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Whey and Cow Milk: Dairy Products Useful for Crop Protection

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ABSTRACT

The study was conducted during spring and summer 2022 at Mare Savin garden centre (Trappes, France) to confirm plant protection properties of some dairy products. Indeed, for crop protection, the search for new non-chemical fungicides useful, durable, affordable and efficient as active substances (a.s.). These suitable products, especially from natural origin called BioControl Agents (BCA) are acceptable to civil society (i.e., low-concern profile, and absence of residues of concern) are of paramount importance as the number of chemical solutions has drastically decreased in recent years. When natural substances from the plant origin are plethoric in literature and some are approved as Plant Protection Product (PPP), natural substances from the animal origin repertoire are sparsely represented in PPP a.s., but lately a few substances have obtained a European Union (EU) active substance approval (i.e. sheep fat, blood meal, fish oil, chitosan hydrochloride from crab shell). Dairy products may also exhibit crop protection properties like whey and cow milk are two of these new BCAs. The corresponding applications under EU PPP regulation (EC) n° 1107/2009 were granted as basic substance according Article 23, respectively in 2016 for whey and 2020 for cow milk for protection of vegetable against mildew and agricultural tools disinfection. These basic substances are approved for an unlimited period of time with no Market Authorisation, for all Europe without zone or Member State consideration, and with no Maximum Residue Limits (MRL). Later, an extension of use for vineyards protection against diseases was granted for whey in 2021.

KEYWORDS: Biorational, BioControl Agents (BCA), cow milk, fungicide, plant protection, whey

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1. INTRODUCTION

Dairy products or by-products are well known for their food and medicine properties raw, processed or fermented (Katouzian-Safadi et al., 2021; Abdel-Salam, 2018; Gamba, 2016; Kenneth and Kriemhild, 2000). Their action is mainly fungicidal (Bugiani et al., 2022; Mudgil, 2022; Shaban, 2023), bactericidal (Osman, 2016; Othman, 2016; Fox, 2021) and fungistatic (Petrova, 2020). Recently interest for new agricultural BioControl Agents (BCA) in plant protection has increased (Marchand, 2023a; Robin and Marchand, 2019) since the disappearance of synthetic chemical control agents (Marchand, 2023b), as desired by the civil society and in line with ongoing agricultural needs (Matyjaszczyk, 2018; Chervin, 2020). Compounds, substances and products with a low concern profile (Marchand, 2015; Marchand, 2017c; Robin and Marchand, 2022) have therefore been seriously investigated and tested since the early 2000s, including whey (aka lactoserum) and from the late 90s milk, with the aim of bringing forward their candidacy as validated crop protection products. Indeed, dairy products have been used in agriculture as generic fertilizers since Middle Ages, but only recently were agronomic trials conducted in order to demonstrate or validate new potential uses including fertilisation (Pane et al., 2012), biostimulation (Caballero et al., 2020; Karaman and Turkay, 2021), food preservation (Fortunati et al., 2019; Izzo et al., 2020; Luz et al., 2020) and plant protection, as previously described (Cerkauskas and Ferguson, 2014; Drury et al., 2003; Marchand, 2016; Nunez-Palenius et al., 2012). Of course, if the plant protection interest was obvious, but no applicant would spend the usual large amount of money necessary for official toxicological test costs and fees in order to be granted as active substance with Market Authorisations at EU level. Indeed, as soon as these Market authorisations would have been obtained and the corresponding Review Report, with quantities, delays, BBCH (Biologische Bundesanstalt, Bundessortenamt und CHemische Industrie) stages and application rates published through the Review Report online on the pesticide database, that end users would contravene these Market authorisations by buying the material as a food product. However, since 2011 (Marchand, 2015; Orconneau, 2022; Romanazi, 2022) with the new EU PPP regulation, a new category of active substance is available, described in the whereas (18) and defined in the Article 23 of the EU PPP regulation; basic substances. The evaluation pathway of these basic substances arises with no fee and less toxicological requirements (especially for food products). It is all these characteristics (delays, absence of fees, waivers, no Market Authorisations) that motivate the applicants for these approval files, together with the fact that the third parties are possibly applicants (cooperatives, association of farmers, SME…). An additional point in the interest of these basic substances is the absence after approval (but this possibility is also the guarantee of approval in this category) of Maximum Residue Limits (MRL). Indeed, the MRLs of basic substances are all assigned in Annex IV of Regulation (EC) 396/2005 regarding Maximum Residue Limits assignation (Charon, 2019) which allows the security of applicators and consumers. Finally, with regard to the modes of action involved in the properties of crop protection, many directions are known or envisaged. The presence of specific molecules such as luciferin (Arzumanian, 2022), but also the vehicle of microorganisms, as well as the effects of pH are relatively described without one or the other of these tracks being preponderant or decisive or additive or even synergistic. Recently, these dairy products show renewed interest in plant protection, as co-formulant (Riseh 2023; Hussam, 2023) or directly as PPP (Wulf, 2023).

The objectives of this work were to show that dairy extracts could have plant protection properties in practice, not only within the framework of uses (WHO, 2023) already authorized in approved Good Agricultural Practices (GAP) Table, but also for potential extensions of uses. These tests are also carried out in gardens by and in the presence of gardeners. In addition, the approvals of these substances mainly consist of bibliographic references, it is now necessary to transmit this knowledge in a practical way and to be able to adjust the doses, the first product taken in consideration being whey/lactoserum. Ultimately, the aim was to show how this biotic protection with dairy products, light and basic, could be interesting in terms of costs, accessibility and gains for small producers, including gardeners.

2. MATERIALS AND METHODS

The study was conducted during spring and summer (May to August, 2022) at Mare Savin garden centre (Trappes, France); GPS position of Saint-Savin 46° 33' 55.148" N 0° 51' 54.702" E. Latitude: 46.565319 and Longitude: 0.865195.

2.1. Regulation analysis

The EU Pesticide database was used to assign the function (i.e., fungicide: FU, bactericide: BA) and the corresponding Implementing Regulations attached to the data for each active substance were found by the same method and cross verification with Implementing Regulation (EU) 540/2011 (Anonymous, 2011) and specifically Part C for basic substances. European Food Safety Authority (EFSA) website and EFSA Journal were used to determine important dates for each substance.

2.2. Basic substance applications

Basic substance applications were constituted using previous

EU templates rev. 9 published in 2014 (last update rev. 11 in 2023) since (Anonymous, 2023a) and all the information, updates, knowledge and skills accumulated by our institute since 2011 (Marchand, 2015; 2016; 2017a; b; c; d; e) for whey.

2.3. *Statement for organic production*

All the experiments were done by garden amateurs; those usages are considered as "Organic" since no chemical pesticides are allowed to use in garden since 2019 January 1st in France, but without label or certification. Accordingly, all trials were conducted in soils not in tray.

2.4. *Allowance of the substances in organic production*

Considering specific provisions in organic food production (Madge, 2010; Sivcev et al., 2010; Salihovic et al., 2022) since 2016, food products from animal and plant origin (Anonymous, 2016a) are directly allowed in organic production, therefore, there is no need to follow a specific pathway to enter part 1 of Annex I of Regulation (EU) 2021/1165 (Anonymous, 2021c) as both dairy products whey and cow milk are listed (10C and 22C, C for Part C of Impl. Reg. 540/2011) without any usage restriction and still present in the corresponding updated Regulation (EU) 2023/121 (Anonymous, 2023b).

2.5. *Field trials*

The test is carried out on 10 cucumber plants at the Mare Savin garden centre in *Trappes*, France (78), latitude and longitude coordinates: 48.777500, 2.002500 (May–August, 2022).

The plants are divided into 2 groups, i.e. 5 cucumber plants per group. The two groups are arranged side by side in a line. In the rest of this document, we will speak of group or plot to distinguish the two groups of plants. The first group of plants constitutes the control while the second is treated in the event of an attack of powdery mildew.

The plants were planted in mid-May 2022 (i.e. calendar week 22) in the ground and watered with manure with a mixture of nettle and horsetail diluted at 10% (5% nettle + 5% horsetail) with a watering can. Watering was carried out every 15 days for two months, three weeks after transplanting. Once a week, a visual inspection of the seedlings makes it possible to determine the presence of powdery mildew. In the case of the presence of powdery mildew, the "treated" group receives a foliar application of whole cow's milk diluted to 10%. The volume sprayed corresponds to 1 Litre for a surface of 10 m².

The cucumber harvests are weighed by group every week. The yield of the plants is then calculated, corresponding to the cumulative harvest per cucumber plant per group.

3. RESULTS AND DISCUSSION

3.1. *Food status*

Dairy products are mainly used as food; therefore, these substances are compliant with Article 2 of Regulation EC n°178/2002 (EC, 2002a) and, as "a foodstuff", according to Regulation EC n°1107/2009 (EC, 2009a) "an active substance which fulfils the criteria of a "foodstuff" shall be considered as a basic substance" (Marchand, 2016).

3.2. *Basic substance applications (BSA) of the dairy products as fungicides*

BSA for whey (Marchand, 2016) was deposited in April 2015, rapidly obtained admissibility by DGSanté in May and was then evaluated to conduct to EFSA outcome (EN-879) by the end of October 2015, then voted on in March 2016 by PAFF Committee and finally published as Implementing Regulation EU 2016/560 in April 2016 (EU 2016b). Similarly, basic substance application (BSA) for cow milk was deposited in September 2017, rapidly obtained admissibility by DGSanté in December and was then evaluated to conduct to EFSA outcome (EN-1482) in August 2018, then voted on in May 2020 by PAFF Committee and finally published as Implementing Regulation (EU) 2020/1004 at the end of June 2020 (EU 2020). Irregular delays from EFSA outcomes to voting above 6 month was already detailed in our previous publication (Orçonneau et al., 2022). Later, these two approved basic substances were respectively granted with no MLR (EU 2016c, EU 2021), as with all other previous basic substances.

3.3. *Extension of uses for the dairy products as fungicides*

Since the initial application, the GAP (Good Agricultural Practices) Table requested was not fully validated for whey, as some uses in vineyards were refused at first evaluation, an extension of use, to rehabilitate theses important missing usages, was submitted soon after the approval and implementation in the Pesticide database (Anonymous, 2023c). This request was later judged favourably after few years of exchanges with the Commission, with the positive vote in March 2021 and publication of a new Review Report (rev. 3) soon after.

3.4. *Regulatory pathway and timing*

The full approval for both BSAs and extensions are described in Table 1. Extension for Whey / lactoserum was deposited only few months after the corresponding basic substance approval, this is a necessary condition for extension deposit. Nevertheless, following whey first extension approval, it would be a worthy goal to consider new extensions of uses for these approved basic substances with no MRL, as the literature reports further successful trials and/or usages that

Table 1: Steps and timing for dairy products approvals

Basic Substance	BSA or extension	Deposit year	EFSA outcome	EU Impl. Reg.	Admissibility to approval (months)	EFSA outcome to Impl. Reg. (months)	Deposit to admissibility (months)
Whey / Lactoserum	BSA	2015	EN-879	2016/560	10	5	0.8
Whey / Lactoserum	extension	2016	EN-1868	2021/	40	30	36.9
Cow milk	BSA	2017	EN-1482	2020/1004	30	22	3.0
Average	-	-	-	-	18.7	11.3	6.3

Table 1: Continue...

Basic Substance	Admissibility to EFSA outcome (months)	Vote to Impl. Reg. (months)	Deposit to vote (months)	Deposit to approval (months|)	Approval year
Whey / Lactoserum	5.3	1.1	10.6	11.7	2016
Whey / Lactoserum	10.2	20.3	57.4	77.7	2021
Cow milk	8.1	1.7	32.0	33.6	2020
Average	8	3	23.4	25.3	-

Note: BSA, Basic Substance Application; extension, extension of use after Basic Substance approval.

were not considered during the initial approvals (Bugiani et al., 2022; Sharonova et al., 2022, Salkovska et al., 2022). Since March 2021 new applications and extension of uses should be requested and applied via IUCLID 6 software (Anonymous, 2023), increasing the time and workload for applicants, which has concretely reduced the number of files and extended the filing deadlines.

3.5. *Recipes*

While the recipe for whey was already described (Marchand, 2016) and unchanged from 6 to 30 l ha^{-1} in the extension of use published in 2021, cow milk is used with spray rate ranging from 10 to 270 l ha^{-1} diluted in water (Anonymous, 2020).

3.6. *Application in fields*

Dairy products, whey and cow milk are mainly used diluted at early stages (BBCH <51) of the crops (Anonymous, 2016b; Anonymous, 2020; Anonymous, 2023c). Later some other uses as tool disinfectant are independent from the crop situation. Some other uses, developed later may cover higher BBCH stages or function (Robin et al., 2018), thus a new evaluation will be needed for any further BSA extension submissions.

3.7. *Use in plant protection*

Numerous publications resulting from trials have since been published on these dairy products (Nunez et al., 2018), although major references on whey were already described in this journal (Marchand, 2016) and were used during first application and extension of use. Ultimately, dairy products exhibit also potential interest as adjuvant or co-formulant in plant protection (Jampílek and Králová, 2018; Kumar and Kudachikar, 2019).

3.7.1. *Whey*

Regarding whey, direct effects in crop protection have been demonstrated (Pscheidt and Kenyon, 2004; Al-Mughrabi, 2007; Bettiol et al., 2008; Abdelbacki et al., 2010; Savocchia et al., 2011, Al-Razaq, 2019; Ntalli et al., 2019; Garg and Kumhar, 2020; Kamel and Afifi, 2020; Muley and Singhal, 2020; Salih and Khrbeet, 2020; Illueca et al., 2021; Shachai and Khrbeet, 2021; Tripathi et al., 2021). Indirect effects are also described via the formation of biofilms (Dopazo et al., 2022; Lopusiewicz et al., 2020) or by maintaining healthier crops (Caballero et al., 2020). All these positive effects have less environmental impacts than chemicals (Gadino et al., 2010; Gadino et al., 2011). Some of these data were used for the initial approval and first extension of use, opening the Good Agricultural Practices (GAP) table of usages. Vegetable gardening crops like tomato and cucumber, along with vineyards are considered by the protection of whey and have been validated in the GAP table (Anonymous, 2023c). However, recent bibliography (2020–2022) published after the last extension of use triggered new possible requests for plant protection of sorghum (Salih et al., 2020; Shajai, 2021), soil treatment and disinfection (Ntalli et al., 2019) and crop protection for post-harvest treatment for fresh fruits and vegetables (Al-Razaq, 2019; Muley and Singhal, 2020) and cereals or rice (Vila-Donat, 2021; Jeyalakshmi et al., 2021) although the approval pathway for applications (including for extension of use) is now more complicated through IUCLID 6 software (Anonymous, 2023).

3.7.2. Cow milk

Regarding cow milk, it has been studied by many researchers (Bettiol, 1999; Chee et al., 2011; 2018, Choudhary et al., 2018; Crisp, 2006; DeBacco, 2011; Ferrandino and Smith, 2007; Guzmán-Plazola et al., 2011; Keinath and DuBose, 2012; McMillan and Vendrame, 2006; Nam et al., 2005; Shah, 2000). Most of the plant protection activity is due to its antifungal properties (Mudgil et al., 2022; Kumar and Kumar, 2021; Sudisha et al., 2011; Wurms and Chee, 2011). Some of these data were used for the initial approval considered by the protection of whey with a validated GAP table of usages (Anonymous, 2023c) for vegetable gardening crops such as pumpkin, Zucchini squash and cucumber, along with vineyards and arable crops (soybean). Furthermore, general disinfection purpose for gloves, fingertips and mechanical cutting tools is allowed for both whey and cow milk in order to protect crops from pathogen transmission via contact.

However, a recent bibliography (2020–2022) published after the last extension of use, triggered new possible requests for strawberries (Nam et al., 2005), ber (*Ziziphus mauritiana* Lamk.) (Choudhary et al., 2020) and apple (Cromwell, 2009) protection against cryptogamic diseases. Current results exhibited in Figure 1 confirm interesting activity and efficacy of cow milk of cucumber protection giving rise to yield increase.

3.7.3. GAP tables

Good Agricultural Practices (Anonymous, 2016) or GAP Table are constituted with all necessary information for the producers in order to use any active substances in field or greenhouses with maximum efficacy and minimum risk for operators and environment (Costantini and La Torre, 2022). This usage is already included in current approved GAP Table for the corresponding basic substance (Table 4). Indeed, the first regulatory applications of whey and cow milk within EU pesticide regulations attempted as basic substances were successful (Romanazzi et al., 2022).

3.8. Active components and mode of action (MOA) as fungicides

Although lactoferrin (Legrand et al., 2005) was described as the main active component in the whey BSA, lactoferrampin (van der Kraan et al., 2004) and lactoferricin (Gifford et al., 2004) also exhibit some antimicrobial properties (Tanhaeian et al., 2018). As do some other components such as β-lactoglobulin (β-Lg) and α-lactalbumin (α-La) (Papademas and Kotsaki, 2019), bovine lactoferrin, bovine lactoperoxidase and glycomacropeptide (Minj and Sanjeev, 2020) or protein hydrolysates (Mudgil et al., 2022). Individual components were also demonstrated to exhibit crop protection properties (Ketta, 2021; Duraisamy et al., 2022). Other effects are demonstrated for dairy products like disinfectant (Li et al., 2015) or pharmaceutical (Tsakali et al., 2010) activities.

Table 2: GAP table of whey usages

Crop / situation (a)	F G or I (b)	Pests or group of pests controlled (c)	Formulation	Application			
			Conc. of a.i. g hl^{-1} (i)	Method kind (f-h)	Growth stage & season (j)	No.of application min/max (k)	Interval between applications (min)
Cucumber, *Cucumis sativus*, Zucchini, squash, *Cucurbita pepo*	G	Powdery mildews: *Podosphaera fusca*, *Podosphaera xanthii*, *Golovinomyces/Erysiphe cichoracearum* and *orontii*, *Sphaerotheca fuliginea*, *Leveillula cucurbitacearum*	60 to 80 g l^{-1}	Foliar spray*	From three weeks after sowing (9th leaf unfolded on main stem) to 9 or more primary side shoots visible (BBCH 19–49)**	3–5	7 days
Grapevine *Vitis vinifera*	F	Powdery mildews: *Erysiphe necator*			From 1st shoots to cluster tightening Spring (BBCH 10–57)		7 to 10 days
Vegetable Gardening Tomato *Lycopersicum esculentum*	F/G	Tomato (Sinaloa) yellow leaf curl virus, *Begomovirus*			First inflorescence visible Summer (BBCH 10-51)		3 to 4 days

Table 2: Continue...

Crop / situation (a)	F G or I (b)	Application rate			PHI (days)	Remarks
		kg a.i. hl^{-1} l a.i. hl^{-1} min/max	Water l ha^{-1} min/max	Total rate each application kg a.i. ha^{-1} or l ha^{-1} min max (concentration recommended		
Cucumber, *Cucumis sativus*, Zucchini, squash, *Cucurbita pepo*	G	0.6 l to 3 l (0.036 to 0.24 kg a.i.)	1000 to 1500	6 to 30 l (0.36 to 2.4 kg a.i.)	Not applicable	Whey should be used rapidly after collection, not stored in metal vessel.
Grapevine, *Vitis vinifera*	F	6 L to 30 l (0.36 to 2.4 kg a.i.)	100 to 300$			
Vegetable, Gardening, Tomato, *Lycopersicum esculentum*	F/G	0.6 l to 3 l (0.036 to 0.24 kg a.i.)	1000 to 1500			

Notes: * spray when there is sun (preferably morning); ** do not apply when any plant in the greenhouse is at a later growth stage than BBCH 49; $ with a maximum of 10% concentration (30 l in 300 l)

Since the effect of pH on the stability of these proteins is known (Chen et al., 2019) and field usages were referring alternatively to acidic or sweet whey (Marchand, 2016). In fact, natural (+)-lactic acid was also described as potential effective substance in acidic whey (Bradshaw, 2015; Shah, 2000). Concretely, after the initial unique "Whey" BSA deposit, two separate BSAs were considered by the Commission for acidic and sweet whey, but in the final pathway after EFSA evaluation both Dossiers were merged before the vote at the PAFF Committee. However, end users are still mentioning and preferring acidic or sweet whey alternatively. Similarly, regarding the basic substance cow milk, raw cow milk is used either skimmed or not alternatively by producers.

3.9. Field trials

Evaluation of whole cow's milk treatment against powdery mildew on the "Vert Long Maraîcher" cucumber variety.

Many studies cited above have demonstrated the effectiveness of cow's milk treatment in the management of powdery mildew on cucumber. As part of the French national action plan ECOPHYTO II+, the Jardinot association tested in 2022 in one of the garden Centres, a milk-based treatment against powdery mildew on cucumber. The purpose of the trials was to evaluate the efficacy of treatment at a concentration of 10% whole cow's milk against cucumber powdery mildew on yield, by comparing with an untreated control.

Weekly monitoring was carried out to assess the intensity of the powdery mildew attack according to an attack severity index defined according to a semi-quantitative scale ranging from 0 to 3 (Table 4). This monitoring was carried out using the guide for amateur gardeners "Observation and monitoring of pests in the garden" produced by the Société Nationale d'Horticulture de France (SNHF) in collaboration with The French ministry of Agriculture and Food (MASA), INRAe and OPIE. In addition to this classification of the presence of powdery mildew, a qualification of the evolution of the attack was made according to whether the attack has increased, decreased or stabilized compared to the previous week.

3.10. Field results

The treatments were carried out as soon as symptoms of powdery mildew were observed on the plants and then every seven days. The treatments took place calendar week 27, 28, 29, 30 and 31.

The first treatments took place five weeks after transplanting, ie calendar week 27. A total of five treatments were carried out over a period of five weeks. The last treatment therefore took place in calendar week 31 (Table 5). A difference in the evolution of the powdery mildew attack was observed between the control group and the treated group. In the control group, the powdery mildew attack was constantly increasing to reach an attack severity index of 3, three weeks after the appearance of the first symptoms. Without treatment, 75% of the plants died after five weeks. For the treated group, the appearance of powdery mildew occurred the same week as the control group. Subsequently, although the first treatment did not limit the proliferation of powdery mildew, the maximum severity index reached was 2 the second week from the onset of the attack. From the third week, a decrease in the attack was observed for this treated group until the disappearance of powdery mildew from the fourth week and this until the end of the trial.

In addition to the protection afforded by the use of milk, the result is not only less damaged crop production, therefore better quality and greater sales possibilities, but also better yields and longer crop production.

The Figure 1 shows the evolution of the cumulative yield of the plants over time according to the plot considered. On the control group and therefore only watered with manure,

Table 3: GAP Table of cow milk usages

Crop/ situation (a)	F G or I (b)	Pests/group of pests (c)	Formulation	Application			
			Conc. a.i. g l^{-1} (i)	Method kind (f-h)	Growth stage / season (j)	No. of application min / max (k)	Interval between applications (min)
Grapevine, *Vitis vinifera*	F	Powdery mildews: *Erysiphe necator*	100%	Foliar application Spraying	From 1st shoots (BBCH 07) to inflorescences fully developed; flowers separating (BBCH 57)*	3 to 6	6 to 8 days
Vegetable Gardening Pumpkin *Cucurbita Pepo*	G	Pumpkins Powdery mildew *Podosphaera xanthii*	100%	Foliar application Spraying	From leaf development (BBCH01) until flowering (BBCH 06)**	3 to 4	7 to 12 days
Flower/ Gerbera *Gerbera jamesonii*	G	Powdery mildew *Erysiphe cichoracearum*	100%	Foliar application Spraying	Before and during flowering (BBCH 51-69)	3 to 4	7 days
Cucumber *Cucumis sativus* Zucchini; squash *Cucurbita pepo*	G	Powdery mildews *Sphaerotheca fuliginea*	100%	Foliar application Spraying	From 3 weeks after sowing (9th leaf unfolded on main stem) to 9 or more primary side shoots visible (BBCH 19- 49)***	3 to 4	7 days
Soybean *Glycine max* (L.) Merr	F	Soybean powdery mildew *Erysiphe diffusa*	100%	Foliar application Spraying	On leaves (BBCH 19 to 49)	3 to 4	7 days
Glove fingertips and mechanical cutting tools. All crops	G, I	Viruses (mechanically transferable) e.g. Tobacco mosaic virus (TMV), Tomato mosaic virus (ToMV) Pepper mild mottle virus (PMMV), Cucumber green mottle mosaic virus (CGMMV)	100%	Dipping	On tools	Before / after every plant contact	Before / after every plant contact

Table 3: Continue...

Crop/ situation (a)	F G or I (b)	Application rate			PHI (days)	Remarks
		l a.i. hl^{-1} min/max	Water l ha^{-1} min\max	Total rate each application l a.i. ha^{-1} min/max (concentration recommended		
Grapevine, *Vitis vinifera*	F	10 to 40	100 to 300	10 to 120	n.a.	
Vegetable, Gardening, Pumpkin, *Cucurbita Pepo*	G	50	400	200	n.a.	No application in presence of fruits
Flower/Gerbera, *Gerbera jamesonii*	G	16	500 to 1000	80 to 160	8	
Cucumber, *Cucumis sativus* Zucchini; squash, *Cucurbita pepo*	G	5 to 10	1000 to 1500	50 to 150	n.a.	
Soybean, *Glycine max* (L.) Merr	F	18	1000 to 1500	180 to 270	n.a.	
Glove fingertips and mechanical cutting tools. All crops	G, I	n.a.	n.a.	n.a.	n.a	Dipping for 2 seconds. For reasons of efficacy use milk with at least 3,5% protein content. Replace the milk regularly (e.g. after each crop row) to prevent cross-contamination of the plants

*: do not apply when any plant is at a later growth stage than BBCH 57; **: do not apply when any plant in the greenhouse is at a later growth stage than BBCH 06 and in presence of fruits; ***: do not apply when any plant in the greenhouse is at a later growth stage than BBCH 49

Table 4: Powdery Mildew Attack Severity Index

Value	Average attack severity index in the garden
0	Absent
1:	Incipient symptoms on at least one plant
2	Symptoms distributed over the lower leaf levels many plants in the garden
3	All plants attacked

the weights of the first harvests were recorded nine weeks after transplanting the plants, i.e. five weeks after attack of powdery mildew. The harvest extended over four weeks in total; the last harvest takes place in the twelfth week after transplanting. For the plot benefiting from curative treatments, the weights of the first harvests were recorded seven weeks after transplanting, i.e. two weeks after the first treatments. A three-week earlier harvest lag was observed for treated plants compared to untreated plants. The harvest

Table 5: Attack index of powdery mildew on cucumber according to the plots at Mare Savin

Date week	Group	Index of gravity attack 0/1/2/3	Trend vs. the previous week	Number of treatments	Week after transplanting
W27	Untreated control	1	Increase	0	Week 5
W28	Untreated control	2	Increase	0	Week 6
W29	Untreated control	3	Increase	0	Week 7
W30	Untreated control	3	Increase	0	Week 8
W31	Untreated control	Death (75%)	Increase	0	Week 9
W27	Treated	1	Increase	1	Week 5
W28	Treated	2	Increase	1	Week 6
W29	Treated	1	Decrease	1	Week 7
W30	Treated	0	Decrease	1	Week 8
W31	Treated	0	Stabilization	1	Week 9

In addition to the protection afforded by the use of milk, the result is not only less damaged crop production, therefore better quality and greater sales possibilities, but also better yields and longer crop production

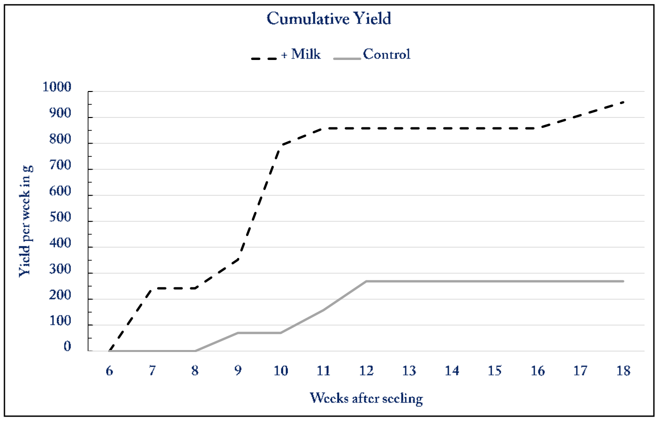

Figure 1: Cumulative yield in kilogram per plant of cucumber according to the number of weeks after transplantation

extends over twelve weeks in total, the last took place eighteen weeks after transplanting. Thus, the harvesting time for the treated plot was almost 4 times longer than for the untreated plot. The cumulative harvests per cucumber healthy plants for the group treated with cow's milk were 3.5 times higher than those of the control plants.

4. CONCLUSION

Dairy products whey and cow milk are approved for plant protection in EU as basic substances. They are efficient on restricted crop and usages against fungal diseases. This work exhibited practical interest for producers of whey treatments as crop protection and yield increase. Indeed, these results supported by bibliography showed potential new applications of whey in plant protection. These results may motivate to test the effectiveness on other fungal bioagressors, opening possible request for extension of use and emergency authorisations at EU PPP regulation.

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