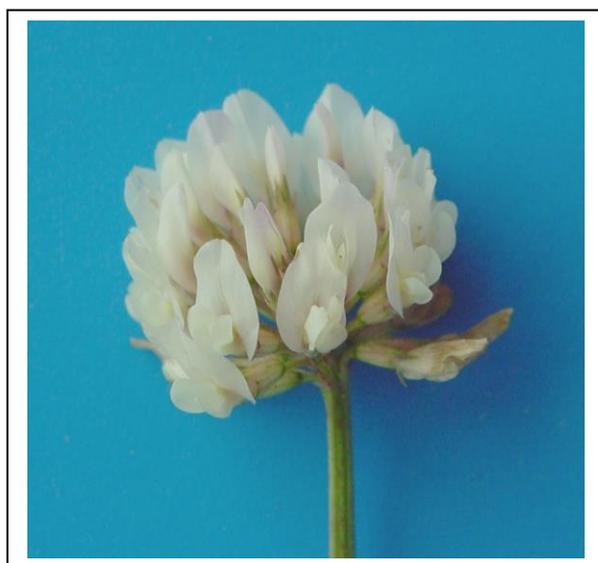


Seed Descriptions of *Trifolium* Species Listed in the AOSA Rules for Testing Seeds



Deborah J. Lionakis Meyer
and
Jim Effenberger

2021 Edition

The 2021 edition contains new information and revised common names as they appear in the AOSA Rules for Testing Seeds (AOSA 2019). Both authors are retired from the California Department of Food and Agriculture, Plant Pest Diagnostics Center, Seed Science Laboratory.

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INTRODUCTION

Trifolium is a large genus of temperate and subtropical herbaceous plants comprised of approximately 300 species (Vincent & Isely 2012; Zohary & Heller 1984). As the name of the genus indicates, the leaves are palmately compound and usually have three leaflets (trifoliolate).

Flowers in this genus are papilionaceous; the upper petal is called a banner or standard, the lateral petals are called wings and the two lower petals join to form the keel. The ovary is superior. In *Trifolium* the fruit are usually one- to two-seeded (Zohary & Heller 1984) or may contain as many as ten seeds in some species (Kirkbride et al. 2003). The fruit may dehisce along one or two sutures or may be indehiscent (Kirkbride et al. 2003). The calyx is persistent (i.e., it remains attached to the fruit at maturity) and may or may not completely enclose the fruit (Zohary & Heller 1984). In some species the corolla also encloses the mature fruit (Vincent & Isely 2012).

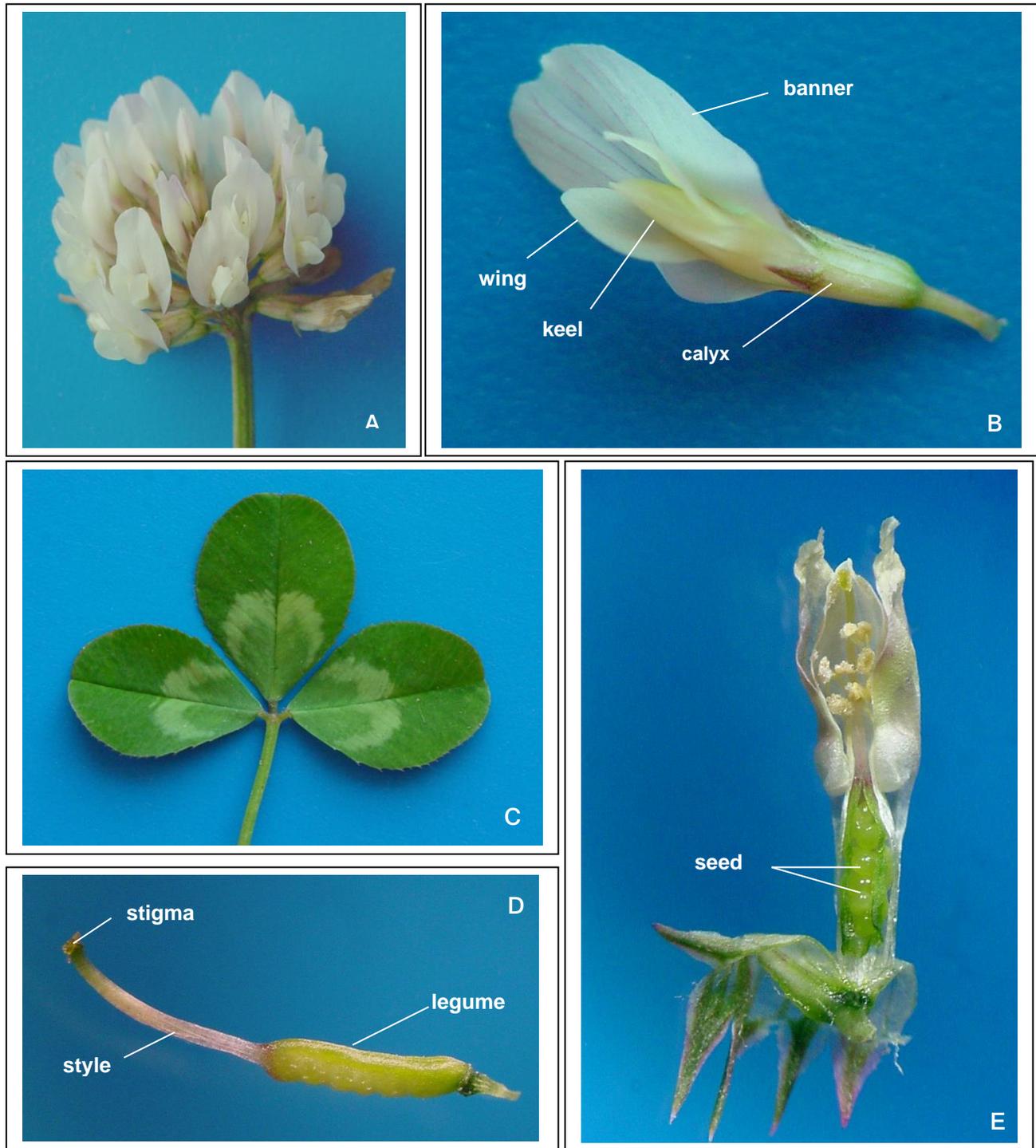
Identification of *Trifolium* seed is dependent upon six morphological characters. These characters include (1) general shape, (2) radicle length relative to the cotyledon lobe, (3) radicle divergence from the cotyledon lobe, (4) surface texture, (5) luster, and (6) color (Musil 1963).

According to Martin (1946) the embryo in *Trifolium* is classified as foliate-bent. This means the embryo is large with thick cotyledons, axile in position within the seed (as opposed to the peripheral position) and bent at the hypocotyl in a jackknife formation. The radicle is therefore folded against the cotyledons, the degree of the bend (i.e., the divergence of the radicle from the cotyledons) influencing the shape of the seed. A thin layer of endosperm covers the entire embryo. The plumule is rudimentary.

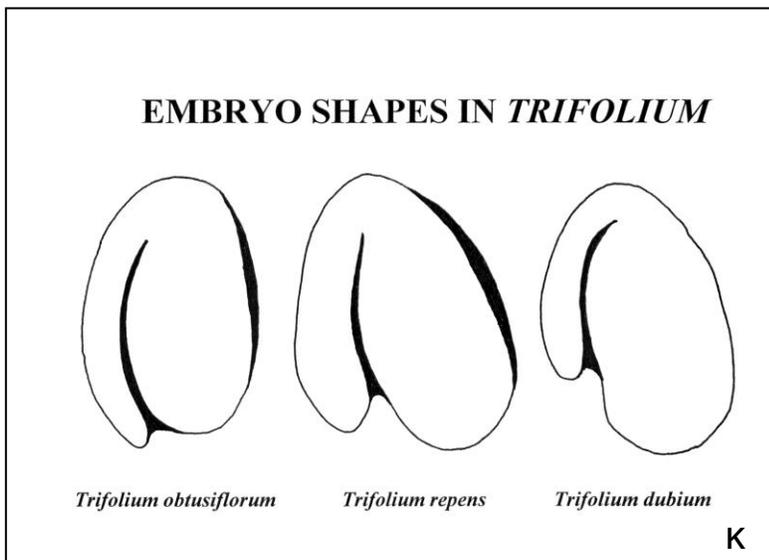
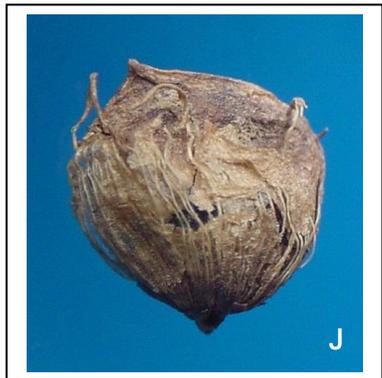
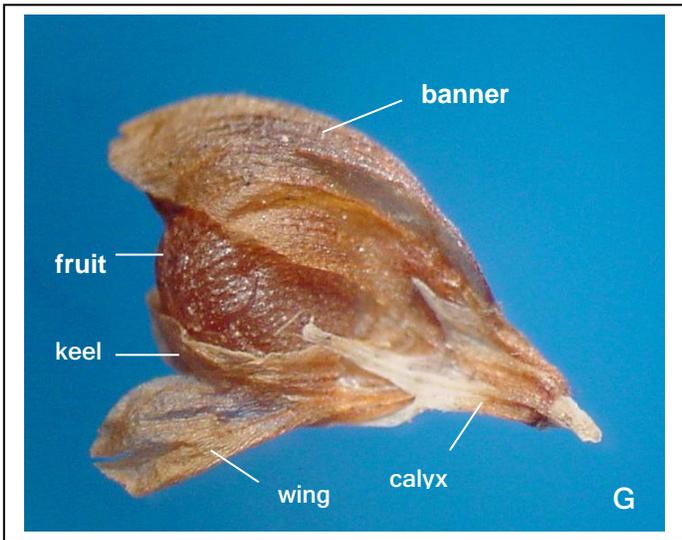
The surface texture of the seed coat in *Trifolium* can be smooth to tuberculate. Seed coats can be dull to highly glossy. It should be noted that the color of legume seeds might darken with age; therefore, this character is not always reliable in older herbarium specimens. In some species the seed coat is lighter in color between the cotyledon and radical lobe forming a visible line.

Although the hilum of legume seeds is usually an important diagnostic character, in *Trifolium* it is of little value. The hilum, located between the cotyledon and radicle lobes, is small and round, with a visible hilar groove (faboid split) (Gunn 1981; Kirkbride et al. 2003).

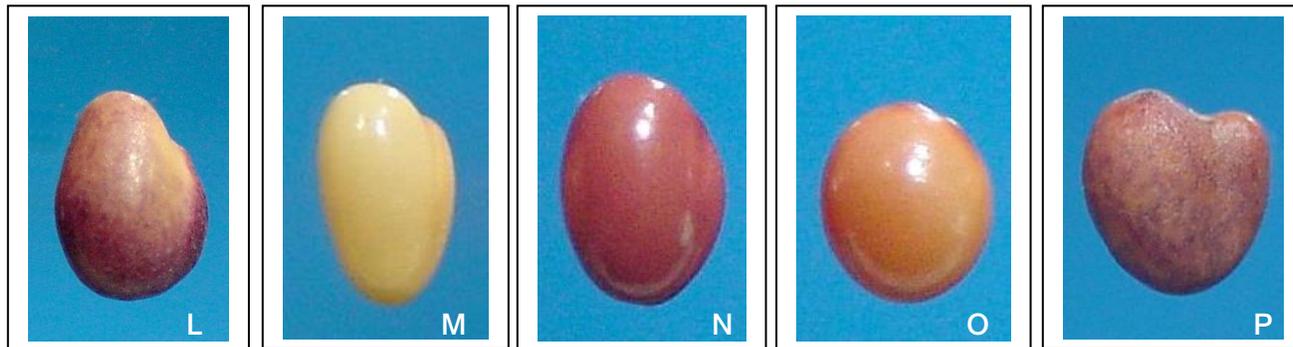
Included here are descriptions, photographs, and diagrams based on various references and personal observations of the 15 species of *Trifolium* listed in the AOSA Rules for Testing Seeds (AOSA 2019). For the purpose of this paper seeds were oriented with the hilum pointed upward and descriptions are based on this orientation. Illustrations and photographs are by D. J. Lionakis Meyer.



***Trifolium repens* L.**, white clover: **A** - inflorescence; **B** - parts of a papilionaceous flower; **C** - trifoliate leaf; **D** - female parts of the flower developing into a legume type fruit containing several seeds; **E** - flower and fruit opened exposing several developing seeds within the fruit.



***Trifolium dubium* Sibth.**, small hop clover: **F** - inflorescence and leaves; **G** - mature fruit surrounded by persistent calyx and corolla (including the banner, keel and wing). ***T. fragiferum* L.**, strawberry clover: **H** - mature fruit within an inflated persistent calyx. ***T. subterraneum* L.**, sub clover: **I** - fruits of fertile flowers surrounded by wire-like calyces of sterile flowers; **J** - single seeded fruit surrounded by calyx. **Embryo shapes: K** - based on Martin (1946), examples of embryo shapes (longitudinal sections) with black areas indicating location of endosperm (note: hilum in the downward position).



General seed shapes: **L** – ovate, broader in the lower half; **M** – obovate, broader in the upper half; **N** – oval or elliptical; **O** – nearly round; **P** - heart-shaped, broader in upper half because the radicle lobe (on the right) is divergent from the cotyledon lobe (on the left).



Radicle lobe length relative to the cotyledon lobe: **Q** – radicle lobe exceeding the cotyledon lobe; **R** – radicle lobe equal to the cotyledon lobe; **S** – radicle lobe shorter than the cotyledon lobe. Note: seeds in Q, R, S are oriented with the cotyledon lobe on the left and radicle lobe on the right.

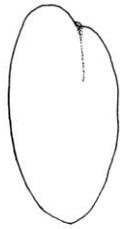
Hilum: **T** – the hilum is small and round, with a visible hilar groove (faboid split). In some species the area around the hilum and the lens are darker in color than the surrounding seed coat. HG = hilar groove (faboid split); M = micropyle; L = lens; H = hilum

General Seed Shapes in *Trifolium*

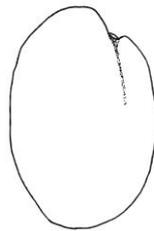
The illustrations below compare the general shape of the seeds of each species but are not intended to compare size of seeds among species.



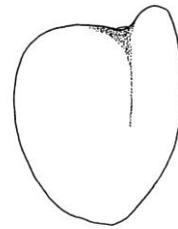
T. alexandrinum



T. campestre



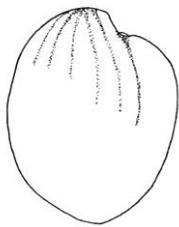
T. dubium



T. fragiferum



T. glomeratum



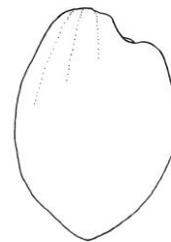
T. hirtum



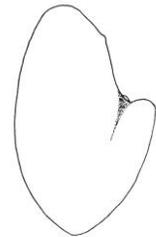
T. hybridum



T. incarnatum



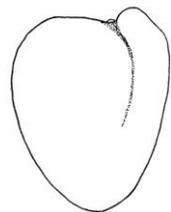
T. lappaceum



T. pratense



T. repens



T. resupinatum



T. semipilosum



T. subterraneum



T. vesiculosum

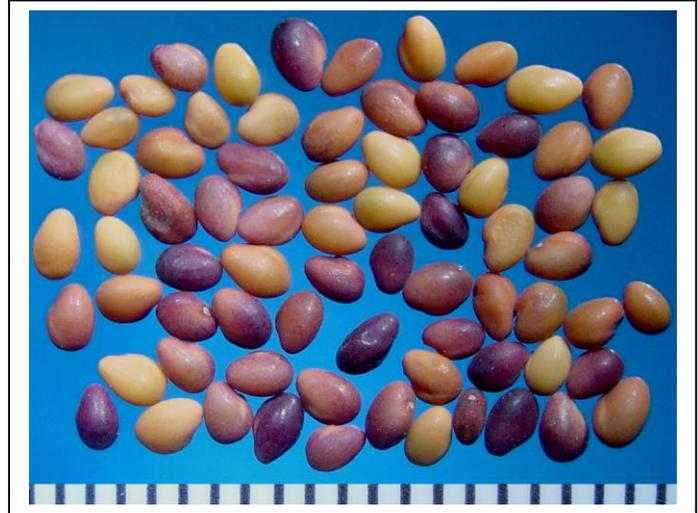
Morphological Characters Important to Identification of *Trifolium* Species in the AOSA Rules

(See seed descriptions for the full range of these characters)

Kind of seed	General shape	Radicle length relative to cotyledon lobe length	Radicle divergent from cotyledon lobe	Surface texture	Predominant seed coat color range	Luster
<i>T. alexandrinum</i>	Ovate	Shorter	No	Smooth	Yellow with red to purple tinge	Dull to lustrous
<i>T. campestre</i>	Narrowly oval to obovate	Shorter	No	Smooth	Yellow with green or rose tinge	High gloss
<i>T. dubium</i>	Broadly oval	Shorter	No	Smooth	Yellow, rose, tan	High gloss
<i>T. fragiferum</i>	Heart-shaped to broadly obovate	Equal to or longer	No	Smooth	Yellow to terra cotta with dark mottling	Lustrous
<i>T. glomeratum</i>	Round to oval	Equal or slightly shorter	No	Minutely tuberculate	Yellow, terra cotta, blue green with purple tinge	Dull
<i>T. hirtum</i>	Ovate, oval to nearly round	Shorter	No	Smooth, with longitudinal wrinkles	Pale yellow, lens & hilum dark colored	Dull to lustrous
<i>T. hybridum</i>	Oval to heart-shaped	Equal to slightly shorter	Yes	Smooth	Yellow to green w/ purple, blue green, or black mottling	Dull
<i>T. incarnatum</i>	Broadly oval to nearly round	$\frac{1}{2}$ - $\frac{2}{3}$ the length of cotyledon lobe	No	Smooth	Yellow with green or pink tinge	Lustrous to glossy
<i>T. lappaceum</i>	Oval to ovate with point at base	Shorter	No	Smooth, with longitudinal wrinkles	Yellow to terra cotta	Dull to lustrous
<i>T. pratense</i>	Triangular to mitten-shaped	$> \frac{1}{2}$ the length of the cotyledon lobe	Yes	Smooth	Yellow with red & purple tinge to entirely purple	Dull
<i>T. repens</i>	Oval to heart-shaped	Equal to or slightly shorter	Yes	Smooth	Yellow to terra cotta, some with green tinge	Dull to lustrous
<i>T. resupinatum</i>	Oval to obovate	Longer	No	Smooth	Yellow to olive-green, with purple tinge	High gloss
<i>T. semipilosum</i>	Oval to heart-shaped	Equal to or slightly shorter	Yes	Smooth	Yellow, green, brown, purple, terra cotta, or black	Lustrous
<i>T. subterraneum</i>	Broadly oval to round	$\frac{2}{3}$ length of cotyledon lobe to equal	Slightly	Smooth	Dark purple, some varieties tan	Dull
<i>T. vesiculosum</i>	Round to oval	Equal to or longer	Slightly	Tuberculate	Terra cotta to red	Dull

Seed Descriptions

Trifolium alexandrinum L. berseem clover



Seed ovate; radicle shorter than cotyledon lobe, not divergent; hilum round, slightly indented, funicular ring white, hilar groove evident; surface smooth, dull to lustrous; base color yellow with varying amounts of red-purple tinge, color deepening away from hilum, some almost entirely reddish-purple; dark line from hilum to lens; distinct line between radicle and cotyledon lobe.

Trifolium campestre Schreb. large hop clover, low hop clover



Seed narrowly oval to slightly obovate; radicle not divergent, slightly shorter than cotyledon lobe; hilum round, shallowly indented, funicular ring white, hilar groove indistinct; surface smooth, highly glossy; color yellow sometimes with green or rose tinged, hilar rim and lens usually dark colored; faint line between radicle and cotyledon lobe.

***Trifolium dubium* Sibth.**

small hop clover, suckling clover, Irish shamrock



Seed broadly oval; radicle not divergent, slightly shorter than cotyledon lobe; hilum round and shallowly indented, funicular ring white; surface smooth, highly glossy; color yellow, rose or tan, hilar rim and lens usually darker colored; faint line between radicle and cotyledon lobe.



***Trifolium fragiferum* L.**

strawberry clover

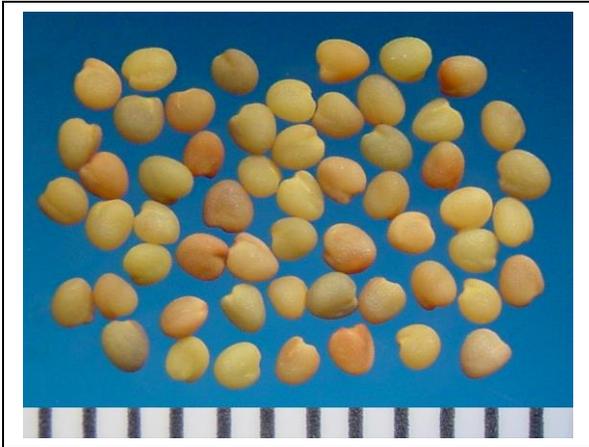
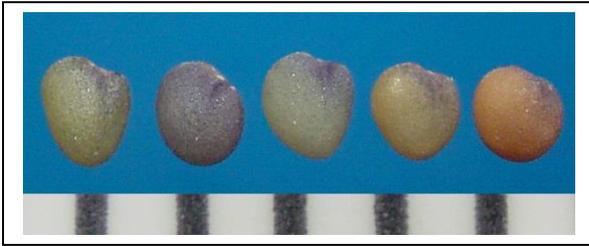


Seed heart-shaped to broadly obovate; radicle equal to or exceeding cotyledon lobe, not divergent, but somewhat angular at base; hilum round, indented, funicular ring white, hilar groove evident; surface smooth, lustrous; yellow to terra cotta base color with varying amounts of dark mottling, mostly in the lower 3/4 of the seed, lens usually darker colored; distinct line between radicle and cotyledon lobe.



***Trifolium glomeratum* L.**

cluster clover



Seed round to oval; radicle equal or slightly shorter than cotyledon lobe, not prominent; hilum round, slightly indented, funicular ring white; surface minutely tuberculate, dull; color yellow, terra cotta, blue-green, some with purple tinge at radicle tip, hilum area, and tip of cotyledon lobe; line between radicle and cotyledon lobe faint to indistinct.

***Trifolium hirtum* All.**

rose clover

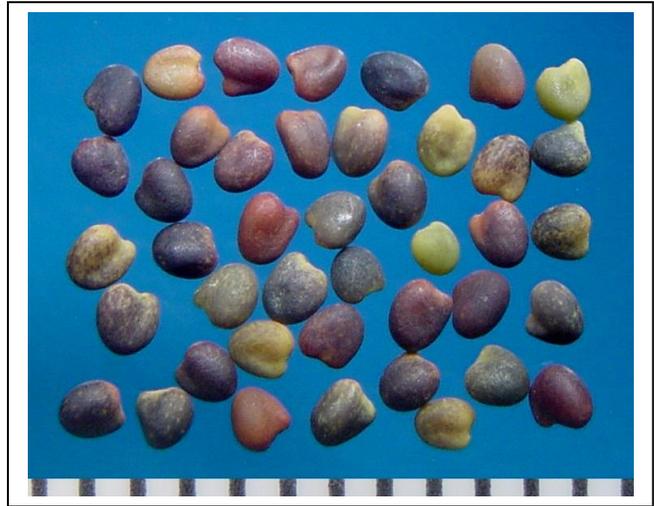


Seed ovate, oval to nearly round; radicle not divergent, slightly shorter than cotyledon lobe; hilum round, slightly indented, funicular ring white, hilar groove evident; longitudinal wrinkles at tip of cotyledon lobe; surface smooth, dull to lustrous; color pale yellow, lens brown, area between lens and hilum sometimes dark colored; line between radicle and cotyledon lobe faint to indistinct.

***Trifolium hybridum* L.**
alsike clover



Seed oval to heart-shaped, cotyledon lobe thicker than radicle; radicle equal to or slightly shorter than cotyledon lobe, divergent; hilum round, slightly indented, funicular ring white, hilar groove evident; surface smooth, dull; base color yellow to green with varying amounts of black, purple and blue-green mottling, some seeds almost totally black, area near hilum usually light colored; no distinct line between radicle and cotyledon lobe; immature seed may be indistinguishable from *T. repens*.



***Trifolium incarnatum* L.**
crimson clover



Seed broadly oval to nearly round; radicle not divergent, ca. one-half to two-thirds the length of the cotyledon lobe; hilum round, minutely indented, funicular ring white when present, hilar groove evident; surface smooth, lustrous to glossy; color yellow with green or pink tinge, hilar rim slightly darker in color, lens brown; no distinct line between radicle and cotyledon lobe.



***Trifolium lappaceum* L.**

lappa clover



Seed oval to ovate, but usually pointed at the base of the cotyledons; radicle shorter than the cotyledons, not divergent; lens usually raised; hilum round, indented, funicular ring yellow, white or inconspicuous; surface dull or lustrous, sometimes covered with minute netting; color yellow to terra cotta; line between radicle and cotyledon lobe may or may not be distinct; some seed with longitudinal wrinkles.



***Trifolium pratense* L.**

red clover



Seed triangular to mitten-shaped, sometimes ovate; radicle less than one-half the length of the cotyledon lobe, divergent; hilum round, indented, hilar groove evident, funicular ring white; surface smooth, dull; base color yellow with varying amounts of red to purple tinge, deepening in color away from the hilum area, occasionally entirely purple, lens dark colored, dark line from lens to hilum; line between radicle and cotyledon lobe may or may not be distinct.



***Trifolium repens* L.**
ladino clover white clover,



Seed oval to heart-shaped, cotyledon lobe thicker than radicle; radicle lobe equal to or slightly shorter than cotyledon lobe, divergent; hilum round, slightly indented, funicular ring white, hilar groove evident to indistinct; surface smooth dull to lustrous; color yellow to terra cotta, some with green tinge, lens occasionally darker; no distinct line between radicle and cotyledon lobe; immature seed may be indistinguishable from *T. hybridum*.

***Trifolium resupinatum* L.**
Persian clover



Seed oval to obovate; radicle exceeding cotyledon lobe, not divergent, angular at base and strongly curved toward cotyledon lobe; hilum round, slightly indented, funicular ring white, hilar groove evident to indistinct; surface smooth, highly glossy; color yellow to olive-green with purple tinge; line between radicle and cotyledon lobes faint to indistinct.

***Trifolium semipilosum* Fresen.**

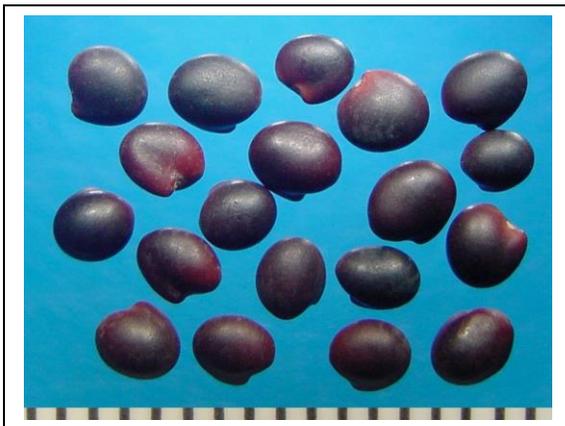
Kenya clover



Seed oval to heart-shaped; cotyledon lobe thicker than radicle; radicle equal or slightly shorter than cotyledon lobe, divergent; hilum round, slightly indented, funicular ring white; surface smooth lustrous; base color yellow, green, terra cotta, brown, purple, or black with varying amounts of dark mottling; no distinct line between radicle and cotyledon lobe.

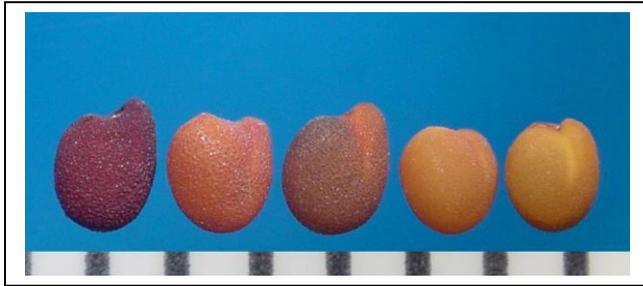
***Trifolium subterraneum* L.**

subclover, subterranean clover



Seed broadly oval to round; radicle two-thirds the length or equal to the cotyledon lobe, slightly divergent; hilum round, indented, funicular ring white to yellow, hilar groove evident or slightly obscured; surface smooth, dull; color dark purple with radicle tip and hilar rim area usually light purple to rose, some varieties entirely tan with slightly darker lens area; no distinct line between radicle and cotyledon lobe; single seeded pod occasionally remaining intact, broadly oval, grayish-white in color.

***Trifolium vesiculosum* Savi**
arrowleaf clover



Seed round to oval, sometimes heart-shaped; radicle equal to or exceeding cotyledon lobe, slightly divergent at tip; hilum round, indented, hilar groove evident, funicular ring white; surface tuberculate, dull; color terra cotta to red; faint light line between radicle and cotyledon lobe sometimes evident.



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