

# Tropical Forages

## *Trifolium* spp. African annual

### Scientific name



*Trifolium decorum* Chiov.

*Trifolium mattirolianum* Chiov.

*Trifolium quartinianum* A. Rich.

*Trifolium rueppellianum* Fresen.

*Trifolium steudneri* Schweinf.

*Trifolium tembense* Fresen.

*Trifolium usambarense* Taub.

### Synonyms

***T. rueppellianum*:** *Trifolium subrotundum* Steud. & Hochst. ex A. Rich.

***T. tembense*:** *Trifolium umbellulatum* A. Rich.

### Family/tribe

Family: *Fabaceae* (alt. *Leguminosae*) subfamily:

*Faboideae* tribe: *Trifolieae*.

### Morphological description

***T. decorum*:** Herbaceous annual to 50 cm tall, stems ascending, glabrous. Leaflets ovate to suborbicular, 30–45 × 18–28 mm, narrowed towards base and with finely toothed margins, especially in the upper part. Petioles up to 120 mm long on lower leaves, upper leaves short-stalked. Stipules ovate-acuminate up to 10 mm. Inflorescences almost round 15–25 mm diameter, 6–15-flowered, long pedunculate of 20–60 mm borne in the axils of leaves. Calyx about 5 mm long, 15–25 nerved; lobes triangular, 2–3 mm long, sparsely pilose at the margins. Corolla purple, 10–14 mm long, twice as long as calyx or more, standard slightly longer than the wings and keel. Pods 6 mm long and 3-5 seeded. Seeds oval, brown and usually 1.5 × 2 mm.

***T. mattirolianum*:** Herbaceous annual to 30 cm tall, erect or decumbent, branching all along deeply grooved stems, glabrous. Leaflets obovate, up to 16 × 14 mm, usually truncate or emarginate at the apex; margins finely spiny-toothed and veins prominent. Petiole up to 50 mm long, in upper leaves much shorter. Stipules with acuminate tips usually united to leaf stalks for about half of length, margins smooth or ragged. Inflorescences 10–20 mm diameter, globose, many-flowered. Pedicels about 0.5 mm long; peduncle long, glabrous. Calyx glabrous, 11-nerved, becoming somewhat inflated and constricted at the throat; lobes abruptly narrowed near the base, subulate, 2–6 mm long. Corolla purple or rarely white, 7–10 mm long; standard longer than the wings and keel. Pods about 3 mm long, enclosed in calyx tube, 1–2-seeded and not dehiscent. Seeds oval, brown and usually up to 1.5 × 2 mm.



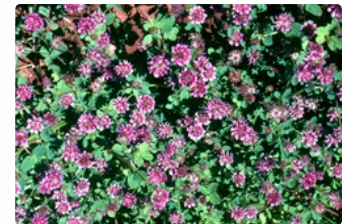
*T. decorum*, an herbaceous annual with glabrous stems ascending to 50 cm tall (CPI 100016)



*T. decorum* capitulate inflorescence with 6-15 flowers (CPI 100016)



*T. decorum* seeds



*T. mattirolianum* an erect or decumbent herbaceous annual to 30 cm tall (CPI 32236)



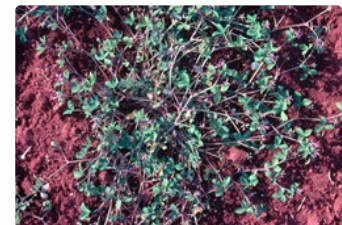
*T. mattirolianum* foliage and inflorescences (CPI 37936)



*T. mattirolianum* large globose many flowered inflorescence (APG 63683)



*T. mattirolianum* seeds



*T. quartinianum* herbaceous, erect or spreading annual to 60 cm tall (CPI 100017)



*T. quartinianum* foliage



*T. quartinianum* globose inflorescences; buds (top centre and left) showing involucre of bracts (ILRI 16358)

***T. quartinianum*:** Herbaceous annual to 60 cm tall, subglabrous, with stout, erect or spreading, grooved and branched stems. Leaflets narrowly oblong, approximately 52 × 16 mm with fine teeth. Petioles up to 40 mm long on lower leaves. Stipules 10–20 mm long with narrowly triangular tips. Inflorescences about 20 mm in diameter and globose, long-pedunculate, bracts several-nerved forming an involucre, outer bracts ovate, lobed or toothed, up to 7 mm long. Calyx about 40-nerved, lobes 4–7 mm long, ovate and overlapping at the base, drawn out into subulate points. Corolla purplish red, occasionally white, 11–12 mm long. Pods about 4 mm long and 4–5 seeded. Seeds oval, brown and usually 1.5 × 1 mm.



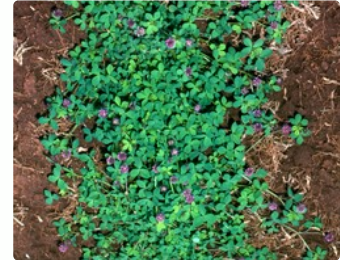
*T. quartinianum* pods and seeds



*T. rueppellianum* pods and seeds



*T. quartinianum* seeds



*T. rueppellianum* an herbaceous erect or decumbent annual to 50cm tall (P 14484)

***T. rueppellianum*:** Herbaceous annual to 50 cm tall, stems glabrous or pilose, erect or decumbent. Leaflets oblong or obovate, approximately 24 × 18 mm, rounded to emarginate at the apex, glabrous or sparsely pilose, toothed margin. Petiole up to 7 cm long, in upper leaves short or wholly united with stipules. Stipules up to 15 mm long, united with petiole for two thirds of their length, with acuminate tips, entire. Inflorescences globose, usually 15–30-flowered, about 17 mm across. Pedicels up to 2 mm long. Peduncle long, pilose near the top, bracts minute. Calyx glabrous or pilose, usually 11-nerved; lobes abruptly narrowed near the base, subulate for most of their length, 2–5 mm long and sometimes exceeding the corolla. Corolla purple or rarely white, 5–8 mm long. Pods 3–4 mm long and usually 2–3-seeded. Seeds oval, brown and usually 1.5 × 1 mm. This is a very variable species and several distinct ecotypes have been identified.



*T. rueppellianum* usually 15-30 flowered globose inflorescence (APG 63734)



*T. rueppellianum* seeds

***T. steudneri*:** Herbaceous glabrous annual to 60 cm tall with many erect to spreading, grooved stems. Leaflets narrowly elliptic, approximately 40 × 8 mm, margins finely toothed. Petioles up to 50 mm long with upper leaves on shorter petioles. Stipules up to 25 mm long with narrowly triangular tips. Inflorescences globose, about 10–20-flowered, up to 13–20 mm across, short-pedunculate. Bracts several-nerved forming an involucre, outer bracts abruptly and sharply pointed, up to 7 mm long, inner bracts oblong, 3 mm long. Calyx about 40-nerved, glabrous or occasionally pilose; lobes triangular, 2–3 mm long. Corolla purplish, 7–8 mm long, sometimes with filiform tips. Pods 4 mm long and usually 2–4-seeded. Seeds oval, brown and usually 1.5 × 2 mm.



*Trifolium steudneri* a glabrous herbaceous annual to 60 cm tall



*Trifolium steudneri* 10-20 flowered globose inflorescence; distinctive narrowly elliptic leaflets

***T. tembense*:** Herbaceous annual, stems numerous, erect or spreading, sometimes rooting at the nodes, glabrous or nearly so. Leaflets elliptic or obovate, approximately 20 × 10 mm, narrowed at the base and with toothed margins. Petioles up to 5 cm long, in upper leaves very short or wholly united with stipules. Stipules about 15 mm long and with the free part abruptly contracted to a fine point. Inflorescences usually globose, 3–16-flowered, up to 23 mm across, long pedunculate. Calyx 5–7 mm long, sparsely pilose at margins, 11-nerved; lobes about 5 mm long, twice as long as tube and gradually narrowing from the 1.5 mm wide base, with broad scarious margins. Corolla purple or rarely white; standard longer than wings and keel and



*Trifolium steudneri* pod cluster seed head



*Trifolium steudneri* pods and seeds



about 9 mm long, abruptly narrowed above the middle into an oblong, truncate, down-curved tip. Pods 5–8 mm long, glabrous, 4–6 seeded. When ripe, pods dehisce along the top prominent margin for seed dispersal. Seeds oval, brown and usually 1.5 × 1 mm.

***T. usambarensis*:** Annual or short-lived herbaceous perennial with stems erect or ascending, to 1 m long, branching throughout, glabrous below, sparsely pilose above, often rooting at the lower nodes. Leaflets cuneate-oblongate, 6–22 × 3–7 mm, usually rounded at the apex and narrow at the base, glabrous or nearly so. Petioles united with stipules for all their length; stipules about 10 mm long with the free part triangular-acuminate. Inflorescences globose or elongate ovoid borne both terminally and in the axils of leaves, many-flowered, 9–18 × 7–13 mm. Peduncle to 6 cm long, pilose above; bracts minute. Calyx usually pilose, 10–11-nerved; lobes subulate, about 3 mm long. Corolla purple (rarely white) with broad elliptical standard, 4–7 mm long. Pods 2–3 mm long and usually 2-seeded. Seeds oval, brown and usually 1.5 × 1 mm.

## Common names

### ***T. quartinianum***

*English:* Quartin's clover

### ***T. rueppellianum***

*English:* Rueppell's clover

### ***T. steudneri***

*English:* Steudner's clover

### ***T. tembense***

*English:* Tembien clover

### ***T. usambarensis***

*English:* Usambara clover; *German:* Usambara-Klee; *Chichewa, Malawi:* there

## Distribution

*T. decorum*, *T. mattirolianum*

**Native:** *Africa:* Ethiopia

*T. quartinianum*

**Native:** *Africa:* Eritrea; Ethiopia; Uganda

*T. rueppellianum*

**Native:** *Africa:* Cameroon; Democratic Republic of the Congo; Equatorial Guinea (Bioko); Ethiopia; Kenya; Rwanda; Sudan; Tanzania.

**Cultivated:** Widespread in tropical Africa.

*T. steudneri*

**Native:** *Africa:* Eritrea; Ethiopia; Kenya; Uganda

*T. tembense*

**Native:** *Africa:* Democratic Republic of the Congo; Eritrea; Ethiopia; Kenya; Rwanda; Tanzania; Uganda

*T. usambarensis*



*T. tembense* an herbaceous erect or spreading annual, sometimes rooting at the nodes (CPI 24978)



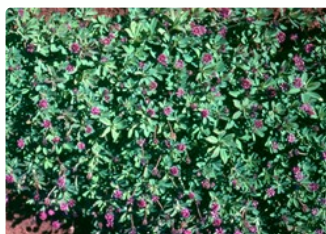
*T. tembense* habit, foliage and inflorescences (CPI 37948)



*T. tembense* pods and seeds



*T. tembense* seeds



*T. usambarensis* an herbaceous annual (or short-lived perennial) with erect or ascending stems, often rooting at the lower nodes (CPI 25377)



*T. usambarensis* inflorescence and leaves; leaflets cuneate-oblongate (P 14621)



*T. usambarensis* seeds

**Native:** Africa: Burundi; Cameroon; Democratic Republic of the Congo; Ethiopia; Equatorial Guinea (Bioko); Kenya; Malawi; Nigeria; Rwanda; Tanzania; Uganda; Zambia

## Uses/applications

### Forage

The East African annual *Trifolium* spp. are considered to make a valuable contribution in native pasture grazing systems, with potential for use as annual legumes for pasture improvement in high altitude areas. They can be used for intercropping with wheat or barley in tropical highlands to improve quality of residues for livestock feed, and can also be used for hay and silage production.

### Environment

Used for intercropping with wheat or barley in tropical highlands to improve soil nitrogen.

### Other

These are all excellent species for bee keeping and honey production.

## Ecology

### Soil requirements

These *Trifolium* spp. are well adapted to a wide range of soils from heavy clay vertisols and nitosols to loams and sandy loams, mostly from pH 4 to 8. *T. quartinianum* grows particularly well on acid soils. *T. tembense* can tolerate low P.

### Moisture

Although best adapted to good moisture conditions and tolerant of seasonal waterlogging, many of the annuals, particularly *T. steudneri*, are also quite drought tolerant by virtue of a deep root system. Annual rainfall in natural range: *T. decorum* (1,000–2,000 mm); *T. mattirolianum* (1,100–2,000 mm); *T. quartinianum* (800–1,900 mm); *T. rueppellianum* (700–2,000); *T. steudneri* (700–2,000 mm); *T. usambarensis* (1,200–1,600 mm). *T. tembense* is regarded as a good legume for seasonally waterlogged areas.

### Temperature

This group of African clovers is found in the cool, largely frost-free tropical highlands. Although well adapted to the highlands, ground temperatures below 7 °C during the growing season retard growth and an elevation of 2,600 metres above sea level is about the upper limit for good forage production in tropical areas. Altitude range for the native area of the various species: *T. decorum* (1,800–3,000 m asl); *T. mattirolianum* (1,300–2,700 m asl); *T. quartinianum* (1,500–2,600 m asl); *T. rueppellianum* (1,500–3,650 m asl); *T. steudneri* (1,100–2,800 m asl); *T. tembense* (1,400–3,200 m asl); *T. usambarensis* (1,600–2,700 m asl); *T. mattirolianum* (1,300–2,700 m asl). *T. decorum* is one of the best *Trifolium* species for use in higher altitudes during the rains when there is no frost. *T. steudneri* can be grown at lower altitudes than any of the other Ethiopian indigenous clovers and is best suited to middle altitudes of around 1,800 m asl with moderate rainfall.

### Light

Competition for sunlight can lead to domination of stands by some of the clovers that express rapid regrowth or tall stature.

### Reproductive development

Time to maturity has been tested in the equatorial uplands with approximately 12-hour days. *T. decorum* flowers from 70 to 110 days after planting (dap), a couple of leafy later flowering genotypes appearing to have potential as fodder (see 'Promising accessions'). *T. mattirolianum* flowers from 94 to 140 dap, usually close to the end of the rains, seeds maturing into the dry season. Unlike the morphologically similar *T. rueppellianum*, *T. mattirolianum* is allogamous. *T. quartinianum* flowers from 65 to 100 dap, producing large flowers to attract bees for pollination. *T. rueppellianum* flowers at the end of the rains, from 60 to 100 dap; autogamous and high seed producers. *T. steudneri* is fast maturing and flowers in August during the wet season (50–90 dap). *T. tembense* is early maturing and flowers near the end of the rains (65–110 dap). *T. usambarensis* is very early flowering, 50–90 dap.

### Defoliation

The annual clovers tolerate moderate to high grazing pressure. Grazing late in the season reduces seed heads leading to reduced regeneration in following years. They respond well to defoliation and compete better with grasses when the pasture is cut to about 5–10 cm. *T. tembense* makes good quality hay, although leaf drop occurs when mature.

### Fire

Fire is rarely an issue in areas where *Trifolium* spp. are found.

## Agronomy

Guidelines for establishment and management of sown forages.

### Establishment

While most are usually sown at 1–2 kg/ha, *T. tembense* is sown at 5–6 kg/ha. Seeds are hard and require scarification before planting to

ensure uniform germination. Seedbeds should be well prepared to a fine, firm tilth. Seeds are best sown just below the surface, lightly covered and rolled. Seeds can also be sown directly into grass stubble, with no further seedbed preparation, and covered using a roller or by light disking. Germination occurs in about 5–7 days and young seedlings can be observed about 2 weeks after planting.

*T. quartinianum* is somewhat promiscuous in rhizobium requirements nodulating on several inoculum strains, unlike the others that are usually highly specific. In their native habitat they nodulate readily with native rhizobia and nitrogen fertilizer is not required. *T. decorum* fixes the equivalent of 85–112, *T. quartinianum* 80–120, *T. rueppellianum* 80–100 and *T. steudneri* 40–65 kg/ha N. Although this is low compared with the other African annual clovers, nitrogen fertilizer is still not required.

## Fertilizer

Fertilizer (di-ammonium phosphate (DAP)) is generally recommended when grown on poor soils at a rate of 25–30 kg/ha P with large dry matter yield increases seen in response to P application on poorer soils. The application of 30 kg/ha P can lead to a significant increase in root weight and the number of nodules in *T. rueppellianum*, *T. steudneri* and *T. tembense*.

## Compatibility (with other species)

Annual clovers combine well with other annual clovers and short-growing grasses. When grown together with *T. quartinianum*, grasses were reported to accumulate more dry matter, crude protein and have higher IVDMD than when the grass is grown as a monoculture. They have been used successfully for intercropping with wheat and barley without significant reductions in grain and straw yields.

## Companion species

Grasses: *Cenchrus clandestinus*, *Cenchrus geniculatus*, *Cenchrus sphacelatus*, *Cynodon dactylon*, *Setaria sphacelata*.

Legumes: *Lotus uliginosus*, *Neonotonia wightii*, *Trifolium decorum*, *T. quartinianum*, *T. repens*, *T. rueppellianum*, *T. semipilosum*, *T. steudneri*, *T. tembense*, *T. usambarense*.

## Pests and diseases

Under cool damp conditions seedlings are sensitive to damping-off disease, mainly caused by the soil-borne fungal pathogen *Pythium* spp., which results in rapid seedling death. Plants are susceptible to red spider mites (*Tetranychus urticae* Acarina: Tetranychidae) when grown in the greenhouse or shade areas. *T. rueppellianum* is susceptible to root-knot nematode, *Meloidogyne incognita*.

## Ability to spread

Plants tend to dry and die back after seed set, but hard seeds may be dispersed by water and small animals and remain in the soil for several years allowing pastures to regrow annually. Substantial seed reserves of *T. quartinianum*, *T. rueppellianum*, *T. steudneri* and *T. tembense* were revealed in the top 5 cm of soil after 4 years of fallow in Ethiopia.

## Weed potential

These species are usually intensively grazed, reducing the opportunity for seed set and dispersal unless managed for seed production. The high rhizobial specificity of most species is a limitation to spread outside their natural environment.

## Feeding value

### Nutritive value

Nutritive value varies with genotype, age at harvest and environment. Clovers should be cut and fed before flowering, after which quality declines as leaf drop occurs. Some indicative values, mainly derived from the Sub-Saharan Africa Feed Composition Database (SSA Feeds), are: *T. decorum* *in vitro* dry matter digestibility (IVDMD) 70–80%, crude protein (CP) 14–22%; *T. quartinianum* IVDMD 60–80%, CP 13–21%; *T. rueppellianum* IVDMD 70–75%, CP 15–20%; *T. steudneri* IVDMD 60–80%, CP 13–24%, *T. tembense* IVDMD 60–80%, CP 10–24 (30% less at full flowering stage in some accessions).

### Palatability/acceptability

In general, these species are highly palatable. Palatability of *T. rueppellianum* and *T. tembense* can be rather low when the plants are young but improves as they mature. After maturity, leaf drop is common in *T. tembense* and so the resulting hay has a high proportion of stem, although this did not affect acceptability by either sheep or dairy cattle.

### Toxicity

These species may contain significant concentrations of saponins, which can cause bloat if animals are allowed to graze large quantities. Usually, grazing on *Trifolium* pastures is controlled to avoid these problems.

### Feedipedia link

<https://www.feedipedia.org/node/660> (*T. tembense*)

## Production potential

### Dry matter

In general, at least 1,000 mm rainfall is needed for high forage production. Yields are variable and dependent on soil temperature, rainfall, fertility and genotype. *T. decorum* can commonly produce annual dry matter yields of 3–4 t/ha (and up to 6 t/ha with application of 40 kg/ha P). *T. quartinianum*, a vigorous, fast growing species with tall plants and large leaves, and one of the most productive of the Ethiopian clovers, can produce good yields within 3 months, 3–4 t/ha DM common, and up to 7.8 t/ha reported. Peak yields of *T. rueppellianum* are obtained about 120–130 days after sowing and usually decline as plants age due to leaf drop, commonly 2–3 t/ha DM and up to 5 t/ha with application of 40 kg/ha P. *T. steudneri* is fast-growing, producing yields of 2–3 t/ha DM, and up to 6 t/ha with application of 40 kg/ha P (some genotypes are quite small and drop leaves rapidly). Peak yields of *T. tembense* are obtained about 120 days after sowing, usually declining as plants age due to leaf drop. Yields of 3 t/ha DM are common, and up to 6.8 t/ha with application of 40 kg/ha P.

## Animal production

*T. decorum*, *T. steudneri* and *T. tembense* forage have been shown to be beneficial for dairy and beef cattle, and for horses. Hay containing 30% *T. tembense* increased milk yield by around 10%. Care should be taken not to use these as the sole feed to avoid bloat.

## Genetics/breeding

Diploid,  $2n = 16$ . Breeding to date has largely constituted selection among wild ecotypes. *T. rueppellianum* and *T. steudneri* plants are autogamous. *T. tembense* flowers are small and only few in an inflorescence. *T. rueppellianum* can form fertile hybrids with the near-identical *T. mattirolianum*.

## Seed production

At least 1,300 mm rainfall is needed for good flowering and seed production. Plants flower at the end of the rains, although some genotypes are very late flowering and plants can flower well into the dry season if there is sufficient residual soil moisture. Pollination is by bees. Species are hard-seeded and so store well. Indicative seed yields are: *T. decorum*, 500 kg/ha (up to 750 kg/ha with 35 kg/ha P on a good stand); *T. quartinianum*, 600 kg/ha (up to 800–900 kg/ha with 35 kg/ha P); *T. rueppellianum*, 200–300 kg/ha direct headed, possibly losing some seed due to pod shatter (up to 750 kg/ha from some genotypes with application of 40 kg/ha P); *T. steudneri* up to 800–900 kg/ha with 35 kg/ha P; *T. tembense*, up to 1,000 kg/ha with application of 35 kg/ha P (pods dehiscent when ripe and seeds can be lost unless harvest is timely).

## Herbicide effects

While herbicide effects on these species have not been tested, effect of herbicides on more commonly cultivated African *Trifolium* spp. such as *T. alexandrinum* may give some indication of their tolerances and susceptibilities.

## Strengths

- Good potential for hay production on sites with acidic soils subject to seasonal water-logging with moderate inputs of P fertilizer.
- Widely adapted to acid soils and low fertility in the tropical highlands.
- Well-adapted to waterlogged heavy clay vertisols.
- Rapidly regenerate each year from seed stock in the soil.
- *T. quartinianum* and *T. tembense* are particularly vigorous and productive annuals with high leaf production.

## Limitations

- Require high rainfall for good herbage and seed production.
- Cannot tolerate frost.
- *T. rueppellianum* tends to drop leaves and stems toughen with age (see 'Promising accessions').

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## Cultivars

*T. quartinianum*

**'Mealton 5'** Released in Kenya (1998). High forage yield potential, reported to produce 1 t DM in 5 months.

## Promising accessions

*T. decorum*

**ILRI 9447.** Selected in Ethiopia. Tolerates waterlogging but is susceptible to frost.

*T. quartinianum*

**ILRI 6301.** Selected in Ethiopia. Excellent for both biomass and seed production.

*T. rueppellianum*

**ILRI 9690.** Selected in Ethiopia. Produces well across a wide range of soil types and altitudes. Its stem is soft and good for feed.

*T. steudneri*

**ILRI 9712.** Selected in Ethiopia. Although lower in biomass production than other annual clovers, produces very well at lower altitudes compared to others. No seed shattering problem.

**ILRI 9720.** Selected in Ethiopia. Although lower in biomass production than other annual clovers, produces very well at lower altitudes compared to others. No seed shattering problem.

*T. tembense*

**ILRI 7102.** Selected in Ethiopia. Excellent biomass production and well adapted to wet areas and waterlogging. Early seed producer but seeds shatter unless harvested daily.



Alliance

