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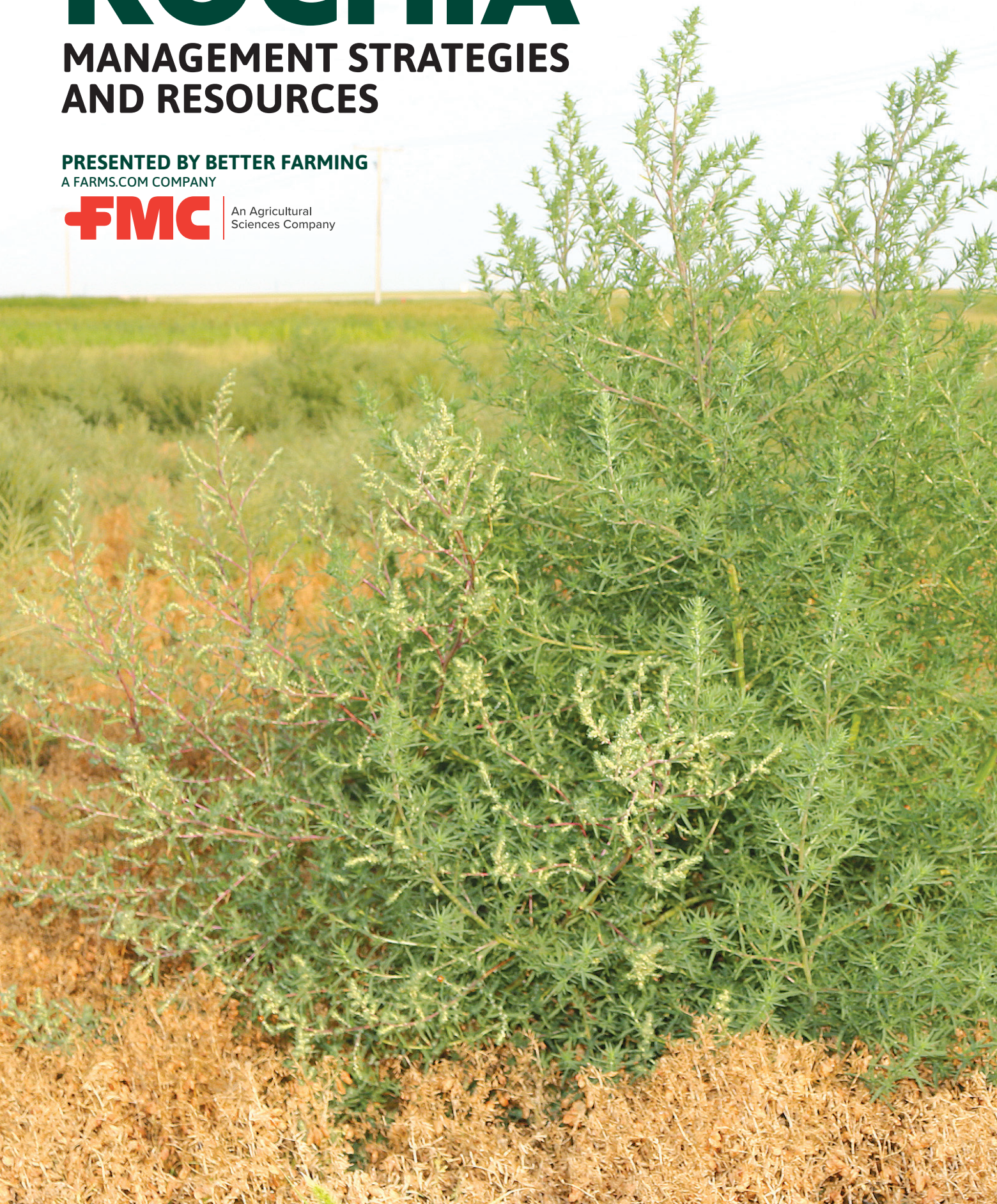

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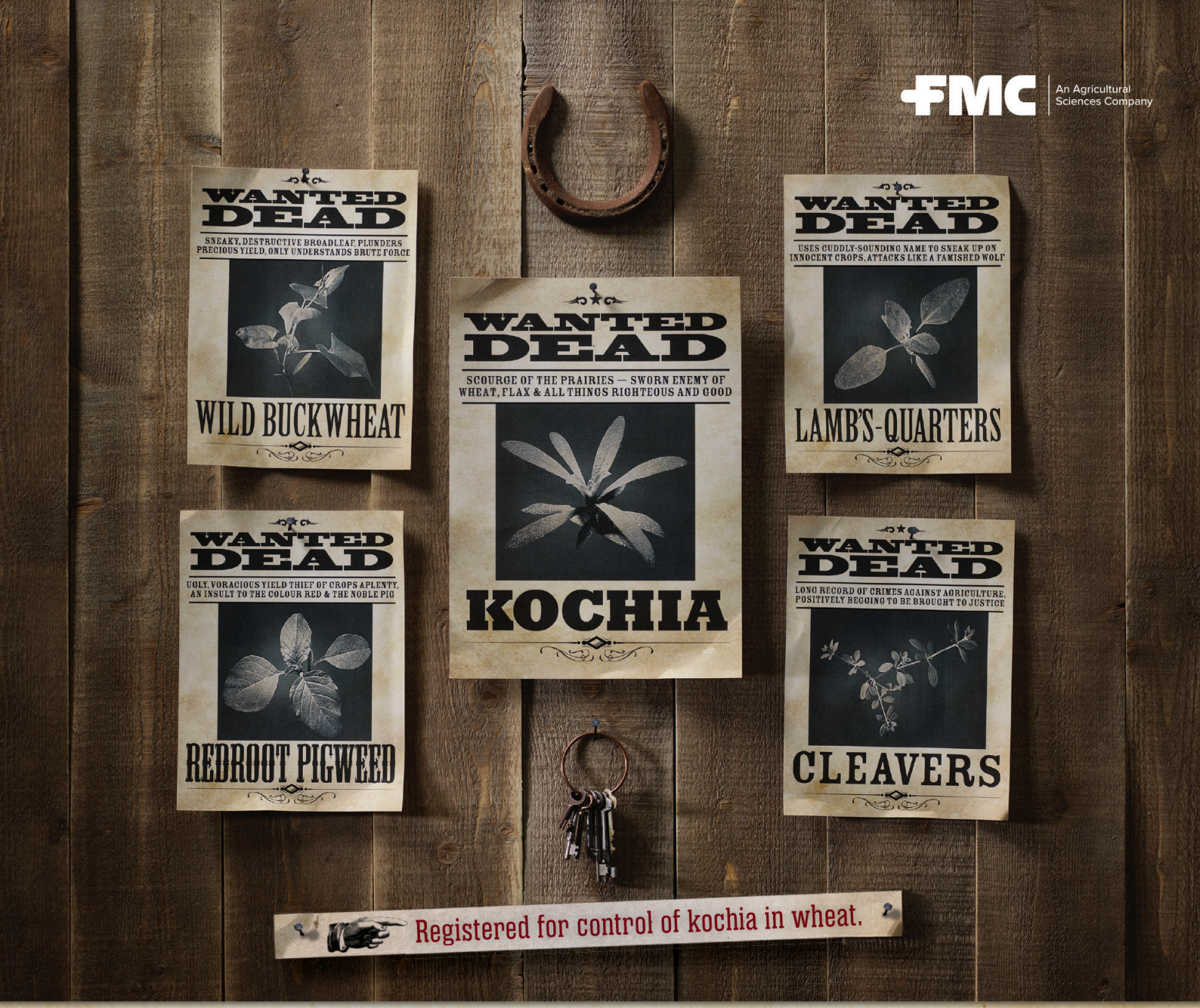

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KOCHIA: TOUGH TO CONTROL, TOUGHER TO MANAGE

Unfortunately, kochia isn't going away anytime soon, especially in the southern regions of Manitoba, Saskatchewan and Alberta. Furthermore, recent reports indicate kochia is moving into the northern regions of western provinces.

With early emergence, rapid growth and prolific seed production working together, kochia continues to wreak havoc on growers' fields across the Prairies.

Early germination and good frost tolerance mean that it is typically one of the first broadleaf weeds to mature. It grows rapidly and can form a dense mat quickly, especially where a plant matured the previous season and dropped seed. This all adds up to kochia being exceptionally competitive early in the growing season.

Uncontrolled infestations have caused yield losses of more than 90% in several crops in Alberta. In Saskatchewan, Dr. Lyle Friesen from the University of Manitoba reported yield losses in wheat as high as 73% in places where kochia stand density was extreme, at 195 plants per m^2. At much lower densities of 21 kochia plants per m^2, 33% yield loss in wheat was reported.

With increased resistance to Group 2, 4, 9 and 14 herbicides, managing kochia requires that growers use all the tools at their disposal in their fight against this weed including mechanical, cultural and chemical controls.

Put these products and insights to work to help manage kochia this year and beyond. FMC

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Articles written by Paige Fehr, BSc.Agr., MSc., AAg for FMC Canada

I SPY KOCHIA: THE BIOLOGY AND LIFE CYCLE OF ONE OF THE PRAIRIE'S MOST TROUBLESOME WEEDS

In the field of agriculture, producers are constantly learning and adapting their management strategies to combat new weed and disease pressures. In recent times, kochia has been a hot button issue for farmers in the Canadian prairies. The first step in effectively combating kochia is to better understand its biology and life cycle.

Kochia (Bassia scoparia), also known as burning bush or Mexican fireweed, is a C4 summer annual broadleaf weed. C4 plants like kochia fix more carbon in their leaves, enabling the plants to produce more photosynthates in hot, dry conditions in comparison to other plants. Kochia generally has a shallow, branched, fibrous taproot and germinates between early spring and mid-summer at soil temperatures between 2° C and 40° C. Germination typically occurs in late April or May in the prairies, but continues in flushes, leading to elongated flowering seasons and sporadic maturity, which exacerbates challenges with weed control.

With its early germination and good frost tolerance, kochia is typically one of the earlier broadleaf weeds to mature. It grows rapidly and can quickly form a dense mat, especially in places where a plant matured the previous

Top left: Kansas State University photo | Top right: Saskatchewan Pulse Growers photo

season and dropped seed. This makes it exceptionally competitive, even early in the growing season.

Physically, kochia is very identifiable and not often mistaken for other common broadleaf weeds. During early growth stages, it has dense leaf hairs on both sides of the leaf with hairy leaf margins. Seedling cotyledons typically have bright pink undersides. At the seedling stage, leaves are club-shaped and the plant grows in a basal rosette pattern, also known as a button.

As the plant matures, leaves are oblong or elliptically shaped, tapering in at the ends. Mature plant leaves maintain the soft, dense, leaf hairs similar to the seedlings, with a waxy surface. These hairs and waxy leaf surface can inhibit herbicide efficacy by reducing the ability of the droplets to enter the plants. In autumn, kochia leaves turn a purplish-red colour. The stem and branches are often tinged red with some green, and covered in white hairs. The plant grows in a highly branched pattern, with alternate leaf arrangement, and, upon maturity, produces very subtle flowers close to the main branches. The flowers are green, round, and grow in clusters.

According to Sustainable Agriculture and Research Education, kochia plants are pollinated through both self-pollination and outcrossing mechanisms. Self-pollination involves the transfer of pollen between flowers on the same plant, whereas outcrossing requires pollen from neighbouring plants to be pollinated and set seed. Pollen can be transferred between plants on the wind and through pollinator vectors, like honeybees. Combined, these two reproduction methods allow kochia to proliferate both in dense stands, and in the case that there is a lone plant segregated from other kochia plants. Reproduction through outcrossing, especially, brings about more genetic variability and, in the case of kochia, contributes to its rapid adaptation and development of multiple herbicide resistant biotypes.

Kochia reproduces only through seed, with each plant having the potential to produce between 15 thousand and 25 thousand seeds. Research led by Dr. Lyle Friesen from the University of Manitoba explained that kochia seeds are between 1.5 mm and 2 mm long, irregularly oval shaped, and are mostly brown in colour with some yellow markings. They are grooved on either side and typically protected in a star-shaped hull.

Kochia has a competitive growth pattern: in areas of lower competition, it tends to grow in a bushier, heavily branched formation, whereas high competition prompts the plant to grow taller and more compact. In competitive environments, kochia can grow up to 6 feet tall. Due to its early emergence and quick growth, kochia often grows taller than the cash crop canopy and limits light infiltration to the crop below.

When the plant matures, it breaks off at the base - referred to as “stem abscission” - before becoming a tumbleweed and rolling across the prairie landscape, dropping seeds along the way. This effective tumbling seed spreading mechanism is one trait that makes kochia a very difficult weed to control.

While seeds typically only survive for one or two years in the seedbed, Dr. Charles Geddes, Research Scientist in Weed Ecology and Cropping Systems at Agriculture and Agri-Food Canada, shared that kochia is a serotinous species, which refers to its aerial seedbeds. This means that some of the seeds are retained on standing plants over winter. These aerial seeds are kept away from the soil, enabling them to avoid predation and decomposition to a greater extent than their dropped counterparts. This duality between seed dispersal and seed retention gives kochia another leg up in terms of its opportunities for proliferation. This emphasizes the importance of early control of the weed, prior to seed set, for long term weed management.

Kochia grows well in dry, saline soil and tolerates heat very well. It also grows well in soils of extreme pH values. As such, it thrives in places where many cash crops struggle. In times of extreme drought, its typical shallow taproot can plunge deeper than 16 feet into the earth to seek hydration from below. Additionally, Dr. Charles Geddes and Dr. Shaun Sharpe report that kochia has been known to exhibit some allelopathic effects, inhibiting the growth of nearby neighbour plants.

Late in the season, kochia stands out bright green against the golden backdrop of wheat in the prairies. It remains green very late into the season, proving to be a challenge when it comes to harvest time as combines often struggle to digest the green matter, sometimes causing frustrating jam-ups. Kochia also has a prolonged reproduction period due to its indeterminate growth pattern, having the ability to produce seed late into the season until frost-kill, even after cash crop harvest. One study by Dr. James Mikelson in Montana determined that kochia can produce up to 4100 seeds per plant between cash crop harvest and freeze-up. Producers should monitor post-harvest kochia growth, especially if a late frost is expected and if kochia is a problem in their early harvested crops. In these cases, there will be more time for late season weed seed germination, and growers should discern whether a late season herbicide is warranted to combat against this.

When designing management plans, producers should spend time on understanding the way in which problematic weeds and diseases progress. In the case of kochia, early weed control is a farmer’s best bet to hedge against infestations. Producers should take care to walk fields often and identify kochia plants early and accurately. The goal is to ensure zero weed seed return, which can only be achieved through early interventions including herbicide layering, mowing, etc. By enhancing our understanding of how kochia grows and reproduces, we will be better equipped to mitigate its detrimental effects to the bottom lines of prairie farmers. FMC

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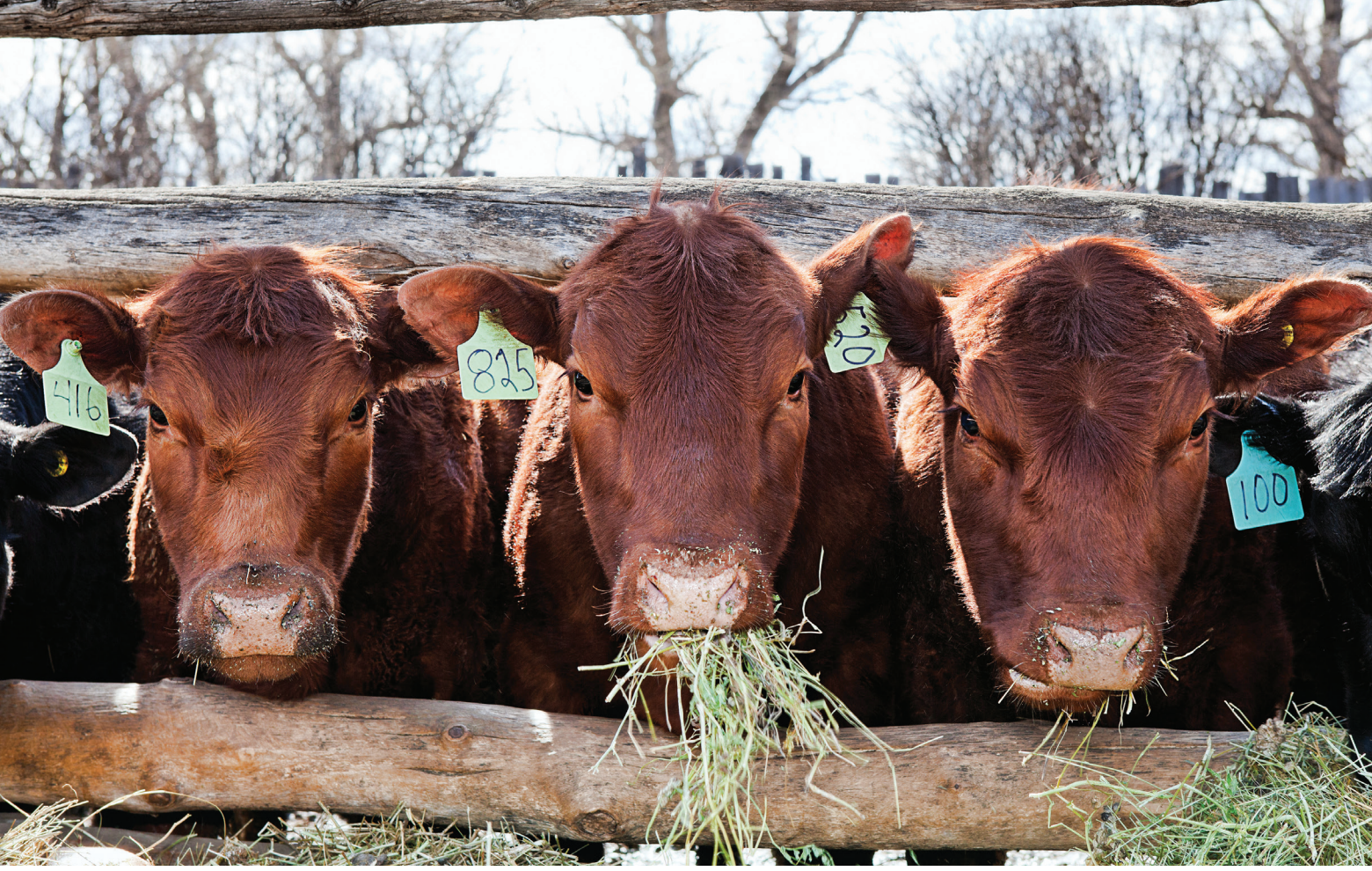

KOCHIA & CATTLE: USING THE PERVASIVE WEED AS LIVESTOCK FEED

Across much of the prairies, the past few summers have been exceptionally hot and dry. As a result, many producers have experienced shortages in forage production, and some have been put in a position of desperation where they must explore the potential in feeding unconventional forages to nourish their livestock.

Kochia - the pervasive weed spreading across the prairies, and a hot topic of conversation in the last several years – is one such non-traditional option for livestock feed that producers have recently been incorporating into hay mixtures in small amounts during prolonged periods of drought.

However, this is not the first time that prairie producers have turned to kochia as a source of feed in times of necessity. The Saskatchewan Research Council reported that, in 1988, kochia was harvested as an emergency forage in Saskatchewan due to widespread drought and the subsequent feed shortage. At that time, the value of the weed for livestock feed was estimated to be $7 million. In recent years, and in the face of a changing climate, farmers in some regions are experiencing similar pressures.

It should be noted that there are many genetically distinct species of Kochia that can be found across North America, Europe, and Asia. In Canada, we typically use the name kochia to refer to the annual broadleaf weed (Bassia scoparia) that can wreak havoc on combines, yields, and a farmer's temper. This is not to be confused with a common perennial species of the plant called forage kochia (Kochia prostrata), which is mainly found in arid places like Arizona, New Mexico, and Utah. Kochia prostrata is not endemic to Canada, and not the focus of this discussion. Here, we are referring to the use of Bassia scoparia - the annual weed found in the Canadian prairies - as feed for cattle in times of feed scarcity.

Kochia tends to perform well in drought situations and on saline soils, and is also resistant to grasshopper infestations. While these exact traits contribute to its troublesomeness as a pervasive weed, these qualities also allow kochia the ability to thrive and be used as forage in times of lesser production of more conventional feed options, like alfalfa for example.

In terms of its nutritional profile, the Saskatchewan Ministry of Agriculture claims that kochia is similar to alfalfa in some regards. In fact, some older studies refer to the plant as “poor man’s alfalfa.” Like alfalfa, kochia has high protein and carbohydrate contents. Crude protein generally runs between 10% - 25% when the plant is in the vegetative state and decreases as the plant matures. A study out of the University of Saskatchewan from the late 1980’s reported that the fiber and fat content in kochia is more digestible for cattle than that

Top: Brenda Carson - Adobe Stock

Using kochia as a component in livestock feed is a short-term emergency solution that may be employed in times of drought and desperation.

which is found in alfalfa, but the protein in kochia is less digestible.

Cattle tend to prefer young, tender kochia sprouts as opposed to the more mature, woodier plants. A study published in 2021 by researchers from AAFC's Lethbridge Research and Development Centre in Alberta determined that it is at this immature stage that the feed quality and nutrition of kochia is higher, and risks of toxicity are lower too. Furthermore, destroying kochia in its vegetative state, prior to seed-set, is crucial for controlling the spread of the invasive weed through livestock manure. For these reasons, it is important that producers bale or graze livestock on the young, more palatable plants. As with a number of other weed species introduced to their diet, cattle may need to be trained to eat kochia when first introduced, but it appears to have good palatability and cattle typically adapt well.

According to recommendations from the Saskatchewan Ministry of Agriculture, ranchers should ensure that the plant accounts for a maximum of 30% of feed ration in cattle (maximum of 25% if baled at maturity) so as to avoid toxicity caused by compounds including saponins, nitrates, alkaloids, and especially oxalates, all of which can be detrimental to livestock health when consumed in larger amounts. Early signs of toxicity in cattle include weakness, laboured breathing, and depression. Cattle that consume excessive proportions of kochia in their diet are also prone to convulsions or sudden death.

Murray Feist, provincial feed specialist with Saskatchewan Agriculture warns ranchers about the risks of calcium deficiency associated with feeding forages high in oxalates, including kochia. Oxalates bind to calcium in the animal's blood, potentially leading to fatally low levels of calcium available for crucial bodily functions. Feist explains that by the time symptoms of low calcium are exhibited, the issues are typically past the point of rectification and lead to death.

Jennifer Heyden, who works for the Saskatchewan Ministry of Agriculture as a Livestock and Feed Extension Specialist, suggests that it is also a good idea to provide additional calcium supplements to offset any calcium absorption inhibitions brought on by the high oxalate content in kochia, as well as hydroxy mineral supplements to encourage trace mineral absorption.

As a precaution, the Beef Cattle Research Council strongly urges producers who choose to include kochia in their forage mixtures to test their feed to determine that they are within safe ration proportions so as not to cause their livestock undue harm or inhibit gains, with the ultimate chance of jeopardizing profits.

While cattle is the most prominent species in livestock production in the prairies, there has also been some research conducted on the usefulness of kochia as emergency feed for sheep. In these cases, Agriculture Canada suggests, based off of a study published in 1990, that the plant not make up in excess of 50% of the animal's diet. There has been limited research on the impact of kochia on goats, but goats metabolize toxins more readily than cattle or sheep due to the microbial composition of their rumens and, according to Sterling Banks, Extension Agent with Utah State University, goats seem to fare well with some kochia in their diets as well.

All this considered, using kochia as a component in livestock feed is a short-term emergency solution that may be employed in times of drought and desperation, and can help producers to reduce the spread of the weed by grazing or baling prior to seed-set. The potential for severe negative health repercussions on livestock is a very real concern with feeding kochia. As such, producers are urged to carefully consider their options and use kochia as a feed source when other viable options are non-existent. It is widely recommended that ranchers utilize feed testing services, consult with nutritionists, and monitor their herds closely for any signs of distress if kochia is to be included in the diet.

Producers should also understand that kochia is classified as a noxious weed in Saskatchewan and Manitoba and must be managed as such. Under The Weed Control Act in Saskatchewan and the Noxious Weeds Act in Manitoba, preventing seed set and seed spread of noxious weeds, including kochia, is of high priority. Producers should refrain from intentionally cultivating kochia (Kochia scoparia) for any purpose, including for feeding livestock. FMC

Top: Stefon Linton - Adobe Stock

CONTROLLING KOCHIA: MECHANICAL, CULTURAL AND CHEMICAL WEED MANAGEMENT

On the western Canadian prairies, farmers and agronomists are fending off an unwelcome guest. Kochia (Bassia scoparia) is a pervasive weed that has proven itself to be well-adapted to our prairie environment. While kochia has been a problem for decades, hot and dry conditions have enabled the crop to thrive and expand its reach in recent years.

SO, WHERE DID IT COME FROM?

Kochia (Bassia scoparia) is native to southern and eastern Russia, and was introduced to Canada as an ornamental plant in the mid to late 1800's. Kochia was typically used as a hedge or background plant, where it's red colour was well liked. Unfortunately for prairie farmers, the plant thrived and became invasive. While kochia has spread into most Canadian provinces and United States, it is most abundant in the semi-arid regions. It is now classified as a noxious weed in both Saskatchewan and Manitoba, and is highly problematic in Southern Alberta as well.

WHY IS KOCHIA SO PERVASIVE?

Kochia's success can be attributed to a few key attributes. It has exceptional seed production – up to 100,000 seeds per plant when there is no competition according to Dr. Hugh Beckie – and seed spread, and has an impressive ability to thrive in inhospitable environments of extreme temperatures, drought and salinity. Additionally, its early germination – as early as 50 GDD – and rapid growth make kochia a tough competitor for cash crops and forages. Since kochia can germinate in cool soils and tolerates frost rather well, it requires early control, often prior to other broadleaf weeds.

Kochia can have a devastating effect on cash crop yields, especially during drought years. However, the weed has one major weakness that gives producers hope for control: seed longevity. According to Dr. Lyle Friesen, more than 90% of kochia seeds in the soil seedbank die within two years. As such, effective control prior to seed set can significantly reduce kochia pressure the following year.

Due to its noxious classification, aggressive management of kochia is of utmost importance. In this article, we focus on some key mechanical, cultural, and chemical control methods that can be used to mitigate the spread of kochia.

MECHANICAL CONTROLS

Mechanical weed control, refers to physical actions that kill, or directly inhibit weed growth. For kochia, mowing the plant prior to seed set appears to be an effective means of manual control. While tillage has been shown to be detrimental to soil structure and soil health when used excessively, it may also be used to manage kochia if done at a very early growth stage. Shallow tillage is typically enough to disrupt kochia growth.

CULTURAL CONTROLS

Cultural weed controls reduce weed pressures through the modification of the growing environment so as to make it less hospitable for weed growth.

Competition appears to be one effective cultural means of limiting kochia proliferation. Yield losses from kochia are directly related to plant density of the weed. While growing winter wheat is not a particularly common crop in the Canadian prairies, Dr. Charles Geddes with AAFC says that it offers a source of early competition against kochia. Winter wheat and other fall-planted crops emerge early in the spring before other crops have a chance to grow.

Crop rotations are another option to keep kochia at bay. By implementing crops that germinate at different times – including winter wheat – and that are compatible

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with different herbicide groups year by year, we reduce the selection pressure for herbicide resistance and allow for other means of control to be employed.

Furthermore, Geddes suggests that increased seeding rates of cash crops and narrow seed rows effectively improves competition against kochia by reducing resources available for the weeds.

Kochia performs well on marginal lands, so control in these areas is especially vital. Seeding salt-tolerant cover crops in field edges or highly saline areas where cash crops do not perform well is one such cultural control. Barley, fall rye, or AC Saltlander – a green wheatgrass cultivar from AAFC – are some options for those salty areas. This offers some competition and limits the risk of kochia populating these otherwise bare patches, and can often be used for baling or grazing livestock.

While growing winter wheat is not a particularly common crop in the Canadian prairies, Dr. Charles Geddes with AAFC says that it offers a source of early competition against kochia.

CHEMICAL CONTROLS

Using chemical controls to manage the spread of kochia requires careful management. This is due in part to the physiology of the plant, and in part to its genetics. Kochia's hair-covered leaves reduce the level of direct herbicide contact. Additionally, the fact that kochia is a C4 plant that thrives in summer heat means that its stomata are typically tightly shut during the day. As such, herbicide entrance into the plant is limited, thereby limiting herbicide efficacy.

All kochia populations in the prairies are considered to be resistant to Group 2 ALS/AHAS inhibitor herbicides, with resistance to Groups 4, 9, and now Group 14 also detected across the prairie provinces. Producers should assume Group 9 resistance, whether proven or not. Some triple-resistant kochia populations have been found, where the biotype is resistant to Groups 2, 4, and 9. As such, the chemical controls effective in controlling kochia are dwindling.

Despite this, and in combination with other mechanical and cultural methods, targeted weed control using herbicides can be effective. It is imperative that kochia staging is a priority when determining a chemical control plan. Since the plant grows rapidly, kochia can outgrow the potential to be chemically controlled within a matter of days. For best chances of control, kochia plants should be 5 cm tall or less at the time of herbicide application.

However, due to physiological barriers to in-crop herbicide efficacy in kochia discussed earlier, namely leaf hairs and stomatal closing, soil-applied herbicides typically offer more effective control against this weed. Producers should aim to spray kochia at pre-seeding or pre-emergence with a tank mix herbicide, such as Group 14 and 9 applied pre-emergence, followed by Group 6 and 27 in-crop. Layering or rotating herbicide groups, in combination with crop rotation, represent best practices to reduce selection pressure for herbicide resistance.

Herbicide Groups 5, 6, 10, 14, 15 and 27 can be effective in managing kochia in-crop in cereal crops. It is important that growers follow the label and consult with agronomists to ensure the herbicides they choose are compatible with their current or subsequently planned cash crop so as not to inhibit growth of the intended crop. Glyphosate (Group 9) should not be used on its own to control kochia.

In response to widespread herbicide resistance in kochia across the prairies, producers must take extra precautions when it comes to using chemical controls against kochia. Integrated weed management that employs mechanical, cultural, and chemical controls appropriately is the best chance we have at effectively controlling kochia. FMC

Top: Oleksandr - Adobe Stock photo

THE EVOLUTION OF HERBICIDE RESISTANCE IN KOCHIA

While kochia is easily identified by its physical traits, there are genotypic traits that we cannot see with the naked eye, namely herbicide resistance. Herbicide resistance to multiple modes of action have developed across the Canadian prairies and is recklessly expanding.

WHAT IS HERBICIDE RESISTANCE?

According to Agriculture and Agri-Food Canada (AAFC), "Herbicide resistance is the inherited ability of a weed plant to survive and reproduce after herbicide treatment. The scale of the problem is closely linked to the repeated use of the same herbicide or a group of related herbicides." Essentially, genetic mutations allow plants to tolerate herbicide applications. When they reproduce, their progeny is often resistant too.

Herbicide resistance mechanisms are broadly categorized as being target-site or non-target-site. In target-site resistance, a point mutation occurs in the enzyme that the herbicide binds to, which would normally cause plant death. Since the target site is disrupted, the plant is more resistant to the herbicide. In non-target-site mutations, metabolic resistance towards the herbicide allows the plant to digest the product into less-toxic metabolites. Through sexual reproduction, multiple herbicide resistance (cross-resistance) through gene-stacking may occur, where progeny inherit resistance traits from both parent plants.

HERBICIDE RESISTANCE IN KOCHIA

The reproductive characteristics of kochia foster the rapid development of herbicide resistance. Kochia is a prolific seed producer and its tumbleweed nature means it can spread broadly across landscapes. Kochia self-pollinates and out-crosses with nearby plants, which contributes to its high genetic diversity.

Resistance to herbicides from Groups 2, 4, 9 and 14 have been detected in the prairies.

Double-resistant and triple-resistant biotypes have also been found, wherein kochia plants are simultaneously resistant to two or three different herbicide groups.

GROUP 2

Group 2 herbicides are acetolactate synthase (ALS) inhibitors and include herbicides like thifensulfuron, imazethapyr and florasulam.

According to the International Herbicide-Resistant Weed Database (IHRWD), resistance to Group 2 herbicides was detected in kochia in Saskatchewan and Manitoba in 1988, and Alberta in 1989. Researcher Dr. Hugh Beckie and his team found that, within 20 years of detection, 85% of prairie kochia was Group 2 resistant. Today, all kochia in Canada is assumed to be resistant to Group 2 herbicides.

GROUP 4

Group 4 herbicides, including fluroxypyr and dicamba, are synthetic auxins that disrupt cell growth in newly forming stems and leaves.

The IHRWD reported that Group 4 resistant kochia biotypes were first detected in Canada in Saskatchewan in 2015. A 2017 survey led by Dr. Beckie tested kochia herbicide resistance across Alberta and found dicamba and fluroxypyr resistance in 18% and 13% of samples respectively. Dr. Shaun Sharpe and his team found dicamba resistance in Saskatchewan to be considerably higher in 2019: 45% of kochia plants tested there were dicamba resistant.

GROUP 9

Group 9 herbicide, singularly glyphosate, is a non-selective aromatic amino acid inhibitor.

Research from Dr. Charles Geddes, research scientist with AAFC, and team revealed that glyphosate resistant kochia was first found in Canada in 2011 in Southern Alberta, at a rate of 4%. Within 5 years, this number jumped to half the kochia population. Dr. Sharpe's 2019 survey of Saskatchewan kochia found glyphosate resistance in 87% of samples. It is suggested that prairie producers manage kochia with the assumption that all populations are glyphosate resistant.

GROUP 14

Group 14 herbicides are protoporphyrinogen oxidase (PPO) inhibitors and can be used for pre-emergence and post-emergence weed control.

Recently in Saskatchewan, suspected Group 14 (specifically sulfentrazone) resistant kochia was found in a wheat crop. Dr. Geddes and his research group also tested resistance to safluenfenacil, tiafenacil, flumioxazin and carfentrazone herbicides in kochia.

While resistance to Group 14 herbicides currently remains low, these findings highlight the concerning speed at which kochia is adapting to tolerate an increasing number of chemical controls.

SO, WHAT CAN PRODUCERS DO?

Clearly, herbicide resistance in kochia is growing across the prairies. To identify herbicide resistance in kochia, producers and agronomists have several options.

Saskatchewan growers can send kochia seed samples to the Crop Protection Laboratory in Regina for multiple herbicide resistance testing at a cost of $125 per sample

per herbicide group resistance test. Growers from other provinces can use the same services for $200 per sample.

In Manitoba, growers can send kochia plant samples into the Pest Surveillance Initiative for laboratory DNA testing services. They test for glyphosate resistance at a cost of $125 per sample. Samples should be collected from green kochia plants and include young leaf material.

Also in Manitoba, Ag-Quest has a commercial lab that tests for resistance to multiple modes of action for $130 per sample.

The Prairie Herbicide Resistance Research Lab in Alberta does not accept samples on a commercial basis, but rather for research. Growers should contact the lab if they have samples they'd like tested.

In short, herbicide resistance in kochia is a pressing issue across the praires, and can differ between locations. The prevalence of each resistance type generally descends in the following order: essentially all kochia is Group 2 resistant; followed by approximately three quarters being resistant to Group 9; Group 4 resistance is at a rate of ~1-in-5, and triple resistance is found in approximately 10% of prairie kochia. Research into Group 14 herbicide resistance is ongoing, and rates of resistance in the general population are not yet known.

While chemical control options for kochia are dwindling with widespread resistance to multiple modes of action, the battle against herbicide resistance must be a united effort amongst farmers and other stakeholders in the agricultural sector. Integrated weed management, including herbicide layering and rotation, combined with mechanical and cultural controls should be implemented to delay and prevent the spread of herbicide resistance in kochia populations across Western Canada. FMC

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DOLLARS & CENTS: THE ECONOMIC IMPACT OF KOCHIA

Kochia is an increasingly troublesome weed in the prairies, especially in the southern regions of Manitoba, Saskatchewan and Alberta. This is largely due to: kochia's ability to thrive in places where cash crops might struggle; its early emergence; rapid growth; and its prolific seed production. With these traits acting in tandem, kochia has caused significant negative economic impacts for prairie producers.

Factors including kochia density, competitive ability of the cash crop, environmental conditions, and emergence timing relative to the crop all contribute to the variation in the economic impact of kochia. Kochia tends to cause the highest yield reductions in drought years and on saline soils where cash crop stands are thin and kochia populations flourish.

While the economic detriment caused by kochia is mainly due to decreased profits from reductions in crop yields, kochia can also reduce profits through other means. Additional time required to perform supplementary weed control practices like mowing, excessive wear and tear on combines, increased herbicide and seed cleaning fees, combined with yield losses, contribute to kochia posing a serious financial burden for growers.

Yield losses of more than 90% have been reported in several crops in Alberta, including corn and sugar beet, as a result of uncontrolled kochia infestations as found by Agriculture and Agri-Food Canada researchers Drs. Charles Geddes and Shaun Sharpe in a 2022 study. Perhaps most relatable for prairie growers: mean crop losses in wheat were reportedly close to 20%, and 13% in canola when early-stage control was not employed. Average yield losses due to kochia were much higher in crops like grain corn, with mean losses of 68%, and sorghum with 62% mean losses.

In Saskatchewan, Dr. Lyle Friesen from the University of Manitoba reported yield losses in wheat as high as 73% in places where kochia stand density was extreme, at 195 plants per m^2. At much lower densities of 21 kochia plants per m^2, 33% yield loss in wheat was reported.

Due to its relatively recent role as a problematic weed, there has been limited data collection on the economic impact of kochia in prairie Canada in terms of overall dollar amounts. Anecdotally, however, it is clear that kochia has a considerable detrimental economic impact on producers' bottom lines, especially during the recent string of drought years, and with the increasing frequency of herbicide resistant kochia biotypes. While proactive kochia management can cost farmers a great deal of time and money in the short-term, their efforts are worth it in the long term. One researcher, Dr. George Frisvold, claimed that effective proactive management can be valued at up to $20 per acre per year over the next ten years in Western Canada.

Kochia management must be a collective effort. Producers should commit to putting up a tough fight against kochia for a few consecutive years. In theory, this will reduce the viable seed bank and mitigate risks of financial losses from the weed in the following years. FMC

THOUGHTS FOR THE FUTURE: KOCHIA IN A CHANGING CLIMATE

In recent years, devastating drought and abnormally hot summers have prevailed in many regions of Western Canada. In the face of a changing climate, these trends are forecasted to persist over the next several decades. Such conditions favour the proliferation of hardy, resilient weeds, including kochia.

According to the Government of Canada's 2019 Changing Climate Report, an average temperature increase of up to 2.3° C is anticipated in the prairies by the year 2050. Particularly in the southern agriculturally dominant prairie regions, more frequent and severe droughts and soil moisture deficits are expected.

Under these conditions, and with increasing levels of atmospheric CO_2, C4 plants, including kochia, are more efficient photosynthesizers compared to C3 plants, like canola and wheat. C4 and C3 are two distinct forms of photosynthesis. C3 plants are generally better suited to cooler, moist environments and C4 plants prefer warmer, more arid conditions.

A group of Argentinian researchers, led by Dr. María Valeria Lara, reported that physiological traits including stomatal closing and reduced photorespiration in C4 plants - traits which C3 plants do not have - contribute to C4 plants outperforming C3 plants in exceedingly warm environments. As temperatures increase and conditions become more arid, the battle between prairie producers and kochia is likely just beginning.

Aside from its photosynthetic capabilities, kochia is also exceptionally tolerant to an array of abiotic stresses associated with a warming climate. Turkish researcher Dr. Bülent Okur explains that, as soil moisture decreases as an indirect result of climate change, saline soil conditions in arid growing environments will be exacerbated. Unluckily for prairie growers, kochia grows successfully in saline soils.

Research out of Michigan State University published in 2021 found that many of kochia's adaptive traits are likely to enable the crop to continue expanding its range northwards as our climate warms. Kochia thrives in arid growing environments, so as these regions expand under a changing climate, so too will the distribution of kochia. For these reasons, kochia is likely to become even more problematic for growers in coming years.

This being said, Natural Resources Canada actually predicts increased capacity for crop production in the prairies in the short-term as our climate warms. Yield boosts in hay and some cash crops are expected because of the longer growing season and more heat units associated with a changing climate.

In their Regional Perspectives Report, and as part of Canada's national assessment process, Natural Resources Canada explained that anthropogenic adaptability in prairie agriculture is crucial in our current environmental situation.

Moving forward, farmers should continue implementing best management practices to reduce the spread of kochia, especially as our changing climate affords it a leg-up over some of the prairie's top cash crops. FMC

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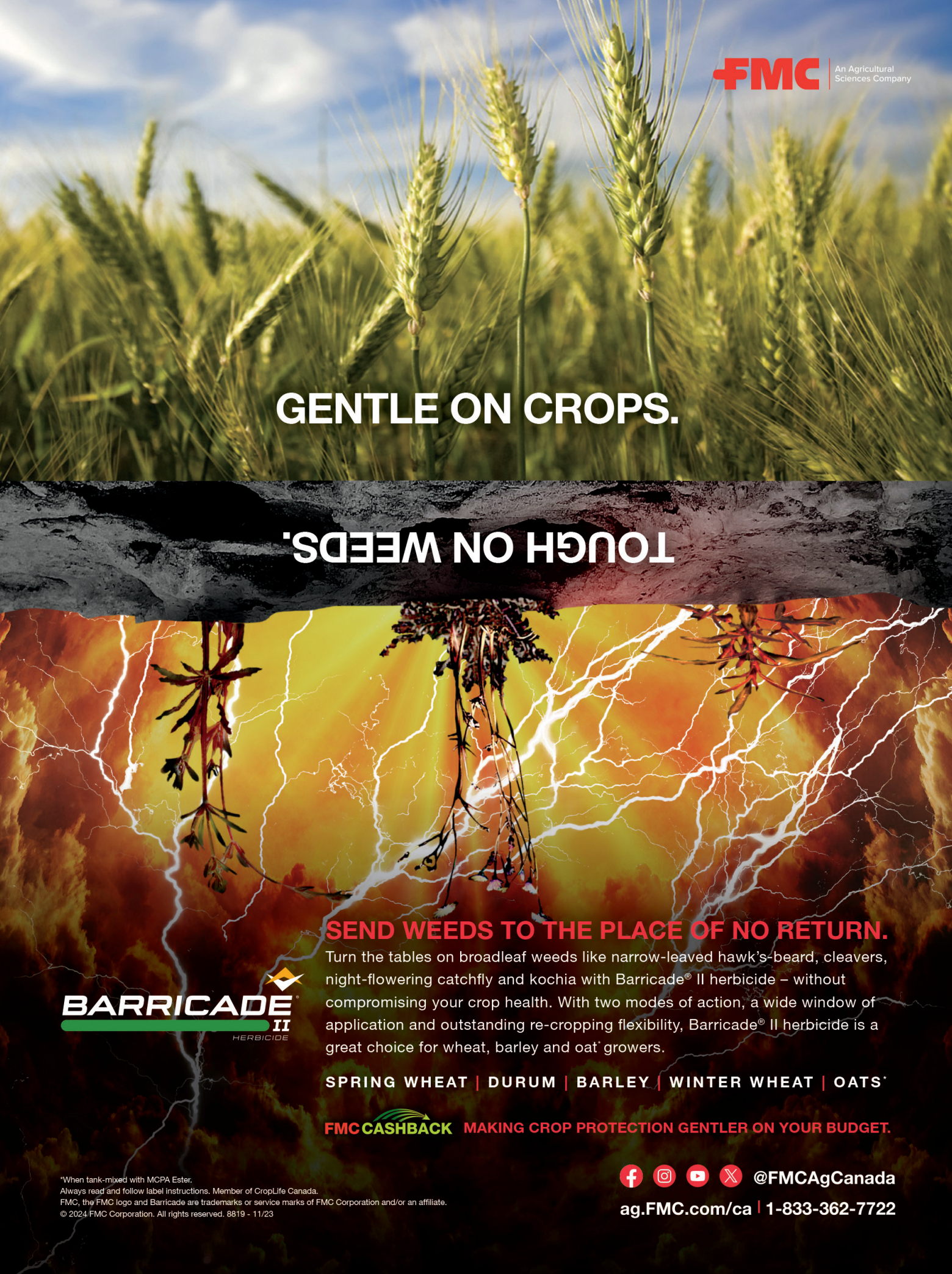
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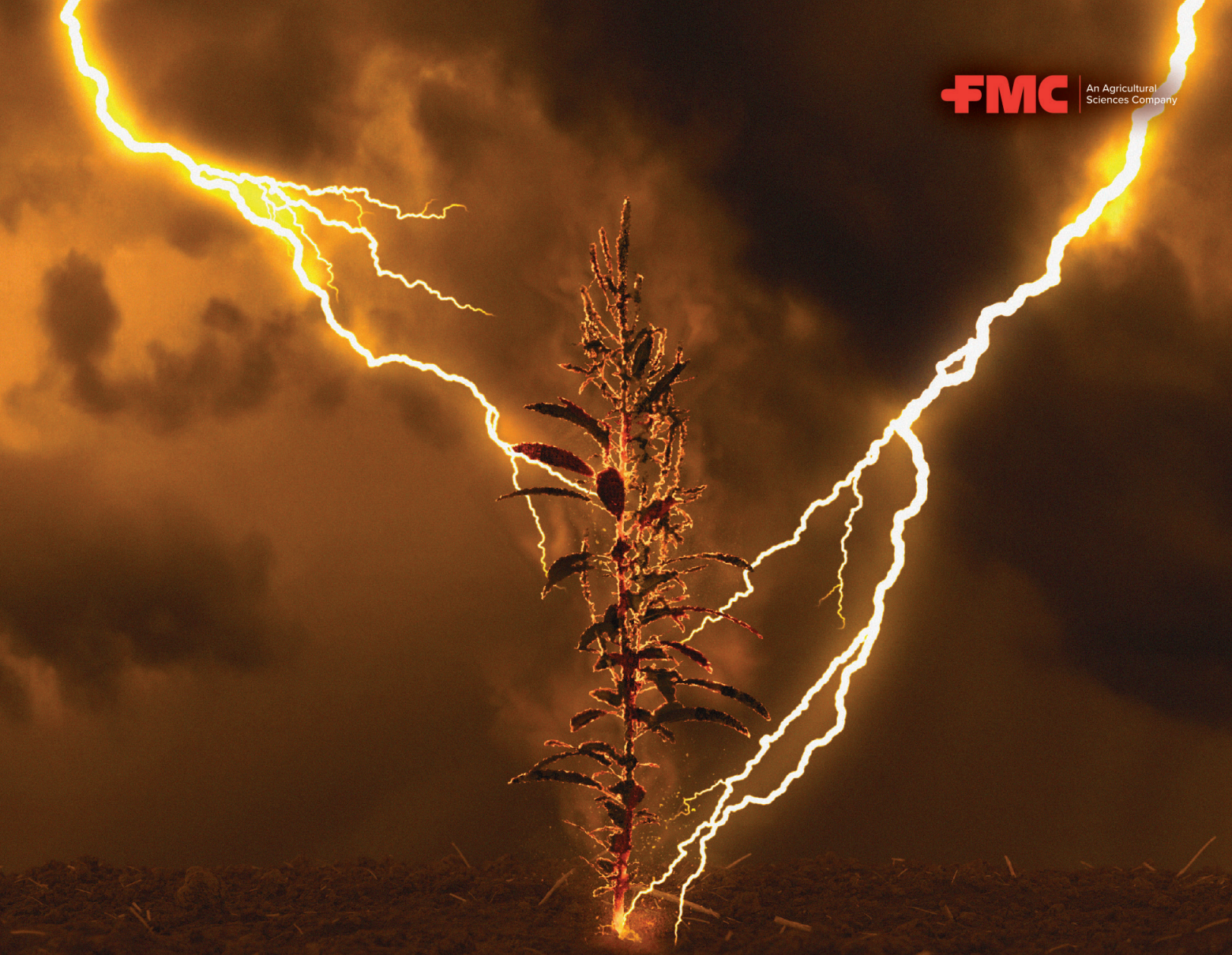

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