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Herbicides and family farming, a marriage of convenience? Cotton growing in Cameroon and sugarcane in Réunion illustrate how herbicides have been closely integrated into farming practices

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Résumé :

Dans des situations et des filières aussi différentes que la canne à sucre réunionnaise en quasi monoculture et le coton camerounais assolé avec des cultures alimentaires, les harassantes opérations de désherbage manuel à la houe (daba africaine, pioche réunionnaise), traditionnellement inhérentes à l'agriculture familiale, se sont vues considérablement soulagées par l'avènement progressif puis la généralisation du désherbage chimique, manuel au Cameroun ou partiellement motorisé à La Réunion. A partir de ces deux exemples empruntés à son vécu d'agronome tropicaliste au Nord-Cameroun et à La Réunion, l'auteur dresse le constat qu'agriculture familiale et désherbage chimique ont noué en quelques décennies des liens fort solides, désormais difficiles à détendre.

Mots-clés : agriculture familiale, coton, cultures vivrières, Cameroun, canne à sucre, île de La Réunion, herbicides, innovations paysannes, glyphosate, 2, 4-D, parcellaire morcelé

Abstract :

For situations and crops as diverse as sugarcane in Réunion (a French overseas department), grown in systems close to monoculture, and cotton in Cameroon, grown in rotation with food crops, the gruelling manual weed control operations using hoes (the *daba* in Cameroon and the mattock in Réunion), traditionally inherent to family farming, have been considerably alleviated by the emergence then widespread implementation of chemical weed control, manual in Cameroon and partially motorised in Réunion.

Based on these two examples taken from his experience as a tropical agronomist in Northern Cameroon and in Réunion, the author concludes that in just a few decades, family farming and chemical weed control have forged very strong links, which are now difficult to undo.

Keywords : Family farming, cotton, food crops, Cameroon, sugarcane, Réunion, herbicides, farmers' innovations, glyphosate, 2, 4-D, fragmented landscape

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Family farmers share similar constraints in different contexts

Two industrial crops in the hands of family farming systems shape the landscapes in Northern Cameroon and in Réunion: cotton, a perennial plant that is grown as an annual crop, and sugarcane, a perennial crop that regrows annually after cutting (harvesting). In Cameroon, cotton is grown in rotation with cereals (sorghum and maize) and legumes (mainly groundnuts and cowpeas); in Réunion, sugarcane is often maintained for 10 years or more before being removed and replanted, sometimes in rotation with pineapples or vegetables. These two situations have one thing in common: these crops are far from being immediately ground-covering, and weed control operations are therefore required, with herbicides now playing a key role in this process.

The inexorable rise of herbicides in Northern Cameroon for cotton and food crops

The introduction of cotton in rotation with food crops in the 1950s

Intensive cotton growing in Cameroon dates back to the 1950s, at the time of the French protectorate (Seignobos, 2020). Traditional sorghum crops were grown in association with other food crops (groundnuts and cowpeas, squash and calabashes, okra and guinea sorrel, etc.) in home fields (close to dwellings) enriched with organic matter, as well as in outfields that were periodically allowed to revert back to bush fallow. Cotton was introduced in biennial rotation with food crops in the form of checkerboard “crop blocks” made up of several dozen “quarters”, i.e. square quarter-hectare plots, delineated with a 50 m long “rope”; cotton had to be grown in pure stands, sown by hand but in perfect lines, to enable ridging with animal traction, an innovation jointly introduced with cotton. Ploughing was also encouraged, followed progressively by NPS mineral fertiliser (ammonium phosphate + ammonium sulphate), then NPKSB (NPK compound fertiliser including sulphate and borate) and synthetic insecticides (Martin & Boubakary, 2019).

The following technical package was adopted: food crops, which were sown and weeded by hand as of the first rains, remained the priority, followed by cotton, with shallow tillage used as pre-sowing weed control in order to sow cotton in weed-free soil; fertilisers were also appreciated for their positive carryover effect on the cereal crops grown after cotton. Since the purchase price of cottonseed was guaranteed and known in advance, cotton became established as the main cash crop, while surplus food crops were sold at highly unstable prices subject to the huge fluctuations on local markets. Every farmer grew first one, then two or three quarters of cotton depending on his workforce (family size).

Intensification and the first herbicides

After the country’s independence (1960) and the partial nationalisation of the cotton development corporation, which became Sodécoton (1974), cotton moved southward with the migratory movement from the overpopulated and drier regions in the north of the cotton-growing area (severe drought in the 1970s). Integrated development projects (including schools, dispensaries and wells or boreholes) were launched, with the creation of cotton tracks (unpaved laterite roads) and cotton ginning plants, and the launch of new agro-technical innovations, including intensive maize cultivation in pure stands with fertiliser and herbicide treatments (Bayero, 2020; Guibert et al., 2015; Martin & Boubakary, 2019).

1976, agricultural frontier in south-eastern Bénoué: in the context of an intensification operation with light motorisation for soil preparation (tillage and harrowing) and crop maintenance (ridging), Sodécoton introduced pre-emergence herbicides applied post-sowing to cotton and maize, and thereby set a precedent in French-speaking Africa (Martin & Gaudard, 1996). These were binary specialities proposed by one, then two agrochemical companies, applied using a portable Handy sprayer (20 l flow, spinning disc powered by large round batteries)[1]. These specialities are no longer in use, but this sprayer has been widely rolled out over time: it is still the most popular to date, although several other disc or pressure sprayers have been tested or used, especially for post-emergence directed spray applications. Motorisation, managed with the strong involvement of Sodécoton, lasted only around 15 years (with, ultimately, the complete failure of Bouyer tractors, according to Lucien Gaudard, pers. comm.), but it led in 1987 to the introduction of paraquat, a non-selective herbicide whose use quickly spread throughout the whole cotton growing area, until it was withdrawn in 2009 (Martin & Boubakary, 2019).

Adverse impacts on soils were corrected by direct seeding with paraquat

The introduction of pre-emergence herbicides in the wake of light motorisation had harmful effects on soils. Indeed, harrowing was required to ensure fine soil surfaces in order to maximise the effectiveness of herbicides, but also to “rake” any large weeds not buried by late tillage. However, with the conjunction of very sandy soils, hilly landscapes and intense rainfall, the destruction of surface roughness by harrowing considerably accelerated surface runoff and soil erosion. With the introduction of paraquat in 1987 to kill the weeds not buried by tillage, harrowing was rapidly abandoned without any noticeable loss of effectiveness for pre-emergence herbicides, provided the soil was moist enough, which is generally the case after sowing (Martin & Gaudard, 1996 ; Martin & Gaudard, 2001).

Paraquat, which was first introduced as an extemporaneous mixture with pre-emergence herbicides, subsequently enabled the emergence of another major innovation: direct seeding on weeds killed (sometimes forming a mulch). This technique then took off, spreading through all parts of the cotton growing area in response to a range of different constraints (difficulties experienced by motorisation groups, health problems or taxation of oxen by some traditional chiefs engaged in political-driven racketeering, different pressures surrounding the cropping calendar) and providing wider scope for sowing opportunities after suitable rains (Martin & Gaudard, 2001 ; Martin & Boubakary, 2019).

In these ways, runoff and soil erosion problems were subsequently mitigated by paraquat.

In Cameroon. Herbicide applications by Handy (1 and 2). 1. Post-sowing on maize after animal-drawn, rough ploughing. 2. Post-emergence graminicide on groundnuts. 3 . Cotton ridging

Photo credits: P. Dugué, Cirad, France (1), Y. Boubakary, Sodécoton, Cameroon (2, 3)

Generic herbicides and cost reduction

Since 1992, the pre-emergence herbicides popularised by Sodécoton are generic products based on active substances such as diuron for cotton and legumes (mainly groundnuts) and atrazine for maize and sorghum (Martin & Gaudard, 1996). These two molecules are available in concentrated formulations and used in lower doses than the first binary herbicides rolled out (i.e. diuron 720 to 544 g/ha, as risk of phytotoxicity, atrazine 800 g/ha, *versus* 1 200 to 1 500 g/ha previously on cotton and 2 000 g/ha on maize). They are still supplemented by manual and/or animal traction maintenance (weeding-ridging in order to bury the two side-dressing applications of fertilisers, first NPK, then urea). Thus, these generic products have reduced costs in relation to the specialities previously marketed, resulting in a spectacular increase in areas treated, of up to several tens of thousands of hectares at the beginning of the 21st century (Martin & Gaudard, 2001).

Farmers rapidly detected synergies between paraquat and diuron or atrazine (respectively inhibitors of photosystems I and II) (Martin & Gaudard, 1996), as well as their complementarity in the context of the biennial cotton-food crop rotation (Olina et al., 2015). Thus, maize treated with atrazine is an excellent precedent to reduce pressure on cotton from *Commelina benghalensis*, a formidable fleshy nitrophilous weed with aerial and underground flowering, which emerges massively after tillage and grows back very easily after weeding from its residues left on the ground[2].

Glyphosate and product range expansion

In 1996, glyphosate became the fourth pillar of chemical weed control in Northern Cameroon (Martin & Gaudard, 2001). It progressively replaced paraquat, since its effect is more lasting, especially on perennials such as *Cyperus rotundus* and *Imperata cylindrica* in cotton rotations, but also against *Oryza longistaminata* in vertisols (black clay soils) used for transplanted, dry season sorghum crops (Mathieu & Marnotte, 2001 ; Saïdou et al., 2014).

Subsequently, and to prepare for any future restrictions on diuron or atrazine, in recent years Sodécoton has diversified its range of selective herbicides by opening up to new binary, pre-emergence products, but also and above all, to post-emergence herbicides: nicosulfuron for maize, pyrithiobac-sodium for cotton against broadleaf weeds, as well as haloxyfop-R-methyl ester and propaquizafop, two graminicides for cotton and groundnuts (Martin & Boubakary, 2019).

Herbicide use on cotton and food crops has thus entered the mainstream: by 2012, almost all areas under cotton were treated with herbicides; the total area under cotton and food crops with chemical weed control stands at around half a million hectares for more than 200 000 smallholder farmers. Sodécoton, which previously imported herbicides, now just provides technical assistance to the CNPCC (Confederation of Cameroon Cotton Producers), which orders them from import-export companies (Martin & Boubakary, 2019).

Northern Cameroon: innovations in line with changes in society

Herbicides play a key role in Northern Cameroon, so much so that they have altered the range of landscapes. This discreet change was noticed by the geographer Christian Seignobos (https://comediedulivre.fr/christian-seignobos), who cites three innovations massively adopted at the start of the 21st century by farming societies in Northern Cameroon (Seignobos, 2017, page 294): Asian motorcycles (including in recent years multipurpose cargo motor tricycles (Boubakary, R&D manager Sodécoton, pers. comm.)), mobile phones and some herbicides. Mobiles and motorcycles increase social links, while herbicides and tricycles reduce the workload. According to this author, along with progress in school enrolment, these choices reflect the maturity and the self-paced evolution of farming societies (Pélissier, 1995).

A labour shortfall alleviated by complementary chemical and mechanical techniques

The CNPCC and Sodécoton jointly manage orders of inputs and agricultural material, as well as seasonal credit and equipment loans. Although the area under cotton per producer has doubled and now stands at an average of five quarters (1.25 ha), the available workforce is dwindling (progress in school enrolment, including for girls, and a decline in the attractiveness of farming for young people). From a marginal input, herbicides have become a major priority input, since they secure crop establishment and guarantee the effectiveness of the fertilisers applied sparingly on cotton and intensive maize (Fok, 2002 ; Olina et al., 2015; Guibert et al., 2016).

In line with this approach to securing crop growth, sales of animal traction machinery for weeding and ridging have long since supplanted those of ploughs (direct seeding with “herbiciding” typically being preferred to post-ploughing seeding) (Vall et al., 2003). Indeed, chemical weed control and crop maintenance with animal traction, which are partly substitutable, are in fact quite complementary to ensure the efficiency of fertilisers efficiency; moreover, chemical weed control is rarely fully effective and mechanical and manual finishing are often necessary. Thus, extreme situations with only mechanical-manual weed control or only chemical weed control are very rare. Complementarity is the rule, despite the introduction of post-emergence treatments, which, in some situations, replace the first mechanical-manual weeding for cotton or ridging for maize (Martin & Boubalary, 2019).

Studying the environmental impacts

Cover crops were successfully tested in the context of participatory research projects in the 2000s. They reduce weed pressure, some of them even fix atmospheric nitrogen (legumes) or can withstand to some extent the dry season. However, their adoption faces problems of cohabitation with transhumant pastoralists and common grazing of crop residues, a holdover from times when human and cattle densities were far lower, and which will undoubtedly evolve over time (Naudin, 2012).

With regard to testing for herbicide residues in water, the first samples should be taken in late 2021 (postponed by one year because of a number of constraints, including a break in flight connections with Garoua, Northern Cameroon), potentially in collaboration with the Pasteur Centre in Cameroon. Any pollution found will need to be examined and compared with rainfall events and their consequences on water runoff and soil erosion for surface water, and with infiltration for groundwater, in connection with farming practices and soil organic status (acceptable or degraded).

The firm grip of herbicides on sugarcane in Réunion

Agricultural hardship, mechanisation and herbicides

In Réunion, more than elsewhere in France, there is an ever-widening gap between the growing total population and the declining agricultural population. However, agricultural production per worker has continued to increase, despite an unfavourable agricultural landscape, which is mostly mountainous, highly fragmented and very rocky. Thus in 2018, sugarcane, the island’s main cash crop, employed fewer than 3 000 planters for around 23 000 ha, or an average of almost 8 ha of sugarcane per planter (compared to 5 ha in the 1970s[3]). Most of these planters are involved to varying degrees in farm diversification systems, with other high value-added products (fruit and vegetables, grasslands and ruminants, landless livestock systems) (AGRESTE La Réunion, 2019).

The mountainous topography of Réunion makes mechanisation problematic, and two thirds of all sugarcane is still harvested by cane knife, with growing difficulty in recruiting cutters. Sugarcane harvesting takes place over five months. The loading of cane into trailers and its transportation to delivery platforms have been fully mechanised since the 1970s; over the same period, the use of selective pre- and post-emergence herbicides became mainstream, after beginning in the 1950s. These two major changes addressed both the growing shortage of farm workers, whether from within or outside the family, and the hardship of farm work throughout the year: full manual weeding using a mattock against *Sporobolus africanus*, for instance, a plant known as “*maries reintées*, *maris durs*”[4], and manual loading of tons of cane using only arms and shoulders as tools became increasingly restrictive and ultimately rejected tasks (Martin et al., 2019).

Towards a reduction in herbicide use

At the start of the 21st century, while generic herbicides were becoming so popular among family farmers in Northern Cameroon, they were subjected in Réunion to restrictions or withdrawals, which were ramped up from 2007 with the Grenelle Environment Forum and the Ecophyto plans (https://agriculture.gouv.fr/ecophyto/). Thus, 2010 saw the launch in Réunion of R&D projects aimed at halving the use of herbicides on sugarcane, with a deadline of 2018, subsequently extended to 2025.

Almost 10 years on, sugarcane research has potentially met the objective at the experimental level thanks to a range of alternative methods (Mansuy et al., 2019). However, there is a *status quo* for herbicide use at the level of Réunion as a whole, undoubtedly because planters are unable to mobilise extra workers in the fields or to invest in alternative equipment while the future of the sugarcane industry is becoming increasingly uncertain (Martin et al, 2019). As for the emblematic glyphosate, its withdrawal as of 2022 could prove disastrous in the short or medium term for the sugarcane industry, which is under threat from short Bermuda grass (*Cynodon dactylon*) (Martin et al., 2010 a) and tall perennial grasses (mainly *Panicum maximum)* (Martin et al., 2010 b).

Glyphosate, around and inside sugarcane fields

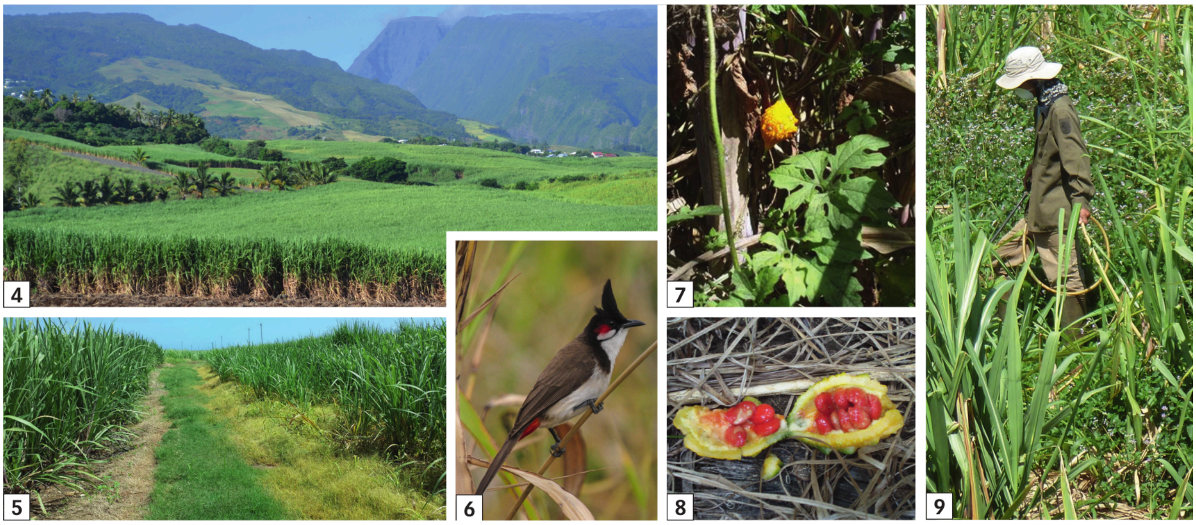
Ending glyphosate use – by 2020 for the main uses and by 2022 at the latest for all uses: this specific complementary objective of the Ecophyto II+ Plan is set out in its first page (Ecophyto, 2019). The INRA (now INRAE) report on uses of and alternatives to glyphosate in French agriculture (INRA, 2017), explicitly states in its executive summary that the phase-out of glyphosate will leave “deadlocks”, or uses without any viable alternative solution, among which those listed in the paragraph on Réunion, p. 46 (Martin, 2019). Contrary to other herbicides, used exclusively or predominantly on sugarcane in Réunion, glyphosate use there, as elsewhere, was multipurpose (Martin, 2019; Caro canne, 2020). The share of non-agricultural uses is now decreasing significantly: for example, foresters no longer use it in natural areas to control invasive plants. However, the share of agricultural uses of glyphosate seems to have risen sharply within the annual volume of 50 tonnes sold between 2009 and 2017 for a total UAA (utilised agricultural area) now standing at less than 50 000 ha (Martin et al., 2019). This increase in agricultural uses has undoubtedly been indirectly supported by certain withdrawals, especially that of glufosinate recently, the consumption of which was increasing (as indicated by its treatment frequency index: TFI = 0.2, equal to a full dose on 1/5 of the area under sugarcane) (Martin et al., 2019).

The AGRESTE-CIRAD joint exploitation of data from the 2014 official survey on plant protection practices produced an estimate of 29 to 30 % for the share of glyphosate used in sugarcane fields in 2014 (Martin et al., 2016). The results of the AGRESTE 2017 survey just published (late August 2020) note a reduction in total herbicide use in sugarcane fields (AGRESTE La Réunion, 2020); however, these surveys, conducted at a single field level rather than the full farm level, do not take account of uses that could be qualified as para-UAA agricultural uses: maintenance of farm tracks and management of field margins (Antoir et al., 2016; Martin, 2019). Here, a parallel can be drawn between Réunion sugarcane plantations and Champagne vineyards: “*In a vineyard such as those in the Champagne region, all the labeled slopes are planted. Plots are often small in size, and* *the resulting narrow grid pattern of weedy banks constitutes an incredible infestation pressure, which is systematically overlooked; indeed, it is generally the weed flora that stabilises the banks*" (Jacques Montégut, 1983).

Controlling Bermuda grass around sugarcane fields

Bermuda grass, *Cynodon dactylon*, known as "*chiendent pied-de-poule*" (hen's foot dog's tooth grass) or "chiendent fil de fer" (wire dog's tooth grass *i.e.* wiregrass) in Réunion, grows at the interface between tracks and field margins, among other places (Martin et al., 2010, Antoir et al., 2016). Wiregrass has the considerable advantage of securing farm tracks by protecting them from aggressive cyclonic rains, but the equally considerable disadvantage of spreading into sugarcane fields, discreetly at first in the shade of tall canes, then in the open after harvesting, rapidly increasing its advantage from harvest to harvest over diminished, dwarfed and depleted canes. This is why planters try to limit it to tracks and to prevent it from penetrating into sugarcane fields that it would be capable of destroying in just a few seasons, turning them into wastelands of grasses, vines (lianas) and bushes (Martin, 2019).

So how do planters control the vigorous advance of wiregrass from tracks into sugarcane fields, knowing that they must reach its perennial root system to neutralise it? This is where the systemic action of glyphosate comes in, by means of one or two spatially bounded annual treatments, applied manually along field margins, treating both tracks and canes at the field-track interface; if necessary, a foray into the field can reduce any invasive pockets (Antoir et al., 2016). When appropriate, glufosinate (now banned) was used on small canes, and subsequently replaced by glyphosate for taller canes. This practice is preferred to manual or mechanical elimination, which becomes extremely laborious (when done manually) or scarcely effective (when done mechanically), and in any case is always problematic after the first regrowth due to soil compaction caused by tractors, trailers and loaders, during harvesting (Martin, 2019).



In Réunion, where the landscapes form a mosaic (4), wiregrass (*Cynodon dactylon*) protects paths but is a threat to sugarcane (5): glyphosate keeps things under control at the interfaces, without being included in the HTFI of sugarcane. The invasive red-whiskered bulbul (6) disperses fleshy-fruited plants, including several vines that are very aggressive for sugarcane, such as bitter melon (*Momordica charantia*) (7 and 8). A planter in his sugarcane field (9) applying a late post-emergence treatment (very probably based on 2,4-D) by spray lance, with a flexible hose connected to his tractor.

Photo credits: J-Y Hoarau, Cirad (4); Yabalex, SEOR, Réunion (6); C. Gossard, Coroi, Réunion (9); J. Martin, Cirad (5, 7, 8)

Eliminating tall perennial grasses in sugarcane fields

A late season, curative, rescue practice targets tall perennial grasses (such as *Panicum maximum*) that have escaped previous control measures, as an alternative to removing their tufts by mattock to eliminate them. Being more resistant to crushing and more rapid in terms of tillering and elongation, these frenemies, close relatives of sugarcane would become extremely competitive in the next regrowth if they were allowed to slip through cane cutting (Martin et al., 2010 b; Antoir et al., 2016). Treatments, taking place among tall canes, are accurately directed: tufts of these tall grasses are trampled underfoot and pressed to the ground, then treated with glyphosate, generally dosed at 2 % of standard formulation at 360 g/l. This practice is certainly gaining ground[5], concomitantly with the withdrawal of asulam, the only selective post-emergence graminicide for sugarcane (Martin, 2019).

These two methods for the targeted, moderate application of glyphosate, one preventive, linear along field margins, and the other curative, directed against big tufts within fields, appear to be on-farm innovations born from necessity. They clearly illustrate the extent to which sugarcane planters in Réunion have adopted and adapted this mainstream agrochemical resource as one of their own tools (Martin et al., 2019).

The treatment frequency index of herbicides did not decrease between 2009 and 2017

A dozen (relatively) selective products used pre- and/or post-emergence make up the range of herbicides currently labeled for sugarcane. The early generation herbicides have disappeared, with the exception of 2,4-D, the oldest of the synthetic chemical herbicides, and metribuzin which, before being approved for use on sugarcane, had widely infiltrated Réunion sugarcane plantations through tomatoes that were once commonly intercropped with sugarcane during the planting year (Martin et al., 2013 a).

Regarding the quantities of active substances, sugarcane herbicides represent around 100 tonnes/year, with 2,4-D accounting for almost half of that amount. Adding the 50 tonnes of glyphosate and another 50 tonnes of non-sugarcane insecticides and fungicides produces the figure of 200 tonnes of pesticides imported and sold annually in Réunion. A specific characteristic of Réunion is that its herbicide treatment frequency index (HTFI) for sugarcane can be estimated at the level of the “Réunion territory”, based on sales statistics for herbicides and areas under sugarcane, which are also monitored. This amounts to smoothing stock carry-overs from one season to the next, an approximation that is well suited to the assessment based on three-year averages advocated by the Ecophyto plan (Martin et al., 2013 b). Thus, for the period 2015-2017, the HTFI for sugarcane – excluding glyphosate – was 3.48, compared to an initial 3.19 for the 2009-2011 average, and a maximum of 3.63 for the 2011-2013 average (Martin et al., 2019). The AGRESTE 2017 survey reports for 2017 an HTFI – glyphosate included – of 3.10, which is very probably underestimated (declarative basis x farmers’ traditional mistrust of the administrative authorities, including in Réunion) (AGRESTE La Reunion, 2020).

These upward then slightly downward variations in the HFTI are essentially due to 2,4-D, whose particular TFI for the last period (2015-2017) was still at 1.55, which exceeds the maximum approved dose (capped at a TFI of 1) (Martin et al., 2016 ; Martin et al., 2019). This specific situation calls for a brief reminder, as even the oldest sugarcane planters in Réunion once used 2,4-D, that was for a long time authorised at higher doses. Nevertheless, 2,4-D is rarely detected in groundwater or surface water (contrary to atrazine, introduced in the 1970s and withdrawn in 2003) (Martin et al., 2013 c).

The auxin herbicide 2,4-D was introduced in the 1950s with two companion products, sodium chlorate and TCA (trichloroacetic acid), and together formed a very popular trio in the Indian Ocean, known as the “Mauritian cocktail” by planters in Réunion and as the “Réunion mixture” by planters in Mauritius (Martin & Esther, 2013). This mixture had to be well diluted: it was therefore prescribed in high spray volumes, or one 200 litre barrel for 100 “*gaulettes*” (2 500 m²). The barrel represented the daily work for one planter equipped with a backpack pressure sprayer, or the work assigned to farm workers (who tried to get it done as quickly as possible by widening the nozzles). This flow – two litres per *gaulette* – is the cause of a persistent practice still being opposed today, consisting in thoroughly “wetting” weeds by treating them with excessive volumes, 600 to 800 litres of spray solution per hectare, including for pre-emergence treatments, even with tractor-mounted boom sprayers (Martin & Esther, 2013).

A high 2,4-D treatment frequency index sustained by fear, tradition and vines

Throughout its long history in Réunion, 2,4-D has had many different episodes. The volatile esters of the first formulations, which were harmful to nearby plants, were replaced in the 1970s and 1980s by the current salt formulations. A national restriction was imposed in 2008, under which 2,4-D could only be used in a given plot every other year. A request for reclassification was approved in 2011, with the concession that the annual maximum approved dose was reduced to 2 l/

ha, compared to 2,4 l/ha until 2002 et 3 l/ha before that (Martin et al., 2013 a).

The particular TFI of 2,4-D increased to almost 2 at the beginning of the 2010s. Several factors can explain this “fever” (Martin et al. 2019). First, the 2008 restriction on 2,4-D, added to the wave of withdrawals in the previous years, caused concern among planters: for fear of running out, they undoubtedly tended to stockpile this low-cost product that can be easily stored from one season to another, until the reclassification of 2,4-D was firmly established (Martin et al., 2013 b). Second, persistent practices surround this old, low-cost, traditional herbicide, which lead to overdoses caused by measuring it as in the past, with the same number of yoghurt pots per backpack sprayer, or cups per barrel (Martin & Esther, 2013). Third, but not least, the increasingly urgent issue of “vines”: these climbing weeds, some of which are voluble, have become a major problem in the last few decades (Martin et al., 2012). Moreover, this high consumption of 2,4-D, seen as a fever by the agriculture administration, undoubtedly led planters interviewed in the 2014 and 2017 surveys to under-report their use of 2,4-D (a 0.4 to 0.5 TFI gap between AGRESTE surveys and macro-monitoring based on figures for sales and areas under sugarcane) (Martin et al., 2016; Martin et al. 2019; AGRESTE La Réunion, 2020).

The invasion of vines since the 1980s

Why are there ever more vines since the 1980s? More than one factor is involved, and as with wiregrass, the fragmented topography of the landscape delineated by banks with rich plant diversity undoubtedly plays a major role (Caro canne, 2004 ; Caro canne, 2007 ; Martin, et al., 2010c ; Martin et al., 2012). The seeds of bindweeds (a whole range of *Ipomoea*) are projected when their capsules burst open (ballochory). The seeds of fleshy-fruited vines (the bitter melon *Momordica charantia,* passionflowers and others) are effectively dispersed by frugivorous birds (ornithochory) across fields, especially by the red-whiskered bulbul (*Pycnonotus jocosus*), which has become invasive throughout the island since its accidental introduction in 1972 (Martin et al., 2012). Planters are powerless to control the “*incredible infestation pressure, which is systematically overlooked*” (Montégut, 1983) specific to this mosaic landscape, especially when it is reinforced by birds, supported by the network of resting places provided by irrigation sprinklers: they can only control it in a curative manner.

The large seeds of vines have the ability to stagger their emergence. Even late emergence can be dangerous. Capable of emerging through a thick mulch, growing discretely in the shade of canes, or more vigorously in light shafts when there are gaps in the sugarcane, they gradually overtop the cane and cause serious damage: canes become entwined and may be broken or smothered within expansive infestations (Caro canne, 2004 ; Caro canne, 2007 ; Martin, et al., 2010c). This partly explains the lateness of some post-emergence treatments, which can be applied if the terrain permits by high-clearance tractors and sprayers, or sprayers mounted on maize trimmers (only four examples, another farmer innovation) only a few of which are in use there. This also explains late, rescue post-emergence treatments on sugarcane pockets threatened with vine overtopping: these are manual interventions, with operators spraying both vertically and horizontally using a backpack sprayer or a hosepipe fitted with a lance spray nozzle connected to a tractor-mounted sprayer parked at the field margin and working in a fixed position. The majority of post-emergence treatments are applied in these ways (Martin & Esther, 2013 ; Martin & al, 2019).

In this fight against vines, 2,4-D is not the only herbicide in use, but it is the main one, alongside companion products such as metribuzin and mesotrione, especially in early post-emergence treatments (when it can be used at lower doses), and two other auxin herbicides, dicamba and fluroxypyr. Dicamba is particularly effective against perennials. Fluroxypyr, close to brush weedkillers, broadens the spectrum of the two other auxin herbicides, especially for “tougher” weeds including woody regrowth; the TFI of 2,4-D, which is currently declining, is more than offset by the increase in the TFI for its companion or complementary products (Martin et al., 2019).

Family farming and herbicides

Peasant farming, as it used to be called, has continued to evolve, like the rest of society, and farming families are no longer sent to work in the fields as they used to be, tethered to hoes or to the handles of ploughs. Animal-traction and motorised crop maintenance have certainly progressed, but are far from being as effective as chemical weed control, especially in rugged terrain, on top of other considerations concerning soil conservation or the propagation of perennials. The notions of the profitability of work and site output are undoubtedly central to the inexorable rise in the use of herbicides in Cameroon and to their firm grip on Réunion: "*In the past, farmers did not leave things to chance, any more than they do today*" (François Sigaut, 1997). As for the alternative methods and innovative systems tested with some success by researchers in both contexts, these have not yet caught on.

Herbicides, which have been massively adopted and widely accepted, like tractors in Réunion or motorbikes in Cameroon, have become a “common good” to be used with discernment and as sparingly as possible, similar to the WHO (World Health Organization) essential medicines, which are expected to be effective and safe, available and affordable (Martin et al., 2019).

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Notes

1 https://www.microngroup.com/the_handy/

2 https://portal.wiktrop.org/search/select?query=combe/

3 These variations, offset by the relative stability of “large farms”, mask far more marked developments for small farms, which often started up with around 1 ha after the agrarian reform.

4 Names given in Réunion to this rhizomatous perennial grass, reflecting how arduous manual weeding can be, leading to exhausted wives (“marie éreintée” or “reintée”) and worn-out husbands (“mari dur”)

5 *In addition, in lowland farms, the use of high-technology machinery such as rototillers, which we could call “rologlypho” in reference to the “rolofaca”: these roll and spray inter-row weeds with pure or highly concentrated glyphosate (two machines in 2013)* (Martin & Esther, 2013).