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Evaluation of the agricultural practices and impacts of chemical inputs on the rapid rotting of vegetables of *LactuCa sativa* L. (lettuce) in Ouagadougou (Burkina Faso)

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Abstract: In Burkina Faso, chemical inputs are used widely in market gardening to increase the yields in the production of vegetables. Most of time, the use of these chemicals causes contamination of market garden products, leading to the rapid rotting of these vegetables. The objective of this study was to help in determination of the chemical inputs impacts on the rapid rotting of vegetables in the Ouagadougou city. In this context, surveys were carried out among vegetable producers (Tanghin, Boulmiougou and Kossodo) and vegetable sellers in Balkuy. Results allowed us to make an inventory of chemical inputs used in vegetable production areas as well as the applied doses, the method of application and the Time Before Harvest on the one hand, and on the other hand to evaluate the impact of the dose, the mode of application and the Time Before Harvest of chemical inputs by market gardeners on vegetables. In addition, most of producers (47.5%) used the mixture NPK, urea and manure in order to increase their production. Moreover, most of pesticides used were toxicity II and mainly insecticide, herbicide and fungicide. In this regard, the educational level was responsible of the bad practices in vegetables production and this highly contributed to the rapid rotting of our vegetables which generates economic and social losses for the country.

1. Introduction

With a Sudano-Sahelian climate, Burkina Faso is an agricultural country because agricultural sector contributes to 35% of the Gross Domestic Product (GDP). In Burkina Faso, market gardening is a major component of the agricultural production sector. Indeed, this component annually generates more than 150.000.000 USD to economy. However, in addition to poor soil conditions, this sector is faced the biotic stress caused by various pests. A previous study revealed that without pesticide treatment, these pests were responsible for 72.5% of damage to cabbage in the towns of Ouagadougou (Pooda, 2017). Most of producers used pesticides to increase yields, maintain healthy crops and satisfy growing consumer demand, in addition to the use of grains, market gardeners wage an incessant fight against insects, weeds, fungi, and plant diseases (Errami *et al*., 2012). But, if the use of chemical inputs in agricultural production is very important, non-compliance with the rules for applying these inputs has negative impacts on produced vegetables. In Burkina Faso, several studies highlighted the non-compliance with Good Agricultural Practices (GAP) by the producers of vegetables (Pooda, 2017; Tarnagda, 2017; Ouedraogo *et al*., 2020). Indeed, it has been observed an excess of chemical inputs (mineral fertilizers and chemical pesticides) in market gardening (Son, 2017) and a failure to respect persistence times (Kolia, 2015) leading to contamination of vegetables. These contaminations can

affect the mineral composition of vegetables, their quality and their quick rot. Literature indicated that some pesticides destroy the organic structure of plants, inhibit germination and chlorophyll synthesis in vegetables (Aprifel Food Safety Committee, 2002). The metabolites of other pesticides can persist in plant tissues. In addition to this, most of producers in West African cities do not observe the Pre-Harvest Period (DAR) of pesticides, which explains the excessive contamination of lettuce samples by pesticide residues (Yao, 2016).

According to the FAO (2013), it often happens that overdosing on fertilizer does not lead to an increase in harvest, but rather a drop in yield. Non-compliance with GAP in vegetables production should be responsible of their quick rot, hence the importance of assessing this impact in the context of market garden production in order to reduce the different losses (FAO, 2019).

The general objective of this investigation was to determine the agricultural practices and the impacts of chemical inputs on the rapid rotting of lettuce in the Ouagadougou city. Specifically, it was question to:

- ✓ identify chemical inputs used in agricultural production areas,
- ✓ inventory the doses applied and the persistence times,
- ✓ evaluate the social and economic impacts of the dose and persistence times of chemical inputs applied in vegetables production.

2. Methodology

2.1 Presentation of the study area

This study was carried out in Ouagadougou city (12°45'N, 1°15'W), the political capital of Burkina Faso. The sites were selected in different market gardening sites of the city, mainly Boulmiougou, Kossodo and Tanghin. In addition, some vegetables were taken at Balkuy's market to conduct this study. The choice of these sites was based on the intensive practice of market gardening activity, the relatively short distance for transporting and preserving samples (Figure 1).

2.2 Plant and technical materials

To conduct this study, the lettuce (***LactuCa sativa* L.**) has been chosen because it is most frequently cultivated in Ouagadougou in the dry season and in the rainy season (**Photo 1**). In addition, Data in Ministry of Agriculture indicated that this lettuce is one of the most consumed crops and the most sprayed with chemical pesticides and even in the spreading of fertilizers. As lettuce is a leafy vegetable, chemical inputs are deposited directly on its leaves at a high dose and at a very short DAR. Besides, lettuce is highly contaminated, even though it is mainly consumed in its raw state. Once rotting begins in a lettuce leaf, it is no longer edible. Other technical materials were used, namely:

- the survey questionnaire, laptop, software, etc.
- educational documents: FAO international codes of conduct, articles, master's theses, reports.

2.3 Study conducting

To carry out this survey, eighty (80) producers of vegetables were questioned on three (03) different sites (Boulmiougou, Kossodo and Tanghin), and twenty (20) vegetable sellers at Balkuy's market randomly depending on the availability of producers and sellers. Qualitative and quantitative data were collected with these people. Surveys are carried out with semi-open questionnaires using the face-to-face technique, with an average interview time of 25 to 35 minutes per people. In addition to surveys, some direct observations were realized on the production sites located at Boulmiougou, Kossodo and Tanghin.

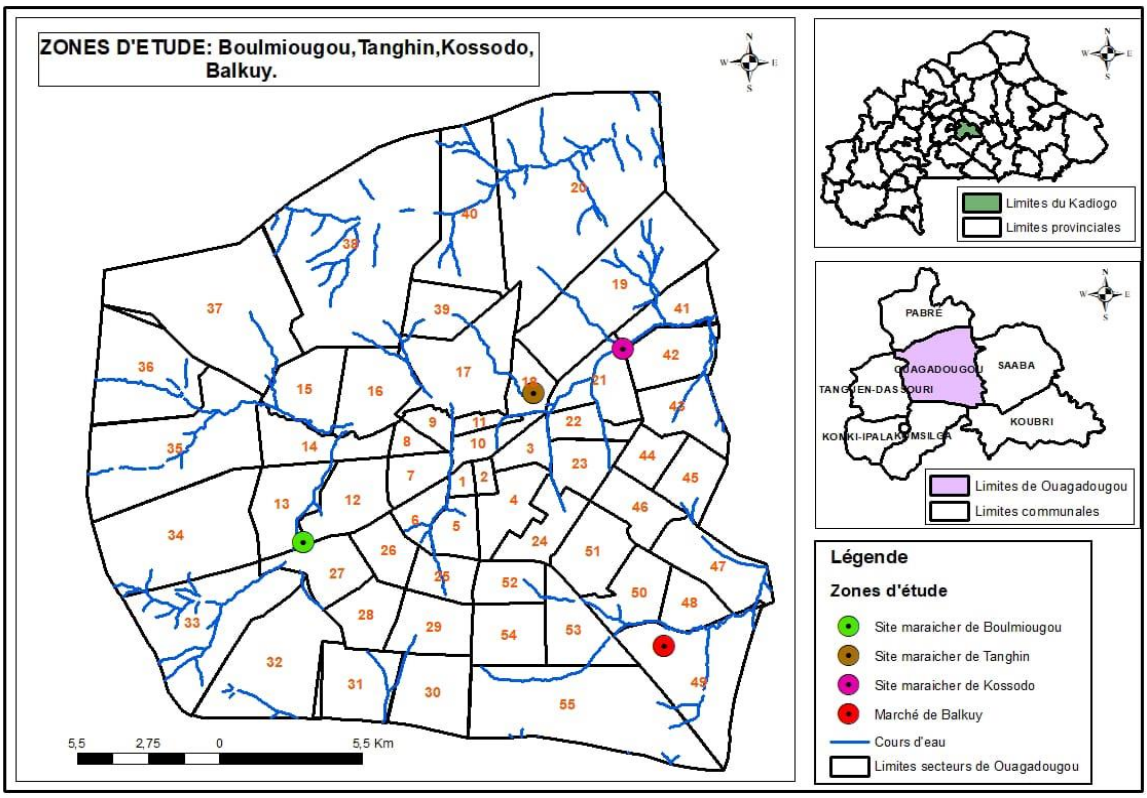

Figure 2. Geographic Situation of the study area (Ouagadougou city) */ IGB /BNDT 2012*

Photo 3. Raw *LactuCa sativa L*

The investigations concerned market gardening, specifically the case of lettuce and the causes of rapid rotting of vegetables in order to determine the causes of rapid rotting of vegetables. To do this, we intended to:

- identify the chemical inputs used by market gardeners;
- evaluate the quantity of doses used per surface area of land;
- know the period and frequency of application of chemical inputs;
- determine the persistence time of these substances;
- identify the expected impacts (social and economic) for populations.

3. Results and Discussion

3.1 Sociodemographic characteristics

The sociodemographic characteristics were based on the sex, level of education and source of professional training of market gardeners. Sample was constituted of eighty (80) market gardeners viz.

thirty-one (31) women and forty-nine (49) men, selected from three market gardening sites and twenty (20) vegetable sellers at Balkuy market.

Results indicated that more than 60% of producers were men, whose 32% men in Boulmiougou, 22.5% in Tanghin and 6.25% in Kossodo. The minority of women on the sites can be explained by the fact that women are more involved in the sale of vegetables.

Concerning the educational level, surveys revealed that 82.5% of respondents have not been to school, 12.5% attended primary school and 03.75% attended secondary school. In addition, investigations indicated that 68.75% of producers received a training with their neighbors or their parents and 43% of respondents received a training from agricultural agents. Despite the training received elsewhere, none of vegetable producers actually applied Good Agricultural Practices according to the instruction's agricultural agents because it seems complicated for some of them. At harvest, the control bed has given good yields (increase) despite this result, some producers choose to back into the old practices. In Boulmiougou site, some producers tried to apply the method of using chemical fertilizers by spreading them directly on the soils instead the lettuce leaves.

From surveys, it has been noted that the majority of market gardeners (82.5%) was illiterate and this similar conclusion was found in previous work (Tarnagda, 2017). Indeed, without any educational level, it is difficult to apply the normal dose, frequency, schedule, instructions for use, and persistence time of chemical inputs. At this regard, the efforts made by the government through training and awareness raising for market gardeners, Good Agricultural Practices will remain enough and insufficient.

3.2 Practices of the use of Chemical inputs

3.2.1 Pesticide inventory

Lettuce cultivation is very sensitive to attacks by insects, and weakly sensitive to attacks by weeds and champions. Thus, to limit attacks, lettuce producers used and applied several phytosanitary products. The investigations revealed twenty-seven (27) trade names of pesticides used by vegetable producers (**Table 1)**. In this Table 1, we noticed three types of pesticides according to the target and 27 trade names used by market gardeners. Those pesticides were regrouped as wells:

- ✓ Nineteen (19) trade names of insecticides including 18 chemical and 1 organic representing 70.37% of pesticides applied. they were mostly used, because insects destroyed more the plants and cultures.
- ✓ Six (06) trade names of chemical herbicides corresponding to 22.22% of pesticides used. This low percentage can be explained by the fact that herbicides impoverish and degrade the soil.
- ✓ Two (02) trade names of chemical fungicides corresponding to 7.40% of pesticides used. Fungicides are little known; their effects do not prevent the sale of their products.

From this Table, the most used pesticide was Sun-Lamda, an insecticide used in all three (03) sites. The use of trade names and type of pesticide depends on the target and varies from one site to another:

- Tanghin: Emaco was the most used by 10/30 producers;
- Kossodo: Sun-Lamda was the most used by 08 producers/26;
- Boulmiougou: Attack was the most used by 11 producers/24.

Table 1. Pesticides according to the target, the commercial name and the number of producers who use this pesticide according to the sites

Pesticide	Common Name	Active matter	Toxicity level	Tanghin	Kossodo	Boulmiougou
Insecticides	Attack	Tefluthrine	II	00	00	11
	Attakan C344 SE	Cypermethine and Imidaclopride	II	04	00	05
	Cap	Captane	II	03	03	00
	Calmeboude	-		01	00	00
	Caima B19	Emamectine benzoate	II		04	00
	Decis 25 EC	Deltamethrine	II	04	00	05
	Emacot 050 WG	Emamectine benzoate Acetamipride	II	11	01	02
	Gamari	-	-	00	01	00
	Garwedtime	-	-	01	00	00
	Hitcel 440 EC	Profencfos, cypermethrine	II	00	00	03
	Ibis A52 EC	Alpha-Cypermethrine Acétamipride	II	02	01	06
	Lamda-Super	Lamda Cyhalothrine	-	02	00	00
	Optimal 250 ml	Lambda Cyhalothrine	II	07	04	00
	Politrine	Acetamipride, Indoxacarbe	II	00	01	00
	Solsaint	-	-	07	08	01
	Sun-Lamda	Lambda cyhalothrine	II	01	00	00
	Rocky 386 EC	Endosulphan, Cyperméthryne	II	00	01	00
	Savahaler	Méthomyl	II	04	00	00
	Cotalm Super 2.5 E.C	Lambda Cyhalothrin	II			
Herbicides	Colla	-	-	00	02	00
	Bibana 480SL	-	-	04	00	00
	Glyphader 360 SL	Glyphosate	III	04	01	00
	Gramoking	Paraquat Dichloride	-	01	00	00
	Gramoquat super	Paraquat chloride	II	00	04	00
	Adwuma-Wora	Glyphosate	III	01	00	00
Fungicides	Benco	Macozebe	-	04	04	00
	Maraton	Chlorothalonil, Cyproconazole	-	02	00	00

Almost all market gardeners used chemical pesticides because 98.75% of them used chemical pesticides and 1.25% used organic pesticides. This choice was explained by the fact that chemical pesticides were easy to find and cheaper while organic ones are ineffective, rare on the markets and

little known. The number of pesticides used by each producer varied from one (01) to six (06). Indeed, Producers who use herbicides and fungicides, applied a single product and only once per crop. To apply insecticides, they used a mixture of two or four insecticides to have high dose to neutralize the insects. A similar study conducted previously concluded that vegetables in Ouagadougou area were contaminated by the pesticides applied during the treatment of plants and cultures (Roamba *et al.*, 2021).

Among the 27 pesticides used in three sites, it was observed only one biopesticide. This number of pesticides was corroborated by the work of Pooda (2017) who found 27 trade names of pesticides on market gardening sites and the most used are insecticides.

3.2.2 Inventory of fertilizers

To optimize yields, lettuce producers use chemical fertilizers and combine organic fertilizers. A few producers (1.25%) used a manure (organic fertilizer). Figure 2 showed that most of market gardeners (47.5%) applied the mixture: manure, urea and chemical NPK.

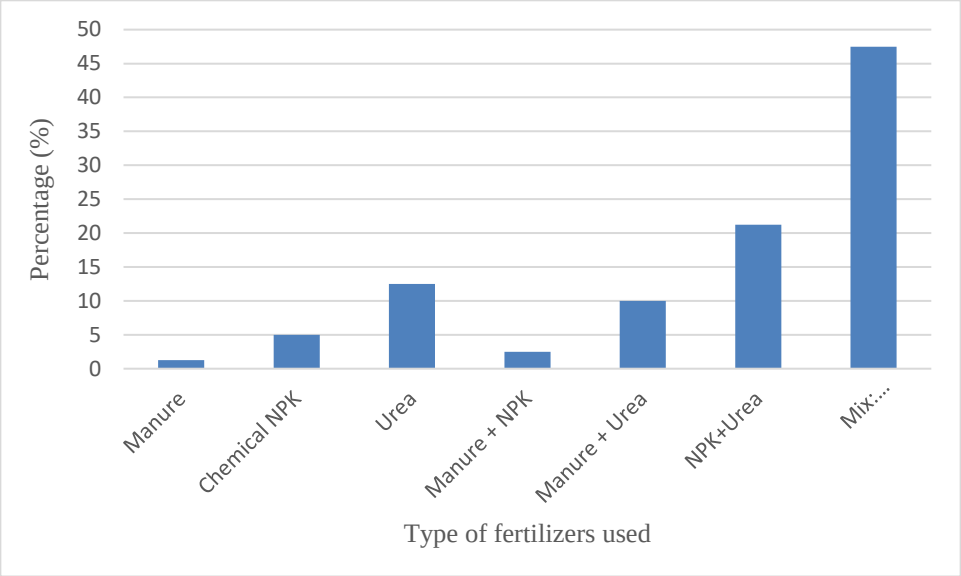

Figure 2. Percentage of fertilizer used

In summary, 98.75% of market gardeners used chemical fertilizers (NPK, Urea, NPK + Urea, Manure + NPK, Manure + Urea and Manure + NPK + Urea), 60% of producers used a combination of organic fertilizers (Manure + NPK, Manure + Urea and Manure + NPK + Urea). Among the producers of three (03) sites, those of Kossodo site used more the mixture including NPK + Urea + Manure. Moreover, the market gardeners of Boulmiougou used mainly the mixture of NPK + Urea and only one of their producers used only manure as fertilizer. The producers from Tanghin site used more the mixture: Manure + Urea, and Urea and NPK, separately. In Table 2, are listed the repartition of producers by site and fertilizer used.

Table 2. Use of fertilizers depending on the site in terms of numbers

Site	Manure	NPK	Urea	Manure+NPK	Manure+Urea	NPK+Urea	NPK+Urea+manure

Tanghin	0	2	5	2	4	5	12
Kossodo	0	1	4	0	2	4	13
Boulmiougou	0	1	1	0	2	8	12

For the fighting against pests, results of investigations revealed that 98.75% of vegetable producers used chemical pesticides. This result is in opposite to that of Diogo *et al.* (2019) in Benin where most of producers used the prepared organic pesticides. The prepared pesticides were a mixture of neem leaves and certain spices including garlic. In terms of fertilizers, market gardeners (98.75%) used chemical fertilizers and frequently combine organic fertilizers (60%) to have a good productivity. This assertion has been observed in the literature (Ouedraogo *et al*., 2019; Ouattara, 2016) which states that market gardening production was characterized by the use of mineral fertilizers and organic amendments.

3.2.3 Knowledge of the surface area, quantity and method of use of chemical inputs

From investigations, the method used and the quantity of chemical inputs applied to the areas of land varied from one market gardener to another. Using a total surface of 1.65668 ha, 524.66 Kg of fertilizer were applied corresponding to a ratio of 316.6936 Kg/ha. The majority of producers (59.33% pesticides and 71.89% fertilizers) have several measuring instruments such as shell cups for powdered pesticides, the cap for Lafi mineral water, or that of the pesticide box for liquid pesticides. Concerning the use of fertilizers, they used fertilizers already attached to retailers in 0.5 Kg; 1 Kg or 0.5 Kg cups; 1 Kg for those who have bags. The percentage of 41.77% of market gardeners does not have a pesticide application quantity and 29.11% do not have a fertilizer application quantity. According to other producers, high dose corresponds to an effective effect in destroying all kinds of enemies of the crop. High dose is therefore a prestige and is equal to high productivity.

The method of using pesticides was spraying (73.75%) and sprinkling (6.25%) in watering cans, cans of Lafi mineral water or with neem branches. The method of using chemical fertilizers was spreading them on crops and only a few market gardeners (11.25%) in Boulmiougou spread these chemical fertilizers directly on the soil.

Socio-demographic surveys revealed that the quantity and frequency of chemical inputs depend on the cultivated area, the persistence of enemies of cultivation, the financial means of the market gardener and the desire to have high productivity. According to some market gardeners, the increase in productivity is equal to the increase in the quantity of chemical inputs (Adechian, 2020). Our investigations revealed that the quantity of chemical fertilizer per hectare was 316.6936 Kg / ha. This number is higher than the one recommended by Souley *et al*., (2017) who found 200 kg/ha. The non-compliance with prescribed doses, especially an overdose of chemical inputs was confirmed by Kolia (2015) which showed that intensive agriculture requires heavy use of pesticides and by Son (2016) which speaks of an excess of fertilizers in market gardening.

3.2.4 Planning for the application of chemical inputs according to producers

Planning is the structuring of the application times of chemical inputs by producers in order to increase yields. Investigations revealed that producers do not wait for pests to be present before

applying pesticides. According to the producers, the schedule can vary from one day to every days. Results of investigations showed the schedule for applying chemical inputs. Indeed:

Concerning the pesticides used on three sites, half of producers (50%) used a 7-day schedule (application of synthetic phytosanitary products every 7 days).

In addition, 20% of market gardeners didn't use a planning(application of pesticides currently at disposal to avoid any contact with pests). These practices have been concluded in a study conducted by Son *et al.* (2018).

About the use of Fertilizers, it was noted 66.50% of market gardeners have a 7-day schedule (application of chemical fertilizer every 7 days until harvest to have a good productivity), 12.50% of producers had a 10-day schedule and 11.50% of producers have a 14-day schedule.

Sometimes, the schedule depends on the market gardener's resources because if the market gardener is wealthy, the schedule will be every day or without a schedule depending on what you want.

The majority of producers have a 7-day pesticide application schedule and this schedule was reduced (every day, every 2 days or every 3 days) depending on the severity of the pests. This result is corroborated by the work of Sawadogo (2016) where the highest treatment interval was 7 days and the treatment intervals decrease depending on the level of attack of the pests. The delay or persistence time among our respondents was more a function of demand. In fact, even when a producer has just applied a pesticide and or especially fertilizer and there is a customer, he can serve it the same day. These deadlines can be superimposed on those found in literature (Diallo, 2020; Tarnagda, 2017).

3.2.5 Frequency of application of chemical inputs according to market gardeners

Application frequency is the number of times growers apply chemical inputs from the start of cultivation until harvest. The frequency varied from once to more than five (05) times per culture as indicated in figure 3.

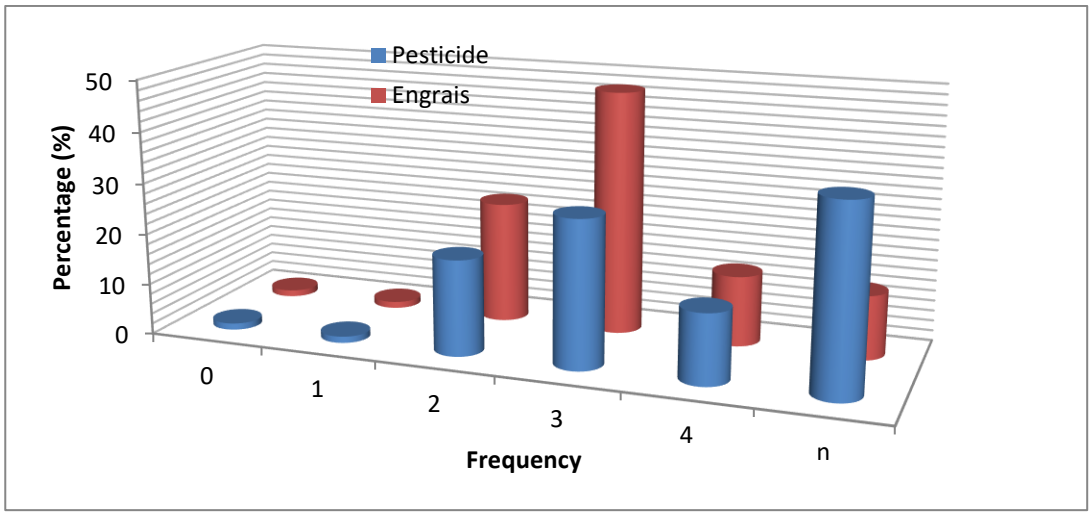

Figure 3. Frequency of application of chemical inputs (number of times)

From figure 3, 36.25% of producers have no application frequency, 28.75%of them have a frequency equal to 3 and One producer (1.25%) does not use chemical pesticides. A study conducted in Morocco revealed the pressure in the use of phytosanitary products for vegetables production and environment (Abbou *et al.*, 2021). Concerning the fertilizer application, the majority (47.50%) of producers have a frequency equal to 3 for each lettuce crop, and 23.75%of them have a frequency equal to 2. However, for the cultivation of lettuce, chemical fertilizer must be applied only once and on the

15th day (INERA researchers). The frequency depends on the market gardener's financial constraints. In addition, the frequency depends on the climate. The no respect of those practices in vegetables production requires for the producers to explore a new approach as recommended in a previous study (Kandil *et al.*, 2015).

3.2.6 Remanence time according to the market gardeners surveyed

Pre-harvest delays (DAR) or residual times are the minimum periods to be respected between the last application of input (pesticides or fertilizer) on a crop and its harvest. Knowledge of the DAR or the persistence time is very important because it determines the degrees of contamination of vegetables by chemical inputs (figure 4).

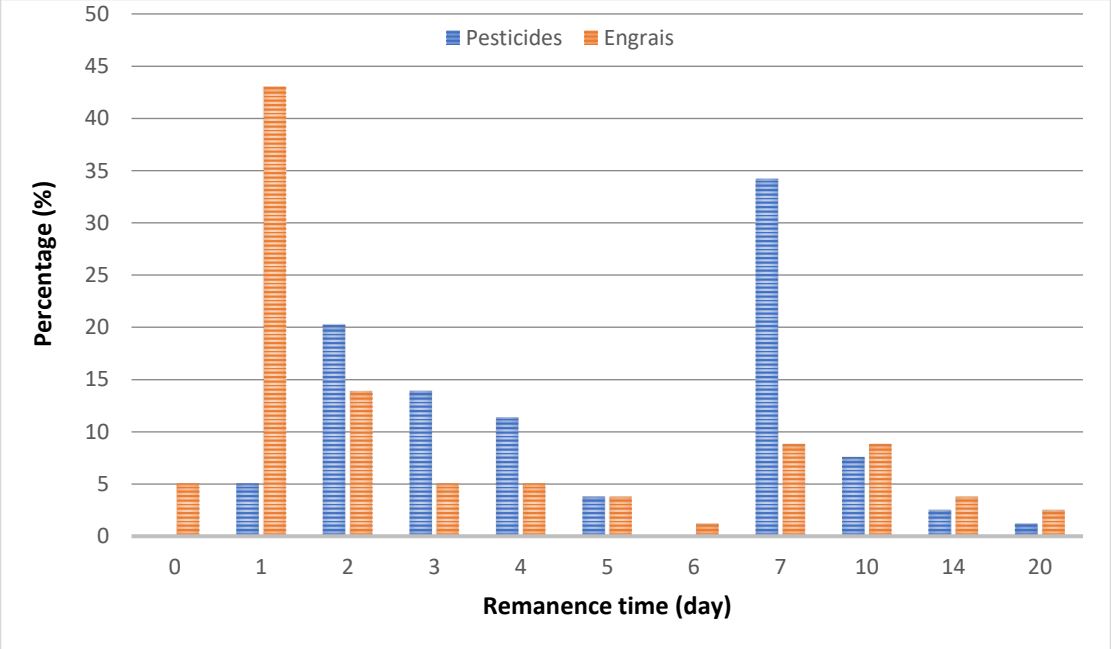

Figure 4. Percentage of persistence times according to producers (in days)

From analysis of this figure 4, the persistence time of pesticides varied from one day to 20 days. Results showed that 34.17% of producers have a DAR of 7 days, 20.25% of them used a DAR of 2 days (and 13.92% with a DAR of 3 days. Research indicated that the half-life of a pesticide corresponds the time it takes for the pesticide to lose half of its initial quantity. According to Tarnagda (2017) the half-life of pyrethroids was estimated at 5 to 7 days, 10 to 20 days for carbamates,5 to 15 days for organophosphates and 28 days to 12.8 years for organochlorines.

Concerning the Fertilizers, their persistence time varied from zero day to 20 days (fig.4). The majority (42.5%) of market gardeners adopted 1 day of persistence time, and 13.75% of them applied 2 days. In addition, the majority of market gardeners started harvesting 24 hours after application of fertilizer while a retention time of one month (30 days) for chemical fertilizers (NPK and urea) is recommended and advised by INERA researchers

3.3 Causes of rapid rotting

The causes of rapid dieback varied from one vegetable producer to another. Results of survey revealed eight (08) causes of rapid rotting of vegetables according to producers and sellers. So, the highest causes were:

- ✓ use of high doses of chemical fertilizers represented42% and the presence of fertilizer residues in vegetables;
- ✓25% of causes were linked to chemical inputs (fertilizer + pesticide).

Our results revealed that the causes of rapid rotting are more linked to the application of a high quantity of chemical inputs and a very short persistence time. This result was corroborated with the study of Adechian (2020) who concluded that the quantity of fertilizer should correspond to the no quick rot of vegetables after harvest. Our results are similar to those found by Parkouda *et al*. (2016), which indicated that chemical inputs (pesticides and fertilizers) are a source of post-harvest losses. In fact, this high quantity of chemical input causes rapid growth without good formation of plant tissues. In addition, the short persistence time showed that the chemical input is still present in the vegetables. So, these contaminated vegetables were less resistant to the heat, freshness, microbes, and the slightest shocks that may occur. Once disconnected from their roots, branches, or soil, these vegetables could be rotted quickly.

3.4 Impacts of chemical inputs on rapid rotting of vegetables

3.4.1 Economic impacts

The abusive use of chemical inputs in vegetables production and non-compliance with Pre-Harvest Deadlines (DAR) are responsible of the contamination of vegetables, which causes rapid rotting of vegetables. This rotting has an economic impact. In fact, the contamination of vegetables reduces their competitiveness on the international market as well as their export. According to the results of the exploratory study on fruits and vegetables (2022), exportations of vegetable decreased by 55% to reach the amount of US$743,672 in 2019. According to sellers in Balkuy's market they harvest the crops in the evening from the market gardeners to be able to sell early in the morning.

All the women surveyed testify that the vegetables now do not take long to rot even if they are in the refrigerator. Housekeepers complain about the rapid rotting of vegetables because they are no longer able to save as in the past. In fact, instead of making a weekly provision with wholesalers, they are forced to make trips to retailers every day to the market. They lose fuel (daily travel) and quantity (purchasing from retailers is more expensive than from wholesalers). According to them, this rapid rotting of our vegetables can be explained by the abusive use of chemical inputs. Thus, the economic impact is felt at the level of the state, producers, sellers and even households.

3.4.2 Social impacts

The rapid rotting of vegetables has a social impact because it reduces the available quantities for consumption of populations and, which increases their purchasing cost. Besides, these vegetables become less accessible to everyone. In Burkina Faso, 13% of households are not able to meet their energy needs and 45% of households do not have access to nutritious food according to the exploratory study on fruits and vegetables (2022). In addition, with the rapid rotting linked to non-compliance with GAP (the overdose of chemical inputs and early retention times), vegetables lose their nutritional values and no longer have their reason for existence. Instead of bringing good health, they produce diseases for people.

Conclusion

Our investigations revealed that the use of chemical inputs was the main factor in increasing yields in the production of vegetables. Market gardeners used several pesticides depending on the target and they do not respect the rules of GAP. In fact, the dosage, schedule, treatment frequency, method of application and persistence time were applied randomly. In addition, our study showed that the main cause of rapid rotting of vegetables was the high quantity of chemical fertilizers and early DAR. Consequently, there are witnessing enormous economic and social losses linked to the abusive use of chemical inputs as well as non-compliance with Pre-Harvest Deadlines (DAR). This loss concerns the contamination of vegetables which causes their rapid rotting leading to a drop in state revenue and that of vegetable producers (through the reduction of exportations, the non-competitiveness of our vegetables on the international market), the drop in income sales women and the high cost of vegetables (through the drop in quantity). The use of chemical inputs in market gardening, in addition to fertilizers to increase yields, pesticides to protect crops against pests remains a major issue in West Africa, particularly in Burkina Faso. Socio-demographic surveys confirmed that the causes of rapid rotting of vegetables are due to chemical inputs (69%), more particularly to the high dose of chemical fertilizer (42%) and to the presence of residues of these chemical inputs (linked to the Early Harvest Time).

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Compliance with Ethical Standards: This article does not contain any studies involving human or animal subjects.

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