roots by symbiotic VAM fungi is often very low [5,6]. This increases their vulnerability to periods of drought and also reduces their ability to absorb microelements. The reduced presence of soil life also generally results in poorer soil structure with a higher risk of soil compaction and more drainage problems with strong rains and also a higher drought vulnerability. It is also known that in absence of a healthy soil life, crops become more vulnerable to pests and diseases. The number of earthworms in the two organic farming systems was very high, while they were virtually absent in the conventional cropping system. They were, however, not counted.

Significance for product quality

The activities of the aforementioned VAM mycorrhizal fungi can lead to higher levels of minerals in crops that are important for the health of the crops and for human health. The products from the conventional plot will probably have complied with the EU Maximum Residue Limits (MRLs) for pesticide residues, but a large proportion of the substances found in conventional soil may have ended up in the onions and other crops. The chronic effect of the presence of cocktails of many different plant protection products on human health is virtually unknown. However, this does not guarantee that there is no influence. Research into these effects is currently being conducted in several places, including on the cardiac arrhythmia, atrial fibrillation (at the AMC in Amsterdam), Parkinson's disease (Radboud University) and Alzheimer's disease. Als the chance to get cancer in the Netherlands is steadily rising. Today it is 50% [9]. Among the 32 pesticides mentioned in Table 3 there are 14 that are possibly carcinogenic according to the database of PPDB [8]. The combined carcinogenic properties of mixtures are, however, entirely neglected by the database. At present, it is not possible to calculate the contribution of residual carcinogenic pesticides in food to the incidence of cancer in the population throughout their lifetime.

Significance for the environment

The effects on biodiversity within

the farming systems and outside its borders are largely unknown, as this type of damage or negative impact is not part of the authorization procedure for plant protection products in Europe. The Board for the Authorization of Plant Protection Products and Biocides in the Netherlands (Ctgb) recently stated that it does not have methods for assessing the possible impact of residues on biodiversity [4]. The assessment frameworks only refer to a small number of species (such as earthworms, mites, honeybees and mammals) that are included in models [7]. There is no monitoring of authorized substances in the terrestrial environment, so the significance of these models for soil biodiversity remains totally unclear. Even if pesticides accumulate in the environment, the Ctgb cannot be held legally accountable so far. It is well known that in the Netherlands in most surface water the European environmental threshold values for pesticides are exceeded on a permanent or regular basis [10].

Several of the substances found have a vapor pressure that allows them to spread through the air, for example glyphosate, pendimethalin, prosulfocarb and chlorpropham. However, substances that are not very volatile, such as azoxystrobin and fluopyram, are also o ften found in the vegetation of nature reserves and residential areas [1,2,3]. The solubility of the substances found varies from 100 g/L for glyphosate to milligrams/L for most commonly found substances, such as fluopyram, azoxystrobin, epoxiconazole and boscalid. They can (and will) be washed out with drainage water, in a dissolved form, or bound to clay particles. These emissions first reach local surface water and ultimately end up in the Wadden Sea. Even concentrations in the order of milligrams/L are considerably higher (often by a factor of 100-1000) than the aquatic standards set out in the Water Framework Directive [10]. During soil cultivation and harvesting, dust particles with attached plant protection products also enter the atmosphere. The introduction of cultivation systems based on the organic or “Planty Organic” cultivation system could significantly reduce the pollution of the Wadden Sea with pesticide residues. The Wadden Sea is recognized as a UNESCO World Heritage site due to its unique geological and ecological significance, representing the largest unbroken system of intertidal sand and mud flats in the world.

Recommendations

· Long-term research into the impact of crop protection product residues on biodiversity in and outside farms should be continued.

· The impact of residue cocktails on cultivated crops should be determined in order to inform farms also about the disadvantages of using these substances.

· Analyses of pesticide metabolites should be carried out to determine whether harmful metabolites (like TFA, trifluoroacetic acid) that are not measured by standard analyses are accumulating in the soil.

· credible methodologies should be developed to calculate the risk of chronic diseases related to lifelong exposure to pesticides residues from food

· The results of further research should be used in the re-evaluation of plant protection products by the Pesticide Authorization Boards, like Ctgb in the Netherlands.

Literature references:

1. Buijs, J., & Mantingh, M., 2022. Research into the spread of pesticides in Drenthe and surrounding areas. Evaluation of 3 years of research into soil, vegetation, manure and air. Vereniging Meten=Weten. 112 pp. https://metenweten.nl/wp-content/uploads/2022/12/2022-Onderzoek-verspreiding-bestrijdingsmiddelen-2.pdf

2. Buijs, J., Ragas, A.M.J. , Hendriks, J., Mantingh, M., 2024a. Correlation between Coleoptera

abundance in cattle excrements and pesticide contamination of nature conservation areas grazed by cattle. Science of the Total Environment. 949(2024)175030. https://doi.org/10.1016/j.scitotenv.2024.175030

3. Buijs, J., Mantingh, M., Nijland, G., 2024b. Measurement of pesticides in air and oak leaves at four locations in Drenthe and three in the Veluwe in 2022-2023. 75 pages. Vereniging Meten=Weten. https://metenweten.nl/wpcontent/uploads/2024/06/rapport2024.pdf

4. Ctgb. https://english.ctgb.nl/

5. Didhiou, P.M., Oerke, E.C., Dehne, H.W., 2004. Effects of the strobilurin fungicides azoxystrobin and kresoxim-methyl on arbuscular mycorrhiza. Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz, Volume 111 Issue 6, Page 545-556

6. Douds, D.D., Janke, R.R., Peters, S.E., 1992. VAM fungus spore populations and colonisation of roots of maize and soybean under conventional and low-input sustainable agriculture. Agriculture, Ecosystems and Environment, 43 (1993) 325-335

7. https://english.ctgb.nl/plant-protection/documents/assessment-frameworkppp/2024/03/01/em-2024-1-march).

8.https://sitem.herts.ac.uk/aeru/ppdb/https://www.spna.nl/dynamic/download/b899dcbec6523fbf8017015a1be581d4867d4ada1d176f8b1da2348860ccfc4e.pdf

9. Nederlands kanker collectief https://nederlandskankercollectief.nl/app/uploads/2023/11/Cijfers-kanker-in-NL.pdf

10. Pesticide Atlas, 2024. https://www.bestrijdingsmiddelenatlas.nl/atlas/factsheets.aspx

11. PPDB, 2025. https://sitem.herts.ac.uk/aeru/ppdb/en/Reports/1362.htm

12. Rispens, A. and H. Westerhof (Eds.), 2022. Van telen naar teeltsystemen, SPNA anniversary edition, 46 pp.

POMIDORNING O‘SISHI, RIVOJLANISHI VA HOSILDORLIGIGA MINERAL, ORGANIK O‘G‘ITLAR HAMDA ORGANO-MINERAL KOMPOSTLARNING TA’SIRI

Normuratov Oybek Ulug‘berdiyevich,
q.x.f. falsafa doktori (PhD)., dotsent, doktorant

Paxta seleksiyasi, urug‘chiligi va yetishtirish agrotexnologiyalari ilmiy-tadqiqot instituti

Annotatsiya. Mazkur tadqiqotda olib borilgan tajriba natijalari tahliliga ko‘ra, pomidor o‘simligining vegetatsiya davrida o‘tkazilgan fenologik kuzatishlar ushbu ekinning o‘sishi va rivojlanishiga qo‘llanilgan agrotexnik tadbirlar, xususan, mineral o‘g‘itlar fonida bentonit, organik o‘g‘it go‘ng hamda ular asosida tayyorlangan organomineral kompostlarning kompleks qo‘llanilishi natijasida ijobiy qonuniyat kuzatildi. Ushbu tadqiqotda biz turli me’yordagi mineral va organik o‘g‘itlarning pomidor asosiy poyasi balandligi, yon shoxlar soni hamda vegetativ va generativ organlardagi NPK miqdoriga ta’siri ilmiy asos bo‘lib xizmat qiladi.

Kalit so‘zlar: takroriy pomidor ekini, ukrop, tuproq, harakatchan fosfor, o‘suv davrlari, fenologik bosqichlar, mineral o‘g‘itlar, organik o‘g‘itlar, organo-mineral kompost, sinergetik ta’sir, fosfor mobilizatsiyasi, o‘g‘itlash tizimi.

Аннотация. Анализ результатов проведенных в данной работе экспериментов показал, что фенологические наблюдения за растениями томата в период вегетации