Guide for the identification of Palmer amaranth (*Amaranthus palmeri*) in South Africa

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Aims

1. One aim with this Guide is to allow anyone to identify and report Palmer amaranth (*Amaranthus palmeri*) wherever it occurs in South Africa.

Identification of Palmer amaranth is complicated because many of its characteristics correspond with those of other amaranth types (species), of which 17 (out of 75 globally) occur in South Africa. For these reasons some of the other amaranth types are dealt with from the outset in this document – refer pages 6 to 12 for photos of other amaranth types which can confound positive identification of Palmer amaranth.

2. Besides seeking assistance with the identification of this plant, we aim to create awareness on the immense threat which Palmer amaranth poses for SA agriculture.

3. We request your cooperation to identify Palmer amaranth wherever it might occur in South Africa, and even in southern Africa.

Contact information appear on page (slide) 37 of this guide.

Why is Palmer amaranth (*Amaranthus palmeri*) considered to be a major threat for crop production?

Because Palmer amaranth was first identified in South Africa as recently as 2018, locally generated data are not yet available for quantifying its impacts on crop yield. However, we have the benefit of access to relevant data out of the USA. Based on the USA experience, immense economic and socio-economic impacts are foreseen for SA agriculture in the foreseeable future, *circa* 2030. 'Lessons learnt' in the USA can assist with accurate predictions on this weed's impacts on local crop yields, as well as with the development of own effective control practices and strategies.

Presented here is a small sample of the information that has been generated through scientific research in the USA:

- Resistance against nine mechanisms of herbicide action has thus far been identified in Palmer amaranth. This is particularly disturbing because there exist only a total of 15 herbicide mechanisms-of-action in the world. Read and learn more: http://www.weedscience.org
- In maize, a single Palmer amaranth plant/m^2 can lead to 10% yield loss; 10 plants/m^2 can cause 90% yield loss.
- In soybean, on average 0.3 plants/m^2 can result in 10% yield loss; 3 plants per/m^2 can cause 50% yield loss.

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- One female plant can produce as many as 600,000 seeds, and seed can remain viable in soil for three years. In an USA field trial Palmer amaranth numbers were reduced by 98% over a 6-year period through intensive control with herbicides and hand-weeding; seed number in the soil seedbank was reduced from 170 million seeds/ha to a low(!) 18 million seeds/ha – in the zero-control treatment, seeds in the soil seedbank went from 170 million to 1.1 billion seeds/ha over the 6-year period.
- Palmer amaranth is endemic to the Sonoran Desert spanning the northwestern parts of Mexico and southwestern parts of the USA – this means it will likely be well-adapted to vast areas of southern Africa!
- By 1975 it was not yet considered a ‘weed of crops’ in the USA; by 1989 it was classified as a weed in cotton in two states; by 1995, in these two states, it was listed amongst the top-10 most harmful (noxious) weeds; by 2005 it was recognized as the *number-1* weed in maize, cotton and soybean in most USA states.

Further reading (just one of many sources): SM Ward, TM Webster & LE Steckel (2013). Palmer amaranth (*Amaranthus palmeri*): A review. In: Weed Technology, Volume 27: 12-27.

Other ‘look-alike’ amaranthus types

Amaranthus hybridus

An important weedy amaranth in SA; originally also from the USA; locally known as Cape pigweed or marog.

Amaranthus hybridus **in lucerne**

Amaranthus hybridus varieties

There exists large genetic variation in the genus *Amaranthus*, inter alia due to hybridization between species.

Amaranthus hypocondriacus
One of the amaranth types cultivated as a grain crop.

Amaranthus cruentus

Another amaranth cultivated for its grain. In South Africa it often stands out from other vegetation in waste (unused, disturbed) areas.

Same as for Palmer amaranth, it was used as food source by the Inca and Astec nations in ancient times.

Amaranthus standleyanus

Origin is the South American continent – these photos taken in Modder River district, Northern Cape province.

Amaranthus spinosus

Of all the amaranth types, *Amaranthus spinosus* is genetically most closely related to *A. palmeri*

"spinosus" means "with thorns"

***Amaranthus palmeri* (Palmer amaranth) i**n ‘n cotton field in Douglas district, Northern Cape, where it was first confirmed in South Africa, in February/March 2018*

***Note:** Subsequently, other populations have been confirmed, i.e. in Howick and Winterton districts (KZN), in the north of Kruger National Park as well as in Mapungubwe National Park (in both cases in the Limpopo River floodplain), and in the vicinity of Kasane town, Botswana.

Article reference: Sukhorukov et al (2021) BioInvasions Records, Vol 10, Issue 1, pp 1-9

Palmer amaranth in Douglas district, Northern Cape province

All three plants in picture are female. In this species the sexes are on separate plants. Ten out of 75 amaranth species the world over have this trait in common with Palmer amaranth.

Characteristics of Palmer amaranth

• The genus *Amaranthus* belongs to the family Amaranthaceae and comprises about 75 species worldwide. In South Africa there are 17 species of which some are indigenous and others of exotic origin but naturalized.

• Palmer amaranth belongs to a sub-group of 10 species that are dioecious (sexes on separate plants), and all 10 are indigenous to the North American continent.

• It is a summer annual that prefers high day and night temperatures, as well as long days. The life cycle is completed in one year (annual plant). Palmer amaranth is killed by frost.

• The stem is typically red-green or purple-green colour, but variations in the dominance of these colours are common. Plant can grow more than two meters tall depending in which type of crop they occur; in low-growing crops such as soybean and cotton, Palmer amaranth tend to have bushy growth habit, whilst in maize it forms a main stem with which it can outgrow maize plants.

• Leaves are hairless and leaves with petioles (leaf stalks) that exceed the leaf blade in length can be found on plants. Young leaves have a lancet (spear) shape and becomes more oval with age. On older plants the veins are of whitish colour, and some leaves have a grey-purple, roughly V-shaped chevron on the upper leaf surface.

• Male and female flowers occur on long terminal spikes, which in the case of female plants can be up to 60 cm in length. Male inflorescences are covered in pollen and are soft to the touch, whereas female flowers are hard and prickly, and obviously do not produce pollen.

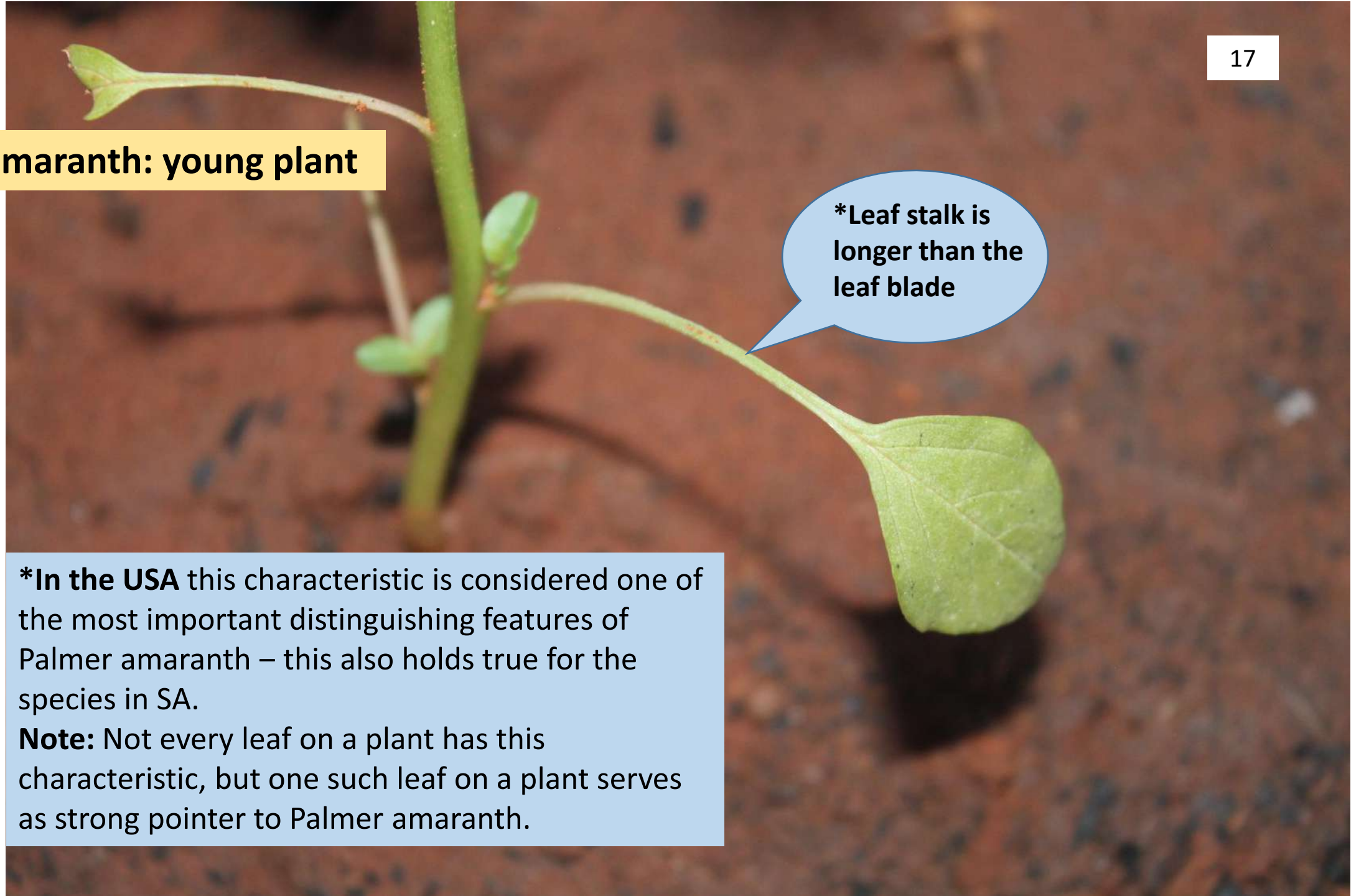
Characteristics of Palmer amaranth (continued)

• Palmer amaranth pollination occurs mainly through wind action. Seeds are small (1-2 mm diameter), smooth, round to flat, and shiny black (actually deep-purple) in colour. Strong wind can carry seed over long distances, as do birds, animals and agricultural machinery. A single female plant can produce from about 60,000 to 600,000 seeds.

• Genetic variability render plants adaptable to a wide range of environmental conditions; it also explains the ability of this species to rapidly evolve resistance to a wide range of herbicide mechanisms-of-action.

Palmer amaranth (female) in Kasane town, Botswana

Palmer amaranth: young plant



***In the USA** this characteristic is considered one of the most important distinguishing features of Palmer amaranth – this also holds true for the species in SA.

Note: Not every leaf on a plant has this characteristic, but one such leaf on a plant serves as strong pointer to Palmer amaranth.

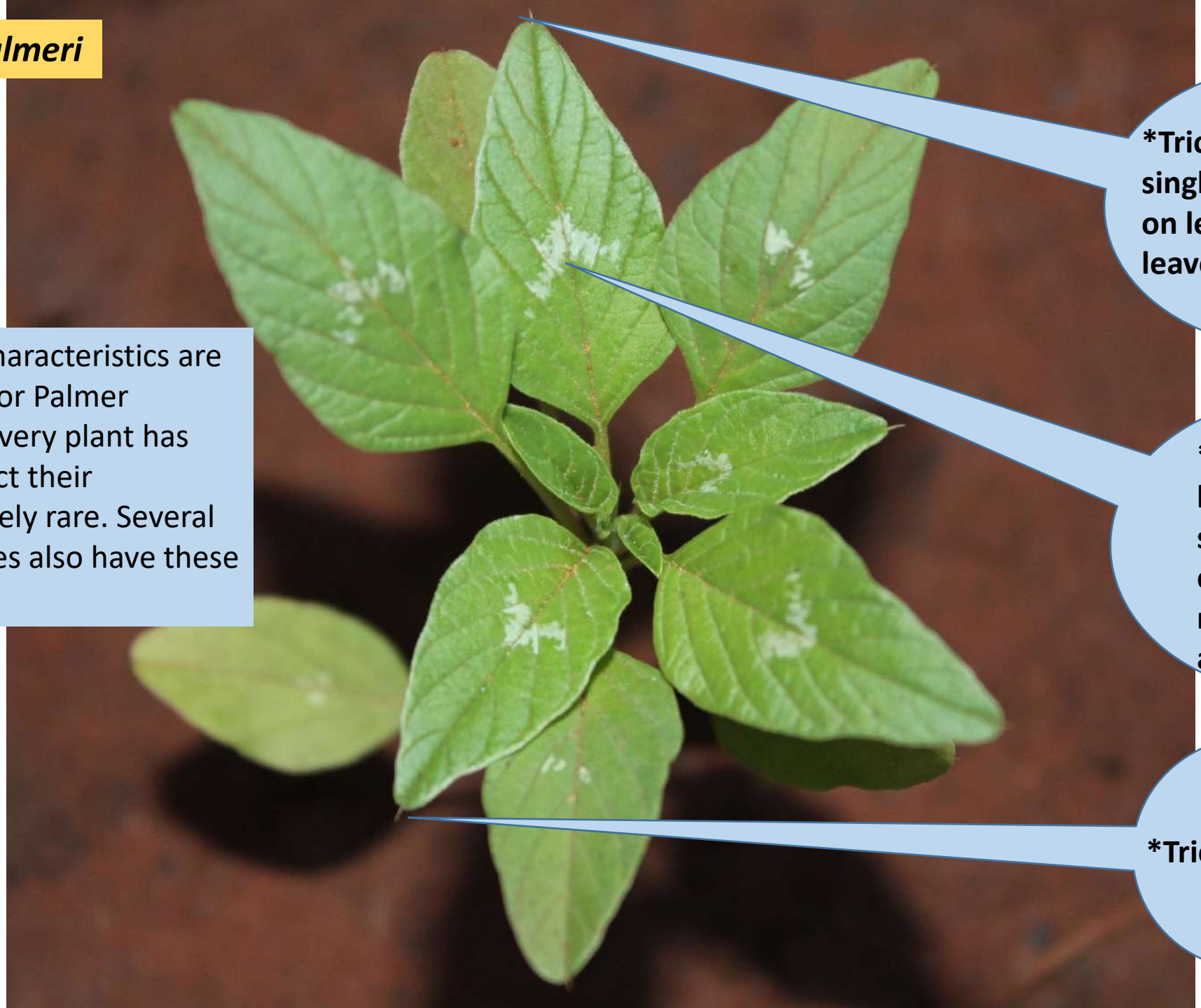
On Palmer amaranth some leaves, especially older leaves lower down the stem, typically has this feature – the length of leaf stalk (petiole) exceeds that of leaf blade.

NB: Not every leaf has this characteristic, but to find a single leaf of this kind on a plant means it is probably Palmer amaranth.

Amaranthus palmeri

*In the USA this is recognized as typical of Palmer amaranth, but in SA there are other amaranth species with the same characteristic.

Amaranthus palmeri



*In the USA these characteristics are reported as typical for Palmer amaranth, but not every plant has these features, in fact their occurrence is relatively rare. Several other amaranth types also have these features.

***Trichome (hair) occur singly in the indentation on leaf tip of some leaves**

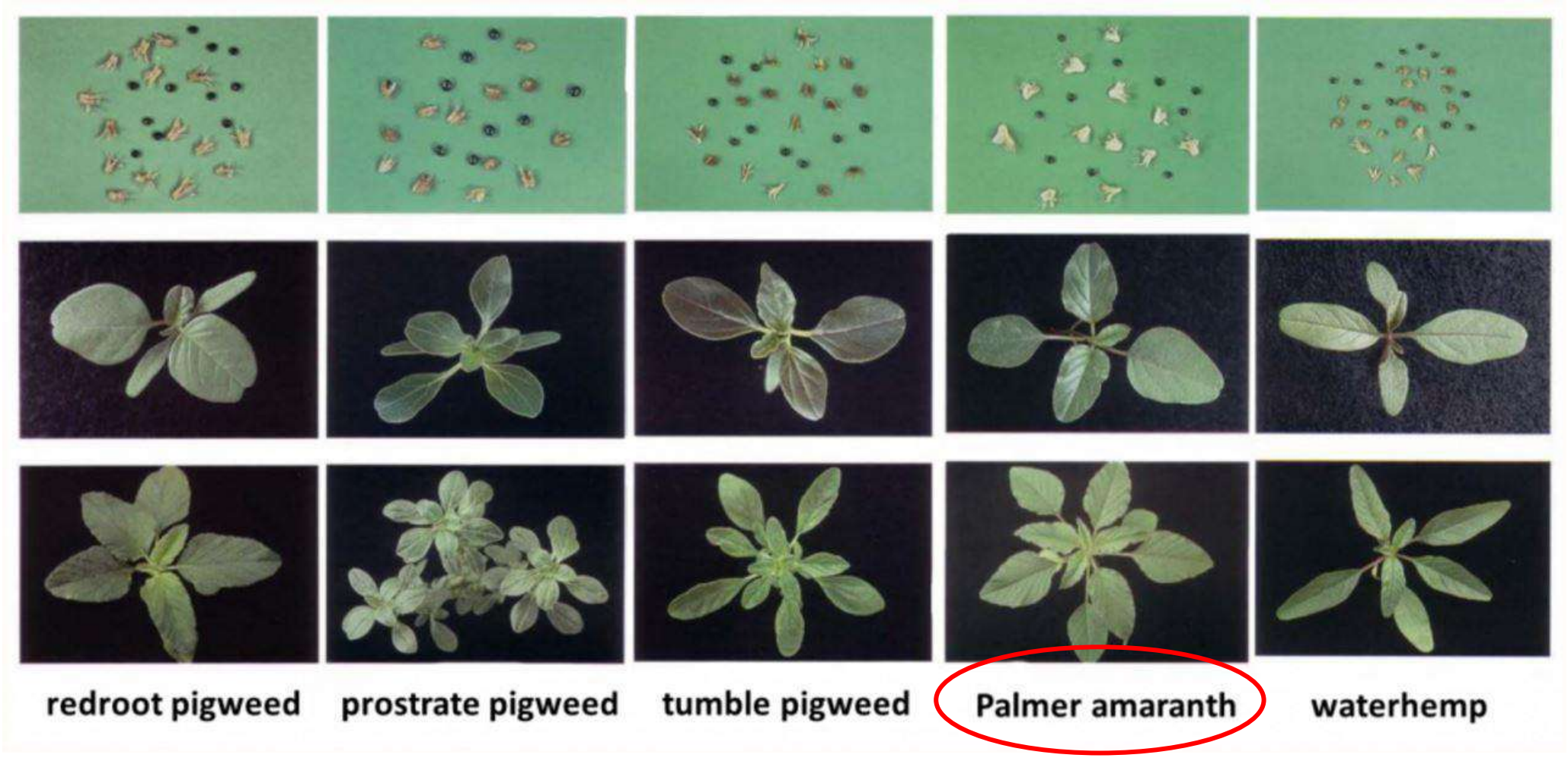
***Chevron mark on leaves occur on some plants; plants either has this marking or not at all**

***Trichome (hair)**

Palmer amaranth seedlings showing variation in morphology

Palmer amaranth seedlings with the obvious long petioles already visible at some leaves. On older plants this feature is more readily found on older leaves lower down the main stem.

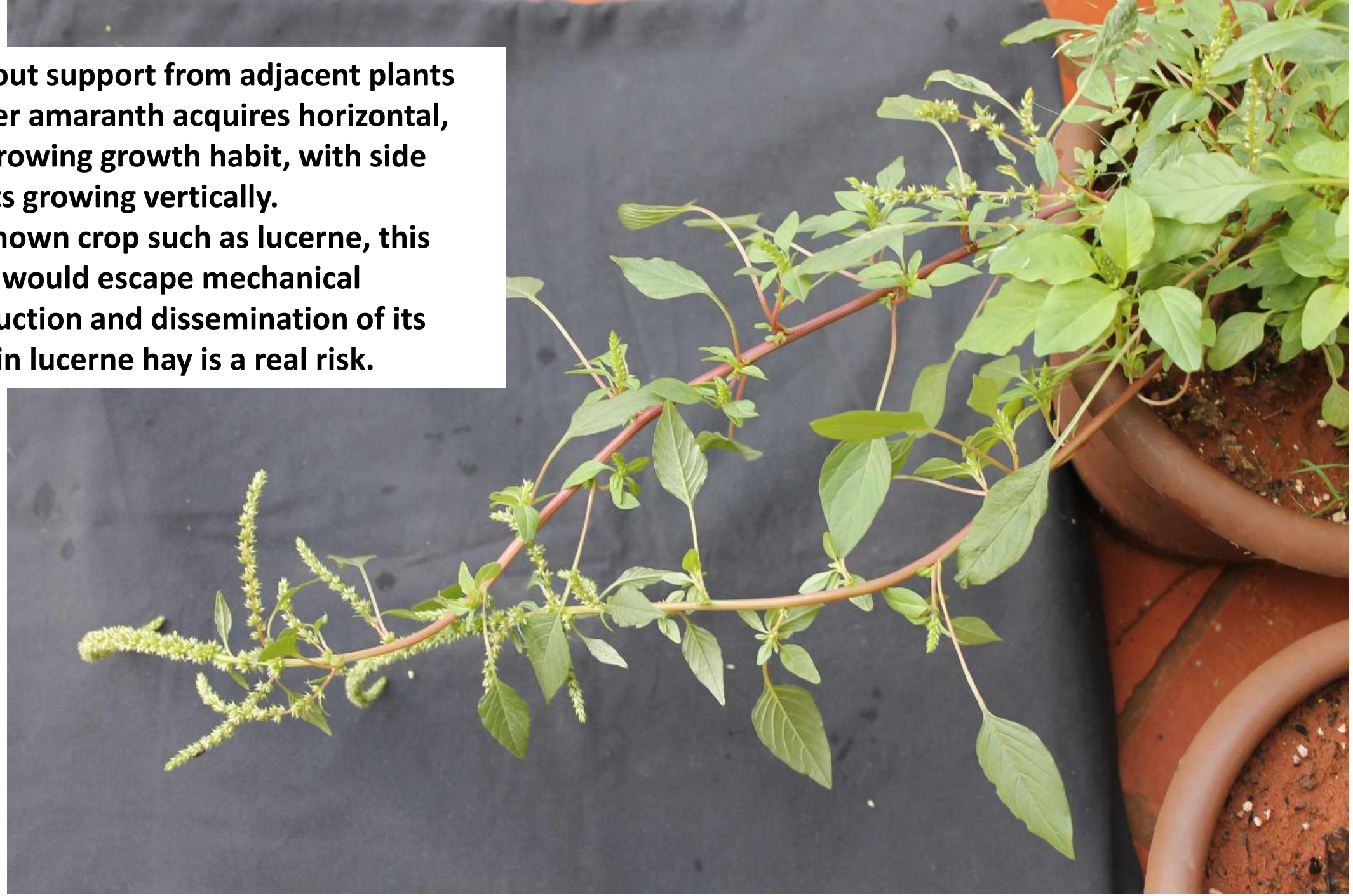
Amaranthus seedling comparison (source: *Nebraska Extension Service,* USA)



NB: Based on this comparison, distinguishing between amaranth species at the seedling stage is rather difficult.

Subsequent photos in this Guide show how the seedlings shown earlier had developed further.

Without support from adjacent plants Palmer amaranth acquires horizontal, flat-growing growth habit, with side shoots growing vertically.
In a mown crop such as lucerne, this plant would escape mechanical destruction and dissemination of its seed in lucerne hay is a real risk.



Flowering parts:

On Palmer amaranth the sexes occur on separate plants, i.e plants are dioecious.

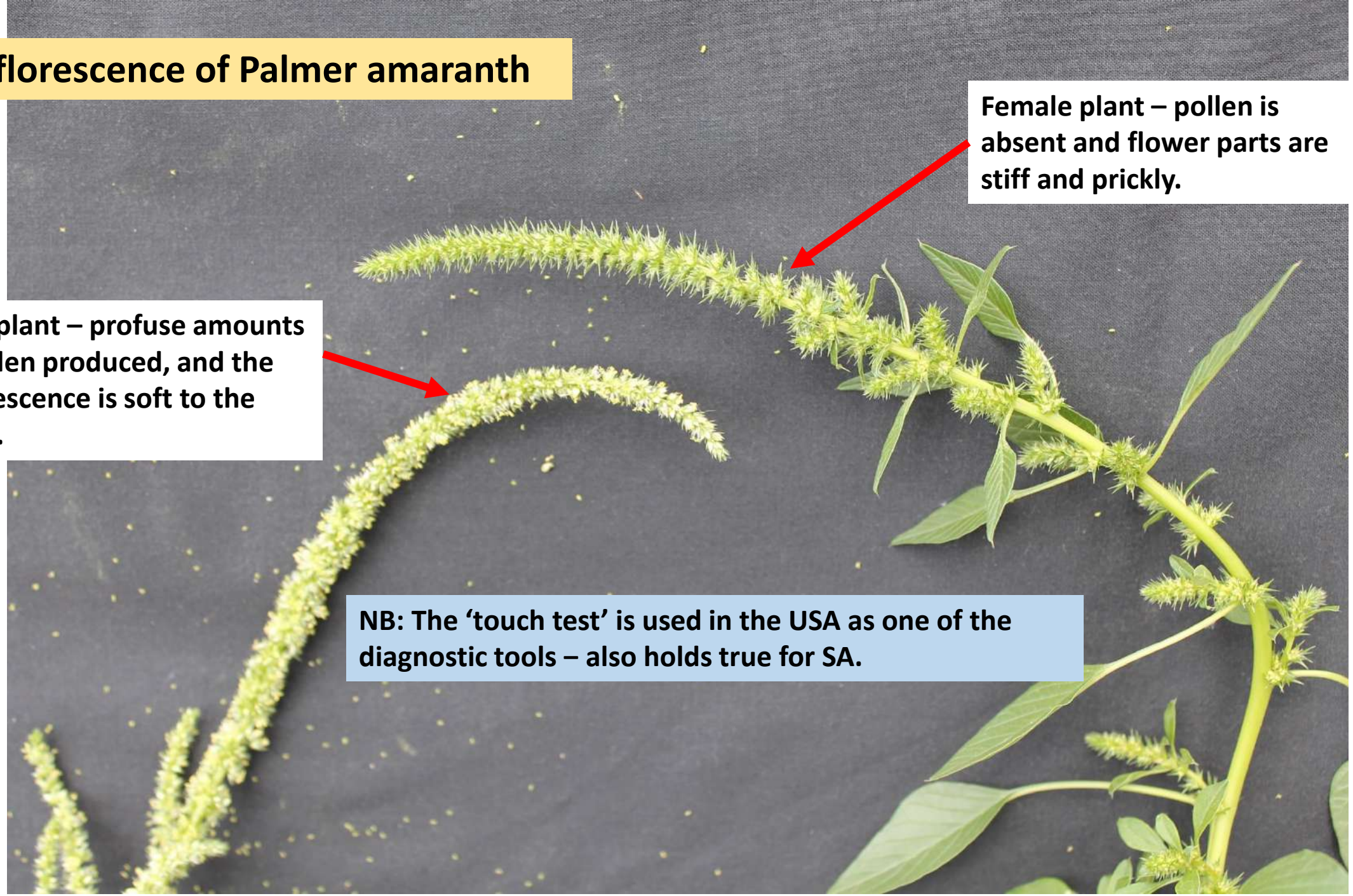
This characteristic is rare amongst amaranth types.

The male plant (both pictures) produces large amounts of pollen.

Palmer amaranth (female plant) in the USA

Palmer amaranth (female) in the RSA

Inflorescence of Palmer amaranth



Female plant – pollen is absent and flower parts are stiff and prickly.

Male plant – profuse amounts of pollen produced, and the inflorescence is soft to the touch.

NB: The ‘touch test’ is used in the USA as one of the diagnostic tools – also holds true for SA.

Male flowers arranged on the spike axis

Pollen smear

Anthers on filaments are clearly discernible under low magnification.

Female inflorescence

Exceptionally well-developed flower parts on female plants of Palmer amaranth — unlikely to be this well developed on other amaranth types.

Palmer amaranth in RSA

Palmer amaranth in USA

Note: Other amaranth types can also have these growths in axils of leaves, but in Palmer amaranth they tend to be better developed and more obvious, particularly on female plants.

Palmer amaranth stems vary in colour; can be reddish/purplish or green, or both combined.
Note: This coloration is also found in other amaranth types.

Important questions/considerations for South Africa

What challenges await us given we now have this formidable weed in our midst?

In the USA this weed spread like wildfire within the relatively brief space of 15 years across the majority of states, this despite concerted efforts led by government to stem the tide. Palmer amaranth is indigenous to the USA, and therefore, it should have natural enemies to contend with there, but this factor apparently did not play in meaningful role in its unsuccessful containment.

Can we contain and even prevent its further spread in the RSA? Can it be eradicated?

Eradication is probably not a practical option, even at this relatively early stage in its distribution. Urgent measures, which includes legislation, is required to contain the spread and impact of Palmer amaranth. Government response is slow, at least at this stage, and the public's response, especially at farm-level, is currently at a disappointingly low ebb. This situation needs to drastically change from apathy to action if we are serious about containing the spread and impact of Palmer amaranth.

Important questions/considerations for South Africa (continued)

How long before Palmer amaranth in SA reaches the damaging levels and impacts on crop yield experienced in the USA?

It has the ability to become an exceedingly harmful weed on the SA Agriculture scene in the need future (circa 2030, based on the USA experience). It has all the makings of becoming our ‘worst-ever’ weed, especially in summer annual cropping systems.

Can we simply take over USA lessons and control measures for Palmer amaranth and apply it locally?

Fortunately, we can learn from the USA experience and need not ‘re-invent the wheel’ as far as the design of control methods and management strategies for Palmer amaranth are concerned. Probably the USA intellectual products will require but minor tweaking to also be effective here. The one lesson which the USA learnt the hard way is that timeous, concerted effort through the team approach is of paramount importance — this, for me, is our biggest challenge.

Is this what awaits us?

The USA situation: Hand-weeding of Palmer amaranth that is necessitated by its evolved resistance to nine (9) extremely important herbicide mechanisms-of-action.

Turn to the next page for the herbicide groups involved

The following *Herbicide Resistance Action Committee* (HRAC) groups are currently (Feb 2022) implicated in a total of 70 proven cases of herbicide resistance in Palmer amaranth globally:

Group 9 (EPSPS-inhibitor, e.g. glyphosate)
Group 2 (ALS-inhibitors, e.g. chlorimuron-ethyl; imazethapyr)
Group 3 (microtubule assembly-inhibitors, e.g. trifluralin)
Group 5 (Photosystem 2 inhibitors, e.g. atrazine)
Group 27 (HPPD-inhibitors, e.g. mesotrione)
Group 14 (PPO-inhibitors, e.g. fomesafen)
Group 4 (auxin mimics, e.g. 2,4-D; dicamba)
Group 15 (long-chain-fatty-acid inhibitors, e.g. metolachlor)
Group 10 (Glutamine-synthetase inhibitor, e.g. glufosinate-ammonium)

Source: http://www.weedscience.org/

Your assistance is important and urgently requested!

Please assist our SAHRI research team at the University of Pretoria, as well as all other entities in South Africa that are concerned and involved with the management of Palmer amaranth, by keeping an eye out for possible populations of the weed, and more importantly, reporting it.

Photos are especially useful for preliminary identification purposes; photos can be sent via Whatsapp or email.

Contact persons in the SAHRI

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SAHRI
South African Herbicide Resistance Initiative

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Several entities and persons are involved with this initiative and campaign, but space limitation allows mention of only the most prominent.

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Thanks are due to *Enterprises UP* for their management role in the SAHRI programme.

We are grateful for the supportive role of the *Herbicide Resistance Action Committee* (HRAC) of *CropLife South Africa*, and the various affiliated agrochemical companies.

'Last but not least' – we thank the crop producers in South Africa for their friendly support whenever we call on their assistance. Your patient indulgence of researcher whims is greatly appreciated.