



Tropane alkaloids

Prevention of contamination in organic crops

In some regions, weeds containing tropane alkaloids are increasingly being found in various crops, mainly corn, millet, buckwheat and sunflowers. They can contaminate the harvested crop with tropane alkaloids which are toxic to warm-blooded animals. To prevent intoxications, the harvested crops have been tested for some time for these plant constituents.

The fight against tropane alkaloid containing plants in the field is of great importance as impurities of the harvested crop can be only partially removed.

The leaflet focusses on a problem that still is largely unrecognized in practice and provides recommendations for the prevention of contamination.



Known active ingredients, new problems

Substances hazardous to health

Tropane alkaloids are natural, secondary phytochemicals, which have been used as active ingredients in pharmaceuticals since ancient times. However, ingesting even relatively small amounts of these substances can result in poisoning. Especially small children and people with heart problems are at risk. Poisoning can lead to restlessness, drowsiness, hallucinations and respiratory paralysis and, in the worst case, can even be fatal.

Tropane alkaloids are present in seven plant families. Those that are of agronomical relevance in Central Europe are predominantly three representatives of the nightshade family (*Solanaceae*): **Black Henbane**, **Jimson weed** and **Belladonna**.



Characteristics of tropane alkaloids

So far over 200 tropane alkaloids have been identified. The active principals in this group, which occur most frequently in plants and contaminate food, include:

Atropine: A racemic mixture of Hyoscyamine and scopolamine; primarily comes from Belladonna, Brazil White Angel's Trumpet (also known as Angels Tears *Brugmansia suaveolens*) and Jimson weed.

Hyoscyamine and **scopolamine:** Both come in varying concentrations in both Datura and Henbane.

To evaluate the toxicity of alkaloids, the European Food Safety Authority EFSA has an acute reference dose (ARfD) as a health-related guideline of 0,016 micrograms per kg body weight (bw), based on the sum of atropine and scopolamine, (group ARfD). This value is currently used for risk assessment of the intake of tropane alkaloids.

For further information see: www.efsa.europa.eu/de/efsajournal/pub/3386.htm

The sap of even a single plant containing tropane alkaloids or individual seeds can lead to contamination of the crop, making it no longer marketable!

In Europe, the most agriculturally relevant tropane alkaloid containing plants are to date:

English Name	Botanical Name	Highest TA concentrations (mg/kg dry matter)	Poisonous parts of the plant (in descending order)
Black Henbane	<i>Hyoscyamus niger</i>	up to 3000 in the seeds	seeds, flowers, leaves
Deadly nightshade	<i>Atropa belladonna</i>	up to 7500 in the seeds	seeds, flowers, leaves
Jimson Weed	<i>Datura stramonium</i>	to 9000 in stems	stems, leaves, flowers, seeds

Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2000) (extract, supplemented)

Other plant families with tropane alkaloid containing species

In addition to the listed plant species from the Solanaceae family there are other tropane alkaloid containing plant families such as the crucifers and convolvulaceae. These species generally have no relevance agronomically but if they occur in marginal strips of cultivated land, they should nevertheless be prevented from spreading further afield.



Bindweed, from the Convolvulaceae family, contains tropane alkaloids, but in much lower concentrations.

Expansion in Central Europe

In recent years, seeds and other parts of tropane alkaloid containing plants were increasingly detected, mainly in threshed seed crops from Austria, Hungary, Ukraine and Romania. In eastern Bavaria and the East German states in particular *Datura* occurs in large amounts to cropland. The problem weeds have been found increasingly in crops such as maize, millet, amaranth, buckwheat, flax, sunflowers and soybeans. These crops germinate late and develop slowly, meaning that the late germinating weeds are poorly suppressed.

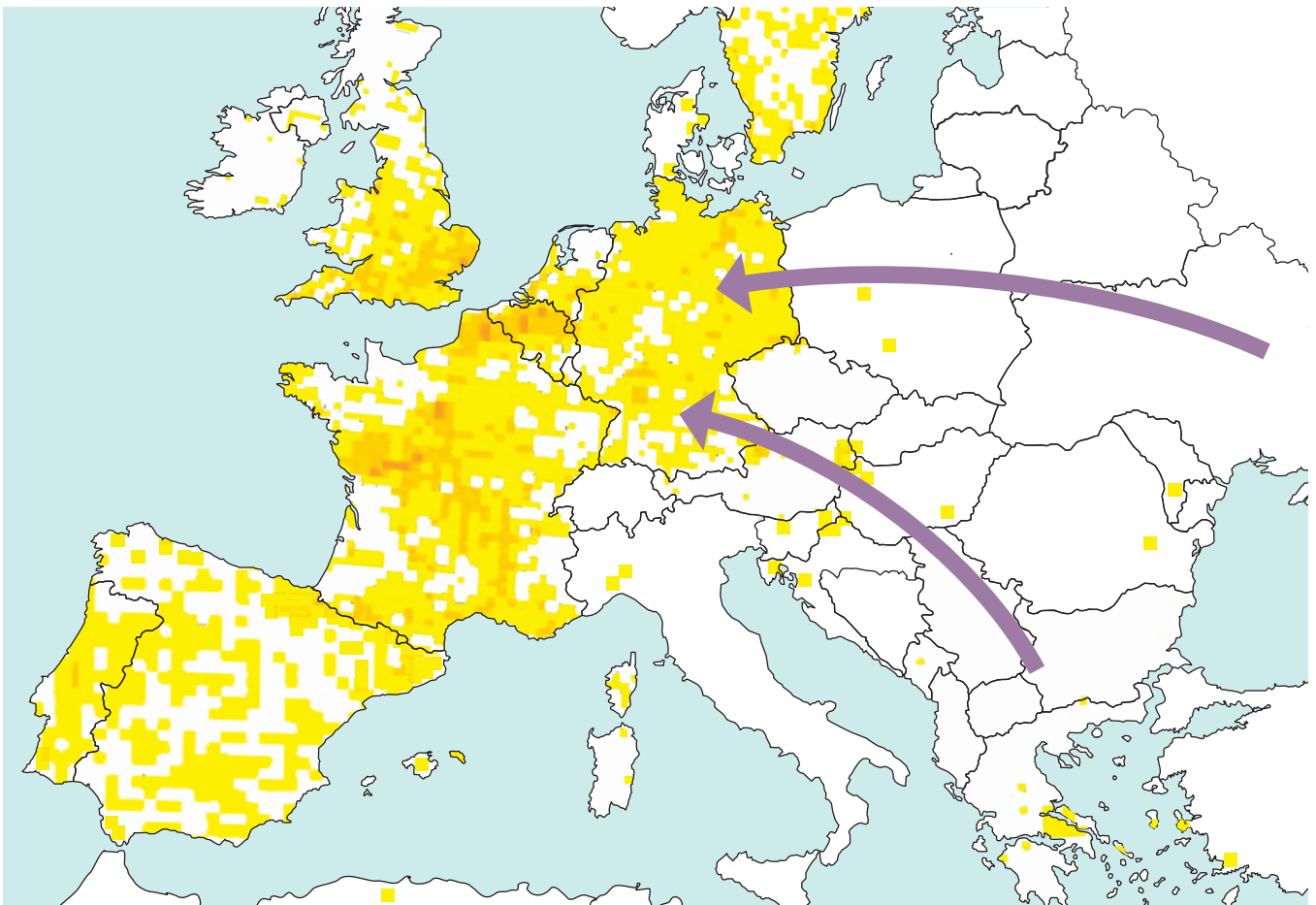
Dispersal into arable land

- › The spreading onto arable land may be via seeds from permanently landscaped flowering strips and extensification areas.
- › In addition contaminated seed from cover crop mixtures can be a portal of entry for the weeds.
- › Entry via compost is conceivable. Especially *Datura* can be introduced with green waste composts from grassland areas or roadside vegetation.



Atropa Belladonna can establish itself on productive agricultural land. Here a young belladonna plant in a parsley field. To prevent seeding into the crop, the belladonna plants should already be removed from the field margins and from areas adjacent to the crop.

Basically, Henbane, *Datura* and *Belladonna* can occur in any culture; for instance in winter cereals after frost damage or in cultures with feeding damage, in which bare areas occur in the crop, where weeds can develop in late spring.



Reported occurrences of *Datura* in Europe according to GBIF (Global Biodiversity Information Facility). Lack of data from Eastern and Southern Europe and Italy can give the impression that *Datura* is not present there. On the contrary, there is evidence that there is a spread of tropane alkaloid containing plants due to climate change from these areas towards north-west Europe.

Most important, agriculturally relevant alkaloid containing plants

Jimson Weed

Datura stramonium



Important facts

- › The entire plant (but most of all the seed) is very toxic!
- › The plants contain hyoscyamine and scopolamine.
- › The seeds survive for up to 40 years in the soil.
- › Related variety: Angels Trumpet (*Datura suaveolens* L.), also a highly toxic ornamental plant.

How is it recognised?

- › Annual, lush growing plant.
- › **Cotyledons:** lanceolate, up to 5 cm long, pointed, gradually narrowing toward the stem, clear midrib.
- › **True leaves:** long-stemmed, ovate, pointed, dark green on top, bottom leaves up to 20 × 20 cm in size.
- › **Stem:** erect, hairless, forked, up to 150 cm long.
- › **Flowers:** large, funnel-shaped, upright, five pointed, white to light blue-violet.
- › **Fruit:** contains four segments, spiny, upright capsules which open at the onset of maturity.
- › **Seeds:** about 4 mm × 3 mm in size, black, kidney-shaped; 100–800 seeds per capsule; 1300–1500 seeds per plant in dense stands and up to 30'000 seeds in freestanding plants. Immature seeds ripen on the ground.

Where found?

- › Worldwide in temperate zones above all in root crops, vegetable and spice crops and home gardens.
- › Preferably on nitrogen-rich soil; but also found on rubble, wasteland areas and roadsides.
- › Heat loving.

Main germination time – Flowering – Seed maturity

- › Main germination time: mid-May to mid-June.
- › Flowering: early June to late August.
- › Seed maturity: August / September.

How to combat?

- › Cut out all *Datura* plants (including plants with immature seed capsules) by hand hoe.
- › Alternate between spring and autumn crops.
- › If possible include perennial clover in the crop rotation.

Black Henbane

Hyoscyamus niger



Important facts

- › All plant parts contain alkaloids.
- › Glandular hairs on the stem and the leaves lead to skin irritation after direct contact.
- › The seeds can survive in the ground for up to 5 years.
- › Plant can grow to 80 cm tall.

How is it recognised?

- › Annual or biennial plant with sticky glandular hairs on leaves and stems with an unpleasant odour.
- › **Cotyledons:** elongated oval, green, with visible veins.
- › True leaves sticky, shaggy haired.
- › **Stem:** sticky, shaggy haired, oblong, oval, pale green, 15–20 cm long, pinnate, coarsely toothed.
- › **Flowers:** yellow, with purple veins, 2–3 cm long, star-shaped calyx.
- › **Fruits:** capsule-like, maturing from August to October.
- › **Seeds:** about 1,0–1,3 × 1,0 mm in size, grey-brown, pitted, partly kidney shaped and flat; up to 500'000 seeds per plant.

Where found?

- › Typical ruderal plant.
- › On nutrient and nitrogen-rich sandy or clay soils.
- › In leafy arable crop fields in warmer areas, on roadsides, stone walls etc.

Main germination time – Flowering – Seed maturity

- › Main germination: April / May.
- › Flowering time: June to October.
- › Seed maturity: August to October.

How to combat?

- › Hand hoe the Henbane plants when still green, removing them as early as possible (wear gloves!).
- › Be careful using mechanical methods: The roots have propagating buds similar to dock plants! Cutting the roots can promote plant multiplication and growth.

Deadly nightshade

Atropa belladonna



Important facts

- › So far of little importance in arable crops.
- › All parts of the plant are highly toxic; consumption can be fatal.
- › The seeds maintain germination for up to 100 years. Usually about 60% of the seeds are viable.
- › Grows predominantly on rich limestone, gneiss and porphyry soils, in forest glades, deciduous and coniferous forests and on fallow land.

How is it recognised?

- › Perennial, herbaceous plant, up to 2 metres tall.
- › In the summer, green flower buds, brownish-purple flowers, green unripe berries and black ripe berries are present.
- › Taproot up to one metre long.
- › **Cotyledons:** broad, almost heart-shaped, with visible veins.
- › **True leaves:** short-stemmed, deciduous, up to 15 cm long, oval and pointed, green-brownish with pronounced veins, which have fluffy hairs on the underside.
- › **Stem:** blunt-edged, often tinged somewhat reddish, slightly grooved, erect and finely haired, branched.
- › **Flowers:** brown-violet coloured chalice consisting of five calyx lobes, hairy on the outside and greenish.
- › **Fruits:** 1-1.5 cm long, tomato-shaped, glossy black, numerous (also poisonous with only 1 Berry).
- › **Seeds:** oval, brown, kidney-shaped and hard, with a textured surface.

Where found?

- › In clearings in deciduous and coniferous forests.
- › On fallow land.
- › Grows at altitudes of 1'700 m above sea level.

Main germination time – Flowering – Seed maturity

- › Main germination time: March / April (needs vernalisation).
- › Flowering time: June to August.
- › Seed maturity: August to October.

How to combat?

- › Be careful during harvest that any Belladonna plants along the forest margin are not harvested together with the crop.

Inspection and control

Inspect crops at risk before canopy closure!

In classical organic cereal production with a diverse crop rotation, weeds with the exception of field bindweed, play no economic role. In the control of tropane alkaloid containing plants attention needs to be given primarily to late crops, since their sowing time coincides with the germination time of the seed weeds. Since the weeds germinate after the completion of weed control, they can usually develop undisturbed in these crops. **Therefore, monitoring particularly late cultures after completion of the mechanical weed control and before canopy closure is essential!** So far there is no alternative to walking the rows of crop.

What to look out for?

- › In tall crops such as corn or millet inspection is best done when the culture is about waist high and several rows can be viewed at once.
- › In low-growing crops such as linseed, soya or buckwheat the weeds are more easily found because they are more visible. In soy bean and buckwheat the weeds are more likely to be found close to threshing in the mature crop.
- › Cover crops are also to be inspected.
- › Where products are delivered into sensitive marketing channels, not only the crops in question must be checked, but all surfaces in the operation as well! This prevents the problem weeds spreading via their seeds and germinating later in crops at risk



Also field margins need to be regularly checked for plants containing tropane alkaloids.

Remove problem weeds from the fields

If discovered in the field inspection, tropane alkaloids containing weeds must be removed from the field. If recognising the plants is difficult, they can be photographed and compared with images in publications or forwarded to the advisory service.

How to proceed?

- › Remove individual plants best by pulling/digging out, or cutting off. In the case of Henbane it's necessary to remove the complete root system, because even small pieces can sprout again. The use of discs and rotary tillers can exacerbate the problem.
- › In flax and other crops with a weak ability to suppress weeds, the weeds are best removed by hand hoe.
- › Hand hoeing is useful also after a late mechanical weeding pass because the weeds in the row are not removed by the inter-row weeder.
- › A second, later weeding can ensure that the crop is free from tropane alkaloid containing plants, and can therefore be very efficient.
- › As is usual also with dock plants, collect the plants that have been removed in a large closed plastic bag (garbage bag) and dispose of them properly.



Ideally, when weeding before crop canopy closure, weeding should also be carried out in the row.

For recurring problems check and adjust the crop rotation

If tropane alkaloids containing weeds reoccur again and again on the operation, the rotation should be reconsidered. It may be useful to have a break from late germinating crops such as corn or millet.

What to look out for?

- › Limit the proportion of risk crops in rotation to a maximum of 25%.
- › Make sure that winter crops predominate over spring germinating crops in the rotation.
- › Do not cultivate two at-risk crops successively. After the occurrence of problem weeds (e.g. in corn), grow a crop that guarantees a rapid canopy closure.



Winter cereals suppress late germinating problem weeds better than spring crops.

Combatting weeds by tillage in summer, as is recommended against thistles or dock, promises little success against plants containing tropane alkaloids. The method combats newly germinated plants, but cannot completely eliminate the weeds because of the large seed bank in the ground and its viability.

Prevent introduction

To guard against contamination of crops with weeds containing tropane alkaloids, the problem plants should be prevented from arriving on the farm for instance in compost or species-rich cover crop mixtures.

Therefore, when there is increased use of cover crops, these crops should also be monitored. Many mixtures are multiplied in warmer areas where plants containing tropane alkaloids occur more frequently. Despite testing seed mixtures for foreign seed material, contamination cannot be excluded.

Harvesting and treatment procedures

Avoid contamination with green plants

When plants containing tropane alkaloids are present at harvest, this can lead to contamination of the crop with high concentrations of tropane alkaloids through plant sap leakage wetting the crop. Due to the late germination and development of for example *Datura*, it is still deep green and thus fully in the growth phase with strong sap flow during the harvest of say maize. The sap is forced out of the plant in the combine harvester and soaks the crop being harvested. To avoid this, not a single plant must be present in the crop. This reinforces how essential the pre-canopy closure inspection is.

For crops that are cut well above the ground for threshing e.g. cereals, maize or millet, short plants such tropane alkaloid containing Black Henbane or black nightshade can be “over threshed” i.e. left standing in the stubble by harvesting above them. These plants reach a maximum height of one metre. Thus, contamination of the crop will be largely prevented. With *Datura*, however this is not possible due to its mature height of up to two metres.

The “over threshing” should be used only as an emergency measure. Infested fields must be managed with an adaptation of the crop rotation, breaks in crop cultivation etc. in any case in the future.

Avoid contamination with seeds

If at the harvest of an arable crop, seeds of weeds containing tropane alkaloids are threshed as well, they may under some circumstances be ground with the crop and thus contaminate processed product batches.

If the grain size of the crop is different from that of the weeds, the problematic seeds may be screened out. This is possible with crops such as corn, soybeans and sunflowers. If the grain sizes are not markedly different, it is difficult to separate the weed seeds.

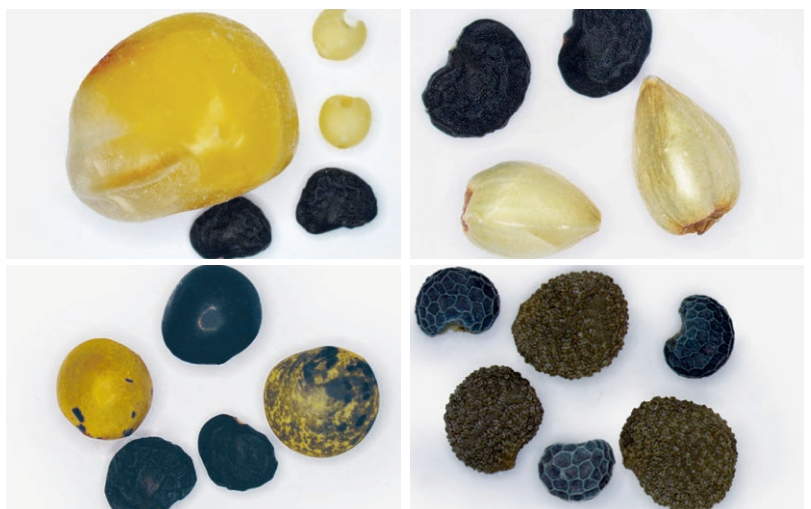
When cleaning the crop with a cylinder or gravity table, contamination may not necessarily be excluded. Optical seed cleaning methods effect a more thorough cleaning. It is therefore worthwhile to seek effective solutions for an optimal separation of the weed seeds in cooperation with processors and other suppliers.



Removing plants containing tropane alkaloids before harvesting is often not economically feasible. Therefore, weed control is of great importance before canopy closure.

What to look out for in the preparation of the crop?

- Identify problem lots early.
- Clean crops as early as possible to avoid contamination by abrasion.
- Crops at risk should be moved as little as possible for the same reason. Batches that are shifted a lot could produce contamination by abrasion.
- Aspiration may remove loosely adhering dust. Dusts adhere strongly to wet grain.
- Combine cleaning principles. Cleaning passes can possibly be repeated.
- If necessary, share seed-cleaning equipment, hire it and/or develop machinery syndicates.
- For raw materials that require hulling, intensive pre-cleaning of the raw material before hulling or other further processing steps is recommended.



Top left: Datura seeds (dark) besides millet and maize seeds; top right: Datura and buckwheat seeds; bottom left: Datura seed and lentil seed; bottom right: Henbane seeds (brown) and poppy seeds.

Depending on the distribution chain, processors respond differently to the presence of tropane alkaloids. For forage maize for instance, every consignment is not examined for tropane alkaloids. On the other hand, each individual batch of corn, which is grown for food or especially for baby food, is checked for tropane alkaloids.

If tropane alkaloids limits are exceeded – whether statutory or those of the processor – the batch will not be accepted.



At risk seeds are examined at crop acceptance for contamination with tropane alkaloids.

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