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Issued February 21, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 267.

B. T. GALLOWAY, *Chief of Bureau.*

NONPERENNIAL MEDICAGOS:

THE AGRONOMIC VALUE AND BOTANICAL
RELATIONSHIP OF THE SPECIES.

BY

ROLAND McKEE,

*Scientific Assistant, Office of Forage-Crop
Investigations,*

AND

P. L. RICKER,

*Assistant Botanist, Office of Taxonomic and
Range Investigations.*



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1913.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY,

OFFICE OF THE CHIEF,

Washington, D. C., September 19, 1912.

SIR: I have the honor to transmit and to recommend for publication as Bulletin No. 267 of the series of this Bureau the accompanying manuscript entitled "Nonperennial Medicagos: The Agronomic Value and Botanical Relationship of the Species," prepared by Messrs. Roland McKee, of the Office of Forage-Crop Investigations, and P. L. Ricker, of the Office of Taxonomic and Range Investigations. The botanical descriptions have been prepared by Mr. Ricker and the remainder of the bulletin by Mr. McKee.

This paper gives the results of an investigation of a large number of species usually known as bur clovers, mostly secured with the assistance of the Office of Seed and Plant Introduction. These species have been extensively tested in California and to a less extent in the Southern States in order to ascertain their agronomic possibilities in comparison with three species already grown in the United States.

The increasing importance of these plants for pasturage and green-manuring purposes throughout the areas mentioned makes the paper a timely contribution to our knowledge of the possibilities of this group of forage plants.

The illustrations for Plates V to XV, inclusive, are from photographs by Mr. E. L. Crandall, except the drawings of seeds on Plates VI and IX, which were made by Prof. F. H. Hillman.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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NONPERENNIAL MEDICAGOS: THE AGRONOMIC VALUE AND BOTANICAL RELATIONSHIP OF THE SPECIES.

INTRODUCTION.

The genus *Medicago*, as commonly accepted by botanists, includes about 7 perennial species, with about 16 subspecies, of which alfalfa is the best known and most important, and about 37 annual species, with about 80 subspecies, one of which, yellow trefoil (*Medicago lupulina*), has also a biennial or possibly perennial form. The duration of several—at least three—species is uncertain. There is considerable difference of opinion among botanists as to the number of annual species, mostly known as bur clovers. In 1873 Urban¹ recognized 39 such species, with 64 subspecies, since which time 3 other species and 17 additional subspecies have been described.

In this paper agronomic and botanical notes are given concerning 14 species and 9 subspecies which have been studied for two to five years.

Three species are more or less cultivated or established in the United States, namely, toothed bur clover (*Medicago hispida*) and its subspecies, principally on the Pacific coast; spotted bur clover (*M. arabica*), mainly in the Cotton States and in California; and yellow trefoil, or black medic (*M. lupulina*), more or less abundant throughout the United States. By far the greatest amount of agronomic information at hand concerns these three species, and the desirability of utilizing any of the other species will depend largely on whether they exhibit any points of superiority.

All the annual medicagos grow under natural conditions as winter annuals, and under cultivation they succeed best when planted in the fall. Yellow trefoil is the only hardy species; other species can be successfully grown only where the winters are not too cold.

In the various sections where bur clovers grow somewhat extensively most of the plants are usually of one species or subspecies. In California toothed bur clover (*Medicago hispida denticulata*) is most widely distributed. *Medicago arabica*, *M. hispida confinis*, and *M.*

¹ Verhandlungen des Botanischen Vereins der Provinz Brandenburg, bd. 15, 1873, pp. 1-35, pls. 1-2.

hispidula apiculata are also found in that State, but to a more limited extent. The wide distribution of *Medicago hispidula denticulata* in California is partially explained by its natural adaptation, but perhaps more by the fact that it is the most widely introduced species, whether intentionally as pure seed for sowing for pasturage or green manuring or unintentionally as a mixture with other seed. *Medicago hispidula*, *M. hispidula apiculata*, and *M. hispidula confinis* were in all probability introduced into California along with *M. hispidula denticulata*, with which they are found nearly everywhere, but in lesser quantity.

Spotted bur clover (*Medicago arabica*) is apparently of more recent introduction into California than *M. hispidula denticulata* and is far less widely distributed in that State. On the creek pasture lands on the Bidwell ranch at Chico, *M. arabica* is more often found than *M. hispidula denticulata*. To judge from the quantity there, it was perhaps first introduced at this point and has been distributed thence to various parts of the Sacramento Valley, where it is found in small areas. According to Mrs. Katherine Brandegee, as reported by Mr. Willis L. Jepson,¹ *Medicago arabica* is almost as common as *M. hispidula denticulata* in San Francisco County. *Medicago arabica* is the commonest species throughout the South Atlantic and Gulf Coast States east of the Mississippi River and succeeds exceptionally well throughout this section. It can stand lower winter temperatures than the toothed bur clovers (the *M. hispidula* group), and for this reason is better adapted to this section, in which the toothed bur clovers more often winterkill. It is practically the only species used for pasturage or green manuring in the Southern States. *Medicago hispidula denticulata* and *M. arabica* succeed well in Texas, the former species being the more generally distributed.²

Yellow trefoil (*Medicago lupulina*) occurs throughout the greater part of the United States, and on account of its hardiness is adapted to sections farther north than either *M. arabica* or *M. hispidula* and its forms.

SOIL AND MOISTURE REQUIREMENTS.

Toothed bur clover and spotted bur clover succeed under varied conditions as to moisture, soil, etc. In California, as well as in the South, they grow on all types of soil from nearly pure gravel to heavy adobe. They do better on the heavier loam soils, but will grow in almost any soil containing sufficient moisture. They make a fair growth even under rather arid conditions. In the dry foothill pasture lands of California the toothed bur clover makes a valuable

¹ Jepson, W. L. Flora of Western Middle California, 1901, p. 313.

² Bulletin 108, Texas Agricultural Experiment Station. 1908.

addition to the native pasturage, and in the dry-land pastures of the valleys it is generally distributed and does well. In different parts of Texas it is found growing along the roadsides and in waste places where the conditions are more or less severe. It will stand a small percentage of alkali. In California it is found on slightly alkaline soils, but not on soils heavily charged with salts. While fairly well-drained lands are the most desirable, spotted bur clover and toothed bur clover produce good crops on moist lands. On California adobe lands, which are sometimes poorly drained and lose their moisture slowly, all three species do exceptionally well. Where there is excessive moisture the crop matures later and remains green far into the summer. While not particularly adapted to shade, both the spotted and toothed bur clovers grow vigorously among the timber along streams. Observation indicates that *Medicago arabica* is better adapted to shady conditions than *M. hispidula*.

Yellow trefoil, or black medic, is somewhat notorious, from the fact that its seed has frequently been used to adulterate alfalfa seed. Nevertheless, the plant has agricultural merit not only as forage, but perhaps even more as a winter cover and green-manure crop when used in the same manner as crimson clover. The seed is usually cheaper than that of crimson clover and the plant more hardy. At the Arlington Experimental Farm the two plants mixed gave excellent results, and yellow trefoil alone compares very favorably with crimson clover alone.

VALUE FOR PASTURAGE.

The general characteristics of spotted bur clover and toothed bur clover make them especially valuable for pasturage. They have high feeding value, spread readily, and make satisfactory growth under varied soil conditions. In the pasture lands of the South, as well as on the Pacific coast, they have spread very rapidly after being once introduced. The tendency of part of the seed to carry over in the soil for several years before germination insures against extermination by failure to develop seed in any year—from whatever cause, such as overpasturing or unfavorable weather. Whether the seed germinates or carries over is apparently a matter of depth in planting. Viable seed sown too deep will not germinate until it is brought nearer the surface. Spotted bur clover and toothed bur clover both contain what is known as hard seed that probably will not germinate the first season, even if other conditions are favorable. Such seed carries over until the second or third year.

Most bur clovers are admirably provided with means for natural dissemination. The spiny burs of some species readily adhere to various animals and in this way are carried long distances. Burs

without spines are distributed by other means. It is commonly observed in California that orchards fertilized with manure from corals produce a heavy growth of bur clover, evidently from seed that passed through the animals undigested and that still retained its power of germination.

In a mixture with grasses, bur clovers are excellent pasturage and make considerable growth of green feed during the winter and in early spring before the grasses start. Green bur clover will often produce bloat in cattle, and care should be taken when first turning them into such fields.

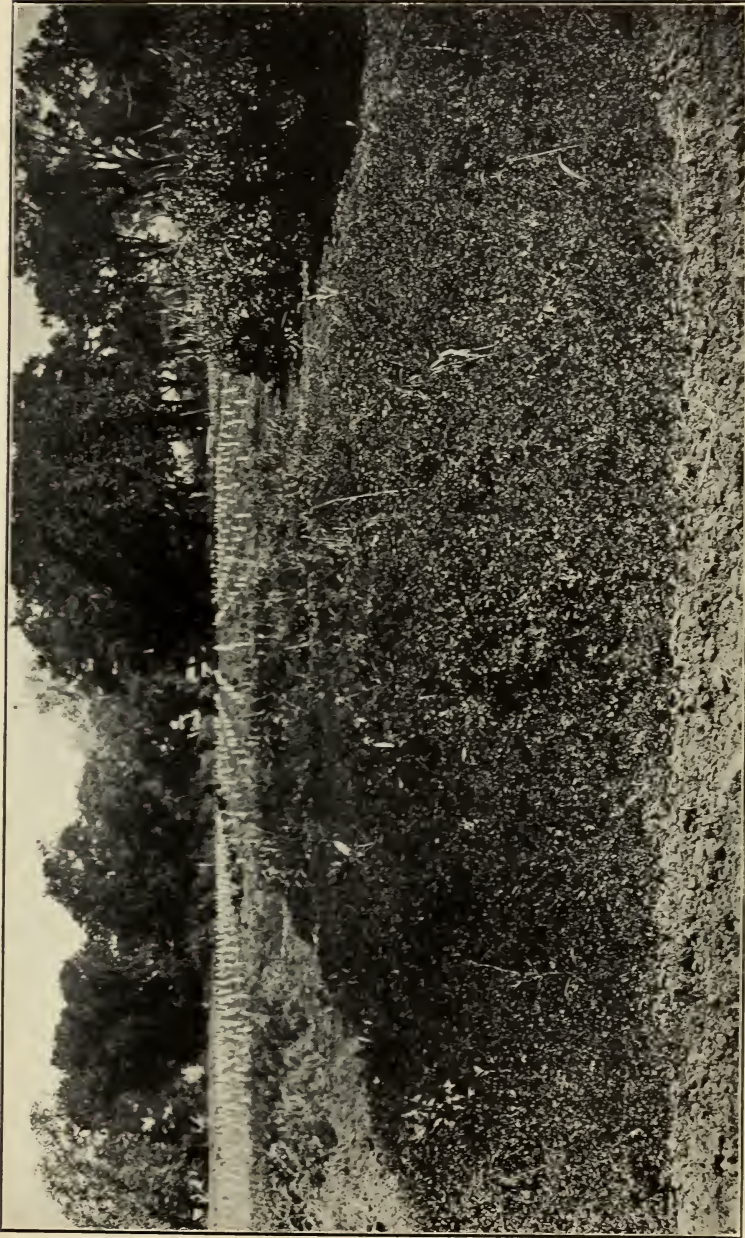
A heavy crop of pods and seed afford a large quantity of valuable feed. In fact, it is the seed and pods that constitute the greater part of the feeding value of this crop when in the dry state. Their feeding value is high, and stock fed on them fatten rapidly. Pastures containing large quantities of matured burs of the common bur clovers are especially desirable for fattening sheep. The time at which the burs are available adds importance to their feeding value, especially in California, where the dry season usually continues from May until November. Here the valley pastures are wholly dry by midsummer, and dry pasturage is all that is available. The bur clovers, being mature, possess their greatest feeding value at such time, but if not then fed are available later. The burs are mostly eaten dry, but those with heavy spines are much more readily eaten after rains have softened them.

The spiny species or subspecies of bur clovers are objectionable as sheep pasturage on account of the burs getting into the wool. For this reason the spineless forms are preferable. *Medicago hispida confinis* is a spineless form of toothed bur clover and *M. arabica inermis* is a new spineless form of spotted bur clover. Button clover (*M. orbicularis*) is another very promising species (Pls. I and II), which, on account of its large spineless burs and heavy yields of seed, is superior to the more common spotted or toothed bur clovers wherever it will make an equally good growth.

SECURING AND MAINTAINING A STAND IN PASTURES.

The seeding of pasture lands to bur clover on the Pacific coast is a very simple process. The seed, either hulled or in the bur, is scattered over the land and, without further attention, is left to itself. Hulled seed will generally give a better stand than seed in the bur and is to be preferred when bought. Seed in the bur is also more likely to contain undesirable weed seeds.

In the Southern States a stand is not so readily secured, owing in part to the fact that nodule-forming bacteria which supply nitrogen to the plant are not present, or at least do not develop readily, except



A HEAVY GROWTH OF BUTTON CLOVER (*MEDICAGO ORBICULARIS*) AT CHICO, CAL.



STEMS OF BUTTON CLOVER (*MEDICAGO ORBICULARIS*), SHOWING APPEARANCE CHARACTERISTIC OF THIS SPECIES.

(One-half natural size.)

in the more favored and better prepared soils. It is therefore necessary to supply inoculation before a good growth can be secured.

In California seeding may be done at any time during the summer, or in the fall before the winter rains begin. In the Southern States summer seeding is not advisable, on account of rains, and seed should be sown in the early fall, so that it will start and continue growth during winter. About the first of September is perhaps the best time for seeding in most sections. When bur clover is once seeded it persists indefinitely. Species with spiny burs, having the advantage of this means of distribution, are perhaps more persistent than species with smooth burs. Spiny burs are less readily eaten by animals. Thus protected, many of them drop or are knocked from the plants, are trampled into the ground, and thus reseed themselves. When not trampled into the ground, the seeds of species with small burs seem to germinate and take root much more readily than those of species with large burs. Large smooth-podded sorts must be pastured lightly or stock kept off in the spring until the seed has matured, else the immature seed is largely eaten, digested, and lost.

PALATABILITY.

As pasturage or hay, spotted bur clover and toothed bur clover are not as readily eaten by most kinds of stock as ordinary grass and hay. Especially in the green state, they possess a slightly disagreeable taste, which at first makes them somewhat unpalatable. The taste is not a serious drawback, as stock soon become accustomed to it, and the green plants of all three species are readily eaten where other feed is not abundant. Whether it is owing to a difference in the palatability of the different species has not been definitely determined, but comparison indicates that in the green state most animals apparently prefer *Medicago orbicularis* to *M. hispida denticulata*.

VALUE FOR HAY.

The bur clovers can not be considered as among the best crops for hay. They are somewhat unpalatable, and their decumbent habit of growth makes them difficult to handle alone. If grown with oats or other small grain for support, they can be handled with sufficient ease to be sometimes profitably utilized in this way. The fact that there are better crops for hay will always limit the use of the bur clovers for this purpose. In California, in seasons when the hay crop is short, considerable quantities of mixed bur clover and wild-oat hay are put on the market, but such hay is considered inferior by the trade and sells at a lower price than grain hay. Table I gives the chemical analyses of bur clover in comparison with alfalfa.

TABLE I.—Average percentage composition of bur clover and alfalfa hay.

Kind of hay.	Number of analyses.	Water.	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.
Bur clover ¹	3	10.11	7.27	12.60	26.37	41.14	3.16
Alfalfa ²	21	8.4	7.4	14.3	25.0	42.7	2.2

¹ Annual Report, California Agricultural Experiment Station, 1894-5, p. 147; 1896-7, p. 113.

² Westgate, J. M. Alfalfa. Farmers' Bulletin 339, U. S. Dept. of Agriculture, 1908, p. 28.

VALUE FOR COVER AND GREEN-MANURE CROPS.

Spotted bur clover is now used to a considerable extent in the cotton-growing States as a winter cover crop, and its popularity for this purpose is increasing. Over much of this area it has given better results than crimson clover. Owing to the scarcity of seed of the spotted bur clover, that of toothed bur clover is frequently sown; but the results clearly show that toothed bur clover is less hardy and in severe winters is destroyed. Toothed bur clover is commonly used as a cover crop in California orchards, as when once well established it volunteers from year to year. In China it is often used as a cover crop on rice fields, and the results of preliminary tests indicate that it will be excellent for this purpose on rice lands in Louisiana and Texas.

Yellow trefoil has proved itself an excellent winter cover crop in Virginia and its wide distribution leads to the belief that it has greater merit than has been heretofore realized.

Inoculation is of paramount importance in attaining a satisfactory stand with any of these species.

SOURCES OF SEED.

Bur clover is little grown in the United States as a seed crop. Spotted bur clover has been grown to some extent for seed in the Southern States, but usually only a small acreage is so handled. In California considerable quantities of seed of toothed bur clover are secured with the crops of small grain, among which it grows naturally as a weed. The seeds of bur clover ripen at nearly the same season as the grain and are of necessity harvested with it. The raising of grain on large areas by individual farmers, as in California, necessitates delay in harvesting much of it, and thus favors the development and ripening of a much larger quantity of the bur clover than would otherwise mature. The bur clovers ripen a little later than wheat or barley, and if these grain crops are cut when first ripe, little bur clover seed is secured. The use of a combined harvester and thrasher in harvesting and thrashing small grain is especially favorable to the saving of bur clover seed, as in this way a minimum number of burs is knocked from the vines.

Bur clover seed is also obtained as a by-product from wool waste. Sheep running in pastures get the burs entangled in the wool and the seeds are thus carried to the mills to be separated as a waste product. Wool from Argentina, South America, where bur clovers are abundant, contains quantities of both toothed bur clover and spotted bur clover. This wool is shipped to the woolen mills, where the bur clover is generally taken out as a by-product. Southern European grazing sections are also sources of bur clover seed, which is carried in wool as from other countries and separated at the woolen mills.

GROWING FOR SEED.

In growing a crop of bur clover for seed several difficulties are encountered. The prostrate growth made by the plants, the failure of the burs to mature all at the same time, and their tendency to drop very easily from the stem as soon as ripe make the harvesting of seed difficult. To grow bur clover as a seed crop on a large scale is most practical in sections having a continuous dry summer. Rains in summer are apt to cause the seeds to germinate in the burs, making them more difficult to handle; but where such rains occur it is both practicable and advisable to raise seed in small quantity for one's own use.

The fact that the greater part of the commercial bur clover seed is *Medicago hispida* and its forms, with little *M. arabica*, makes it almost necessary for the farmer in the Southern States to grow his own seed at the present time. As has been stated, *M. arabica*, according to our present knowledge, is the best species for the South. Before seeding, the land should be put in as good condition as possible by plowing and harrowing, and if the seed is to be harvested by any method such as sweeping, the field should be run over with a float or roller to leave a smooth surface in order to facilitate the harvest. If a drill is used to sow the seed the ground should be especially well firmed.

TIME OF SEEDING.

In sections having a mild winter climate, bur clover should be sown in the fall. In California, where dry weather prevails throughout the summer, the seed may be sown at any time before the fall rains begin. Where summer rains occur, as in the Southern States, the planting should be delayed until the first of September. In dry sections, where it is desirable to start the seed in the fall with irrigation, the planting should be done about the first of October. The object is to sow the seed so late that a subsequent irrigation will not be necessary. Summer seeding in the South is not advised, as the young plants starting at that time are liable to suffer from drought, and where a

heavy growth is made the plants tend to mature and die rather than continue growth through the winter. When seed in the bur is used, earlier planting may be practiced than when hulled seed is used. Germination will be delayed on account of the protection afforded by the burs, and the result is the same as a later planting of hulled seed.

METHOD AND RATE OF SEEDING.

The clean seed may be sown broadcast or by using an ordinary grain drill with press-wheel attachment. Special care should be taken to cover the seed thinly. The drill should be used only on well-firmed soil, as otherwise the seed will be planted too deep. The press-wheel attachment is necessary for the best success when a drill is used. In general, broadcast seeding will perhaps be found the most satisfactory and is the only method that can be employed when the seed is sown in the burs. A light harrowing is all that is necessary to cover hulled seed sown broadcast and will usually cover seed sown in the bur. When the land is left with light furrow markings, such as are made by a large-toothed harrow, seed not covered by the harrow at the time of seeding will fall into these small furrow depressions and be covered by the washing of subsequent rains. Good stands have been secured by this method without covering the seed at all at the time of sowing, and it probably will be found satisfactory in sections where a continuous rainy season occurs.

INOCULATION.

In the Southern States inoculation of the land is necessary to grow clover for the first time. In California the soil apparently is in most places already inoculated. The best method of inoculation is perhaps to mix a small amount of soil from an old bur-clover field with the seed, whether hulled or in the bur. The quantity of soil used need be only a mere dusting. Sowing seed in the bur seems also to insure inoculation, and for this reason it is commonly practiced in the Gulf Coast States. Open and loamy soils are most easily inoculated, and it is recommended that to establish bur clovers on a place an old garden patch or other well-prepared and manured piece of land be selected.

HARVESTING AND THRASHING.

The limited work that has been done with bur clovers has not entirely demonstrated the best method of harvesting the seed but has at least indicated the difficulties to be overcome and has suggested improvements on methods used. Several processes have been tried. The combined harvester and thrasher has been used in an attempt to

cut and thrash the crop direct from the field at one operation, as small grains are harvested in the West. The seed of bur clover ripens continuously through a long period; hence, a large quantity of unripe burs are harvested even if the crop is cut when the yield is at its maximum. The green burs and accompanying green portions of the stems, which are gathered with the ripe burs and seed, contain much moisture and without special drying are likely to heat before they can be taken to a huller and the seed separated.

If the bur clover is sown with a grain crop which is allowed to ripen thoroughly, the difficulty just mentioned is largely overcome, but the yield of seed by this method is small, because the burs drop from the plant so easily as soon as ripe. It is also necessary to let the grain crop become overripe in order to allow the bur clover, which matures a little later, to develop its maximum yield of seed. The use of a common self-rake reaper has been suggested but not yet tried. The idea is to cut the crop when a maximum amount of seed is ripe and then to handle it as the seed crop of red clover or alfalfa is handled. The use of the reaper should reduce the loss of pods to the minimum possible with ordinary farm machinery, but whether the method is practicable remains to be demonstrated. The readiness with which the burs drop from the plants will make this method difficult at best, but by operating at a favorable time, as on a cloudy day or early in the morning, the loss of burs will be reduced to a minimum.

The idea of air suction has been tried in an attempt to overcome the difficulty occasioned by the burs dropping from the vines. This process has been tried by Mr. R. W. Jessup, of Oakland, Cal., who reports it only a partial success. A power suction machine was used and 20 acres of burs harvested. The vines were allowed to become thoroughly dry and were then cut with an ordinary mower and raked into windrows. The ground was thus left comparatively clean and in shape for the suction machine to operate. In the process of mowing and raking, all the burs were knocked from the vines, so that a maximum yield was obtained. By this method a quantity of other substances, such as sticks and small stones, were gathered with the burs and were very objectionable on account of the damage to the cylinder in the process of hulling. To overcome this objection a special device for cleaning foreign substances from the burs as they were harvested was used in connection with the suction machine in 1911. This device made the machine more satisfactory, but the method at best is somewhat expensive. With a heavy yield of seed the expense is reduced.

A method of harvesting first employed in the West and South is to allow the seed to ripen thoroughly and then to cut the vines with an

ordinary mowing machine and rake them into windrows. The burs are then swept together with large barn brooms and hauled from the field. The burs gathered in this manner are mixed with more or less gravel and other foreign substances, which must be removed before the seed can be satisfactorily hulled or used in the bur. This separation is accomplished by the use of handbarrow screens and an ordinary fanning mill regulated to blow the burs over; or, if running water is handy, a quicker and more satisfactory method is to throw the burs into the water. All heavy substances sink, and the burs and lighter substances are dipped from the stream. To facilitate this method of separation the channel of the stream should be narrowed in the shape of an open V, which generally aids in collecting the cleaned burs. To dip the burs from the water a large handbarrow, with a bottom made of wire netting, has been found very satisfactory. The burs are spread on canvas to dry, after which they are ready for the huller.

All bur clovers, whether with large hard burs, like *Medicago turbinata*, or small soft burs, like *M. hispida denticulata*, or large soft burs, like *M. orbicularis*, are successfully hulled with an ordinary clover huller.

YIELD OF SEED.

Few data as to the actual seed yield of the various species of bur clovers are available. Table II gives the results of tests made at Chico, Cal.

During the winter of 1907-8 seasonal conditions were rather unfavorable to the production of heavy yields of seed, and the figures given (Table II) are undoubtedly somewhat lower than may be expected in a more favorable year. In the test referred to, the seed was sown in the fall before the winter rains began, and the crop was allowed to develop under natural seasonal conditions, without irrigation.

During the winter of 1908-9 *Medicago orbicularis*, *M. hispida nigra*, and *M. hispida confinis* were again grown for seed in one-twentieth acre plats. In this test the seed was sown early in October, with irrigation at time of seeding only. A good winter growth was thus insured. The yield of seed in the irrigated plats (Table II) was considerably greater than in the nonirrigated plats, which amounted to little.

During the winter of 1909-10 *Medicago orbicularis*, *M. scutellata*, *M. hispida confinis*, *M. hispida nigra*, *M. turbinata*, and *M. hispida terebellum* were again grown in one-twentieth acre plats. They were sown in October, 1909. The plats were irrigated before seeding only. The seed yields are not entirely comparable, on account of variation

in the stands germinated. The plat of *M. hispida terebellum* had a very poor stand, and those of *M. turbinata*, *M. hispida nigra*, and *M. orbicularis microcarpa* (No. 7738) were thin. *M. orbicularis* (No. 10725), *M. hispida confinis*, and *M. scutellata* had good stands.

The large seed yields of *Medicago orbicularis*, which is a very promising species, have been very consistent through the four years.

Hulled seed of bur clover weighs about the same as alfalfa seed—60 pounds to the bushel.

TABLE II.—Yields of seed per acre at Chico, Cal.

S. P. I. No. ¹	Species tested.	Yield of hulled seed per acre.			
		1908	1909	1910	1911
		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
10725.....	<i>Medicago orbicularis</i>	860	790	1,160	947
7738.....	<i>Medicago orbicularis microcarpa</i>	520		300	
16879.....	<i>Medicago hispida terebellum</i>	390		40	
26077.....	<i>Medicago scutellata</i>	240		950	
26076.....	<i>Medicago turbinata</i>	230		180	
26071.....	<i>Medicago hispida nigra</i>	470	440	160	
26070.....	<i>Medicago hispida confinis</i>	320	375	350	
	<i>Medicago hispida denticulata</i>	450			

¹ Seed and Plant Introduction number.

RELATION OF WEIGHT OF SEED TO VOLUME AND WEIGHT OF BURS.

The weight of seed in a given volume of burs varies considerably, mainly owing to differences in bulkiness of the burs in the several species. These variations are due not entirely but largely to differences in length of spines. Species with long spines have less seed in a given volume than spineless forms, especially when closely related types are compared.

The weight of seed in a given weight of burs also varies somewhat in the different species, mainly owing to differences in the texture of the burs. The harder types of burs have the smaller percentages of seed. Table III shows that the weight of seed in a bushel of burs in the different species varies from 1.75 pounds in *Medicago arabica* to 4.66 pounds in *M. turbinata*; and that the weight of seed in 100 pounds of burs varies from 20.89 pounds in *M. turbinata* to 33.78 pounds in *M. hispida denticulata*.

RELATION OF WEIGHT OF BURS TO THEIR VOLUME.

The great differences in the spines and in the texture of the burs make decided differences in the weight of burs in a given volume in the several species. A given volume of a species having very short or no spines or of those with hard burs is much heavier than of species having long spines and soft burs. Considerable variation in

weight is caused by packing the burs, especially of the spiny species, and for this reason the weights can be only approximated. Table III shows that the weight of a bushel of burs in different species varies from 6 pounds in *Medicago arabica* to 22 pounds in *M. turbinata*.

TABLE III.—Relation of weight of burs and seed to volume.

S. P. I. No.	Species tested.	Weight of 1 bushel of burs.	Weight of seed.	
			In 1 bushel of burs.	In 100 pounds of burs.
		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
26077.....	<i>Medicago scutellata</i>	14	3.83	27.38
10725.....	<i>Medicago orbicularis</i>	8	2.66	33.5
26076.....	<i>Medicago turbinata</i>	22.33	4.66	20.89
26071.....	<i>Medicago hispida nigra</i>	8	2	25
9749.....	<i>Medicago ciliaris</i>	8.66	2.16	25
16879.....	<i>Medicago hispida terebellum</i>	11.99	3.18	26.39
	<i>Medicago denticulata</i>	6.16	2.08	33.78
	<i>Medicago arabica</i>	6	1.75	29.16

RESEMBLANCE TO ALFALFA SEED.

The seeds of a number of species of bur clover resemble alfalfa seed very closely. The most common are the *Medicago hispida* group, *M. lupulina*, and *M. arabica*, the seeds of which are of lighter yellow color, lacking the rich, greenish yellow shade of alfalfa; and all are uniformly larger except *M. lupulina*, which is somewhat smaller and is the only species in which the difference in size is readily noticeable. *Medicago arabica* is further distinguished by having a small, well-developed projection at the end of the hilum.

VITALITY OF SEED.

As mentioned elsewhere, bur clover seed retains its vitality for a very long time. Seed three years old will generally show delayed germination, but it is only after several years that the percentage of germination is noticeably decreased. (Table IV.) Not only does seed retain its power of germination when kept under dry conditions, as in a seed room, but it will carry over in the soil for a number of years in the same way.

TABLE IV.—Germination tests of *Medicago arabica*.¹

S. P. I. No.	Age of seed.	Duration of test.	Germination of unclipped seed.	Hard seed.	Good seed.	Germination of clipped seed.
	<i>Years.</i>	<i>Days.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
16213.....	6	12	20	60	80	77
21550.....	4	12	30	65	95	90
23661.....	3	7	26	53	79	77
26878.....	2	7	19	76	95	94

¹ Results obtained by the Seed Laboratory, Bureau of Plant Industry.

It has been observed in California, in orchards kept free from all growth during the spring months and no seed allowed to develop, that a good stand of the toothed bur clover occurs each year for four or five years after the last crop of seed was allowed to mature in the orchard.

Plantings of a number of species of bur clover were made in pots so that this point could be more definitely observed and showed that it was a common occurrence for seed to carry until the second year before germinating, even when the depth of planting and other conditions were favorable for growth.

INSECT ENEMIES.

The clover-seed chalcis fly (*Bruchophagus funebris* How.) which attacks red clover¹ and alfalfa² is also common in bur clover. The small flylike insect lays its eggs in the ovules; the larvæ develop in the seed and reach maturity by the time the seed is ripe. The amount of seed thus destroyed at Chico, Cal., is considerable, especially in that maturing late. Of the early-maturing seed perhaps 10 per cent is destroyed, while the loss of late seed may be as high as 75 per cent. All species tested are subject to its attacks, some more severely than others. No practical way of controlling this pest seems to be known.

DIFFERENCES IN THE BURS OF DIFFERENT SPECIES.

The pods, or burs, of the different species of annual medicagos differ very much in size, form, and with regard to the spines (Pl. III). They also vary widely in weight and texture.

In such species as *Medicago orbicularis* and *M. scutellata* the burs are very large and spineless, being decidedly flattened in *M. orbicularis* and nearly spherical in *M. scutellata*. The pods of both are soft and somewhat papery. In *Medicago ciliaris* and *M. echinus* the burs are very large and have heavy spines. The spines are erect in the former and decidedly appressed in the latter species. The texture of the bur tends to be hard in *M. ciliaris* and a little less so in *M. echinus*. The general form in both species is oval. In *M. turbinata* the bur is large, oval, very hard (in the most common type), and has a few short tuberclelike spines. *Medicago rigidula* and *M. murex* are somewhat similar to *M. turbinata*, but they are smaller and commonly have longer spines. Of species with smaller burs, some, as *M. hispida denticulata* and *M. arabica*, have spines, and some, as *M. hispida confinis*, are without spines. All variations between these types are found, and there are many other forms which mark botanical characteristics peculiar to definite species.

¹ Circular 69, Bureau of Entomology, U. S. Dept. of Agriculture, 1906, p. 7.

² Farmers' Bulletin 339, U. S. Dept. of Agriculture, 1908, p. 41.

DESIRABILITY OF A BUR WITHOUT SPINES.

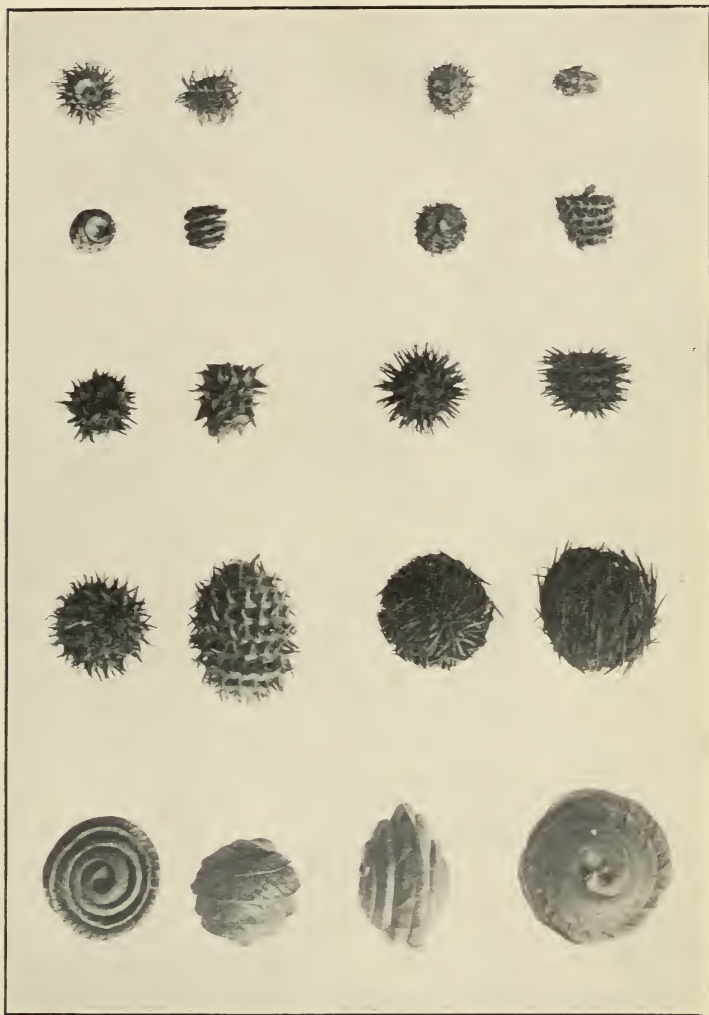
For various reasons a bur without spines is more desirable than one with spines. Spineless burs do not catch in the wool of sheep, an objectionable feature of ordinary bur clovers. On the other hand, they may be objected to on account of being deprived of this means of distribution, as the smooth burs will not hang to stock to be carried about and are a little harder to maintain in pasture, especially the larger podded varieties. Furthermore, the spineless burs are more readily eaten by stock. As already explained (p. 10), the weight of evidence favors the smooth bur.

STUDIES RELATING TO VARIATION IN THE BURS OF DIFFERENT SPECIES.

Since the fall of 1908 a large collection of bur clovers has been used in a study to determine to what extent the burs of the various species and subspecies vary from their normal type. This collection comprises 202 selections, and includes 20 species and subspecies.

It may be well to mention here a few difficulties encountered in the work. Like the seeds of many other legumes, fresh seeds of bur clover do not germinate readily. A common experience has been that the entire lot of seed of a selection failed to germinate. Some difficulty has been found in so protecting the plantings as to be perfectly sure that mice had not carried seed from one selection to another. To get soil absolutely free from bur clover seed is somewhat difficult where bur clover is naturally abundant, and it has necessitated extra care. The first year all the soil used was sifted through screens sufficiently fine to exclude any bur clover seed that it might contain. In the second and subsequent years the soil used was taken from 4 feet below the surface of the ground, at which depth it was found to be free from all germinable seed. The latter method is satisfactory at Chico, Cal., where the work has been carried on. Plants grown in soil from a depth of 4 feet have been found to make a growth quite as good as plants grown in soil taken at the surface.

In order that the comparison between the original burs selected and the burs of their progeny might be as accurate as possible, burs of each selection from which seed was taken for planting (or burs as nearly like the type as could be found) were saved for future comparison. In the descriptive records of the plants the following points were observed: (1) Pubescence, (2) leaf markings, (3) size and color of leaflets, (4) size and number of flowers, (5) size, color, and shape of stems, and (6) general notes. Besides descriptive notes, typical burs produced in each season were saved, together with herbarium specimens of most of them, so that comparison of any variation in the progeny from the original selections could be noted.



PODS OF TEN SPECIES OF *MEDICAGO*.

Top row, *M. arabica* and *M. hispida denticulata*; second row, *M. hispida confinis* and *M. hispida terbellum*; third row, *M. muricata* and *M. hispida nigra*; fourth row, *M. ciliaris* and *M. echinus*; bottom row, *M. scutellata* and *M. orbicularis*. (Natural size.)



BRANCH OF *MEDICAGO MUREX* (No. 0147), SHOWING VARIATION IN CHARACTER OF PODS.

The plants have been grown each year in 7-inch pots. The plantings have been made each year in the fall, and the first year (1908-9) the plants were carried through the winter in a cool greenhouse. The second year (1909-10) the plants were carried through the winter in an ordinary lath house, and the third year (1910-11) in a glass-covered lath house. Every year in the spring the pots were plunged in soil to their entire depth and allowed to remain in the lath house until the seed was mature.

VARIATION IN *MEDICAGO MUREX*.

From plantings made in the fall of 1908 a very marked variation occurred in two selections (F. C. I. No. 0147 and S. P. I.¹ No. 16875) which had been received under the names *Medicago polycarpa* and *M. murex*, respectively. A single plant of each produced burs varying not only in shape, but ranging from spineless to forms having many medium-sized stout spines (Pl. IV). The variation with regard to spines was as great as could be. F. C. I. No. 0147 and S. P. I. No. 16875, which had been received under different specific names, proved to be identical, both being *M. murex*. In their first season and in subsequent years the plants of these two numbers were noted as being identical in general growth, size, shape, color, and markings of stems, leaves, and flowers.

In the fall of 1909 plantings were again made as in 1908, but this time seed from the progeny of the 1908 plantings was used. Burs of F. C. I. No. 0147 and S. P. I. No. 16875, both smooth and spiny and also including intermediate forms, were planted. Each series represented all types of burs taken from a single plant. The resulting plants from the varying types of burs were all alike, and they were like the plants of the year before. The following spring (1910) these plants fruited, and all the early burs were spiny and essentially like the spiny forms produced in the spring of 1909. To see whether adverse conditions would produce such a variation in the burs as occurred in 1909, pots containing the plants were lifted out of the ground in which they had been plunged, to cause them to dry out more readily. Abnormal or spineless burs began to form at once on the plants thus lifted. A week later a hot spell of a few days' duration dried all the plants severely, and spineless burs began to develop also on the plants not lifted. From that time on, hot weather prevailed and varying burs continued to form. (See Pl. X, fig. 1.)

In the fall of 1910 plantings were made again as in previous years. In the spring of 1911 pots were lifted as before, with the same general results. The burs without spines produced in 1911 were not as well developed as in 1909, but showed the same general variations.

¹ F. C. I. is an abbreviation for Forage-Crop Investigations; S. P. I., for Foreign Seed and Plant Introduction.

VARIATION IN MEDICAGO CILIARIS.

In the spring of 1910, at the time of lifting the pots of *Medicago murex*, pots of *M. ciliaris* were also lifted, to note the effect on burs of this species. Up to this time all the burs developed had been normal. In two or three days after lifting the pots the burs began to show elongation. Burs subsequently produced were decidedly elongated, and the spines were much shorter than normal. In the pots not lifted the plants continued to produce normal burs until severely checked by a hot spell some time later, after which abnormal burs were produced on all the plants. (See Pl. XI, fig. 1.) In the spring of 1911, pots of this species were again lifted as in the previous year, with the same general results.

VARIATION IN MEDICAGO MURICATA.

The pots of *Medicago muricata* were not lifted as were those of *M. murex* and *M. ciliaris*, but in the seasons of 1909, 1910, and 1911 it was noted that the burs formed late in the season varied greatly with regard to spines. In some instances the burs were nearly smooth and varied from this type to nearly normal burs. The burs formed earlier in the season were always normal and spiny. Plantings of this species had been made in the open field in the fall of 1910 and were observed to determine the extent of variation under field conditions. The results were practically the same as with the pot-grown plants. The burs which developed early were normal and with spines, while those formed late in the season varied from nearly smooth to nearly normal. (See Pl. IX, fig. 2.)

VARIATION IN OTHER SPECIES.

Besides *Medicago murex*, *M. ciliaris*, and *M. muricata* the following species were planted in the fall of 1908 and the two succeeding years: *M. scutellata*, *M. orbicularis*, *M. orbicularis microcarpa*, *M. orbicularis marginata*, *M. hispida*, *M. hispida nigra*, *M. hispida confinis*, *M. hispida apiculata*, *M. hispida denticulata*, *M. hispida terebellum*, *M. echinus*, *M. turbinata*, *M. tuberculata*, *M. rugosa*, *M. lupulina*, *M. radiata*, *M. arabica*, and *M. intertexta*.

Within each of these species, types and variants were selected from a general lot of burs and the seed planted, to note variations in the progeny. In none of these species was there the marked variation of burs on single plants noted in *Medicago murex* and *M. muricata*, but in every species the burs on individual plants varied somewhat in size and the spines varied more or less in length. In *M. hispida* and its subspecies the variation was so great that the smallest burs produced in the different subspecies were smaller than the typical

burs of the nearest related subspecies having a smaller bur. (Pl. V, fig. 1.) In all cases the number of burs of the progeny that varied from the type of the species or subspecies was much less than the number of those that were typical.

It has been noted that burs of the same species vary in color, ranging from very dark or almost black to straw color. General observations had indicated that the dark color might be due to moisture in contact with the burs before and after ripening. That the dark colors were due to such contact was demonstrated very clearly on a large scale in the spring of 1911 at Chico, Cal. Until the burs were ripening the weather had remained clear and dry, and the burs developed were all light colored. Then a light rain fell during one night, and the next day all the burs that were fully developed and ripening (which included the greater part of the crop) turned black. No other rain fell, and all the burs that matured later were light colored and remained so.

The following species growing in the open at Chico at the time of the rain referred to were noted as showing a similar change in color: *Medicago orbicularis*, *M. orbicularis marginata*, *M. ciliaris*, *M. scutellata*, *M. turbinata*, *M. muricata*, *M. tuberculata*, *M. rigidula*, *M. hispida*, *M. hispida confinis*, *M. hispida apiculata*, *M. hispida terebellum*, *M. hispida nigra*, and *M. arabica*. The discoloration in *M. arabica* was not as marked as in the others.

To test this phenomenon artificially, burs of *Medicago orbicularis* that had developed without becoming wet or discolored were dampened and left over night; the next morning all had become dark, with the exception of a few burs that were mature and dry. It would seem from these observations that the dark-colored burs in all species are probably those that have come in contact with moisture during the period of their ripening and before they are fully mature. The color of the burs can not be used as a character on which to base botanical subspecies.

VARIETAL STRAINS

To determine whether varietal strains exist in different species or subspecies, a number of selections were made representing types with regard to length of spines and size and form of burs. Two types of burs of *Medicago scutellata* were selected and planted. In one type the bur was so coiled as to have a definite truncate end, while in the other the bur was more nearly conical. All the progeny of the truncated type produced truncated burs, and by far the greater part of the progeny of the conical burs produced conical burs and only a few tended to be truncated, as shown by the bulk of burs harvested.

A large number of burs of *Medicago orbicularis* and *M. orbicularis microcarpa* of various types were selected—double convex, convex on one side only, and burs open (or loosely coiled, as in *M. orbicularis marginata*). The seed from the selected burs was grown in the field in plats. Most of the burs from the progeny plants were like the type planted, as shown by the bulk of burs harvested.

In the *Medicago hispida* group, burs representing the different sizes and lengths of spines were planted. In a number of cases they reproduced true to the type selected. *M. hispida confinis* produced two types, the bur of one having $2\frac{1}{2}$ to 3 turns and the other 4 to $4\frac{1}{2}$ turns. Another type approaching that of *M. hispida confinis*, but with spines sufficiently developed to throw it out of that group, reproduced true to type. In the other groups of *M. hispida* the types were not so definitely marked, but a few showed variations. The other species showed no definite varietal strains, but the work was not extended enough to say that they do not exist. Thus far the work indicates that there exist definite varietal strains within at least several of the species and subspecies, and that these may be grown as pure strains by selection. On account of the variations that may occur within the different species, a type or variety can not be defined by the appearance of the burs in a bulk lot of seed. As already explained, an individual plant may produce burs that are as different as the burs of two subspecies, but when grown under normal conditions most of the burs on individual plants will be true to type.

POLLINATION IN THE VARIOUS SPECIES.

The flowers of the various species of bur clovers are similar in form but differ somewhat in size, in the number borne in a cluster, and in the details of the explosive mechanism. Seven of the species studied have a tripping mechanism similar to alfalfa, so that after tripping the stigma is exposed—*Medicago scutellata*, *M. rugosa*, *M. turbinata*, *M. muricata*, *M. rigidula*, *M. ciliaris*, and *M. echinus*. In *M. echinus* the flowers are in clusters of six. The other species have the flowers in clusters of two. *Medicago turbinata* often appears to have single flowers in a place, because one of each pair usually dies in the bud or withers shortly after it opens and fails to develop a pod.

All the bur clovers studied except *Medicago echinus* seem to be readily self-fertile. The various species have been grown in a greenhouse where little, if any, cross-pollination was probable, and with the exception of *M. echinus* all set pods freely. Alfalfa plants growing in the greenhouse beside the bur clovers set no seed except when artificially tripped. A number of flowers of *M. echinus* were tripped by means of a toothpick to determine the effect on seed setting. These

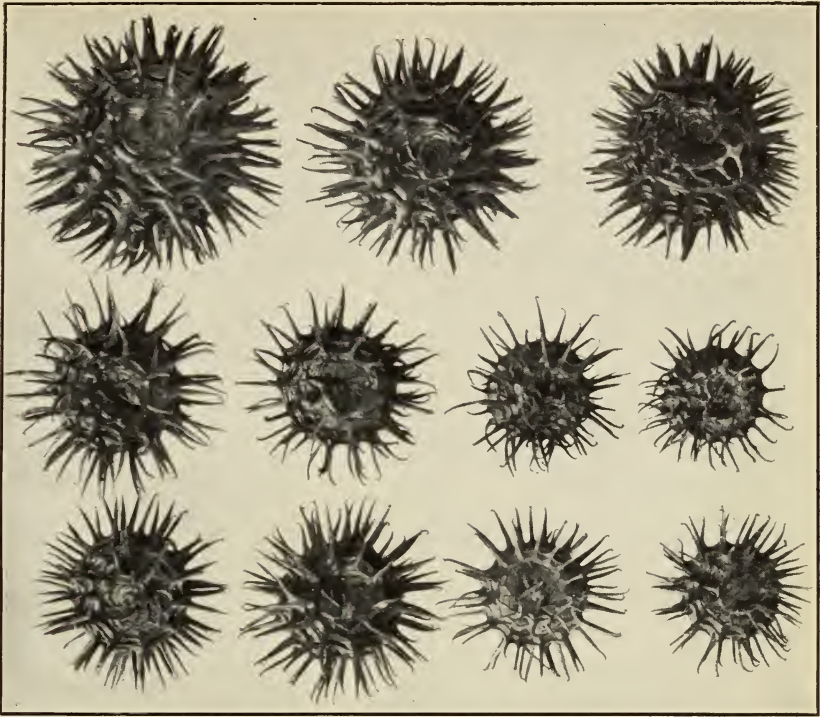


FIG. 1.—ROWS OF BURS FROM SINGLE PLANTS OF MEDICAGO, SHOWING VARIATION IN SIZE.

Upper row. *M. hispida nigra*; middle and lower rows, *M. hispida denticulata*. (Enlarged $2\frac{1}{2}$ diameters.)

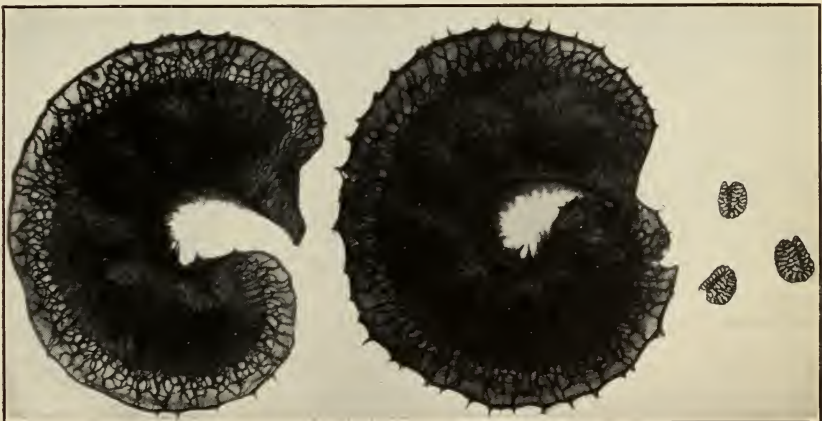


FIG. 2.—PODS AND SEEDS OF MEDICAGO RADIATA, SHOWING SEED AND VENATION OF PODS.

(Enlarged 2 diameters.)

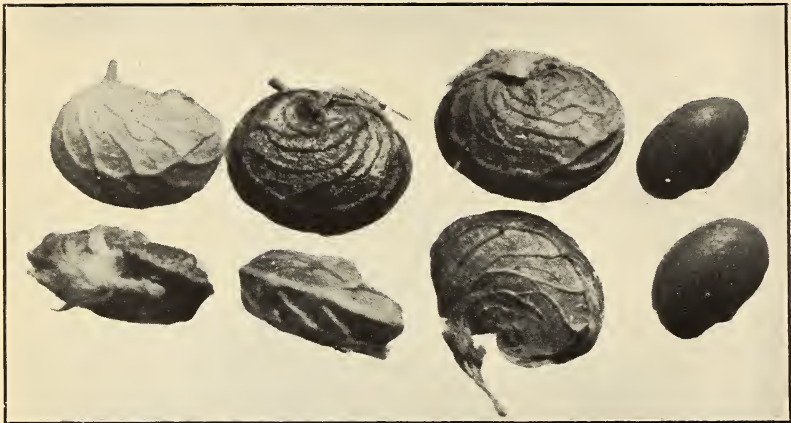


FIG. 1.—PODS AND SEEDS OF *MEDICAGO LUPULINA*, SHOWING VENATION OF PODS AND PROMINENCE ON THE SEED AT THE TIP OF THE RADICLE.

(Enlarged 9 diameters.)

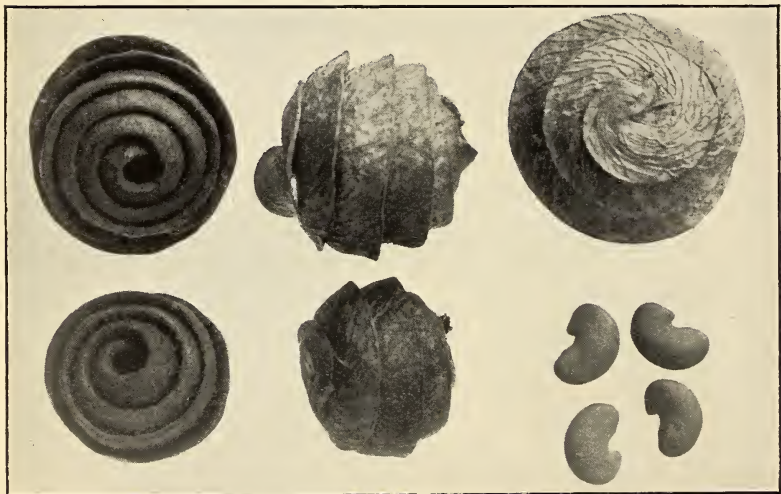


FIG. 2.—PODS AND SEEDS OF *MEDICAGO SCUTELLATA*, SHOWING VENATION AND WINDINGS OF PODS AND CHARACTERISTICALLY NOTCHED SEEDS.

(Enlarged 2 diameters.)

flowers, as well as the alfalfa flowers, set a number of pods, but the exact percentage was not determined. Other flowers were tripped and cross-fertilized with pollen from another plant of *M. echinus*, with the apparent result that more pods were set from these flowers than from those tripped but not cross-pollinated.

GENERAL CLASSIFICATION OF THE SPECIES.

The nonperennial species of *Medicago* here considered may for convenience be divided into six groups. The most of the species in each group are so nearly alike in flower and leaf characters that they are distinguished with certainty only when the pods have matured.

The first group contains a single species, *Medicago radiata*, the leaflets of which are mostly rather small and the stems somewhat woody, procumbent to erect. The pods are large, flattened, kidney shaped, and have a row of short, simple or sometimes forked spines along the back. The seeds have the surface somewhat convoluted and the radicle as long as the seed.

The second group contains one species, *Medicago lupulina*, having stems slightly procumbent or suberect in habit, with rather small, strigose-veined leaflets and small kidney-shaped pods.

The third group contains three species, *Medicago orbicularis*, *M. scutellata*, and *M. rugosa*. The stems in this group, as in the following three groups, are more procumbent and, unless the stand is thick, have a tendency to become trailing. The pods are rather large, disk shaped, consist of several thin spiral windings, are of a papery texture, and are without spines.

The fourth group contains four species, *Medicago rigidula*, *M. turbinata*, *M. tuberculata*, and *M. murex*. The pods of these species are harder in texture, more closely wound, of an oval form, and vary from smooth to tubercular and spiny.

The fifth group contains two species, *Medicago ciliaris* and *M. echinus*, which have rather large, closely wound, oval pods, with windings the edges of which are thickly covered with interlocking spines.

The sixth group contains two species, *Medicago arabica* and *M. hispida*, which have smaller, somewhat short cylindrical pods, with windings the edges of which are usually covered with more or less erect spines. Forms of both species are found without spines.

In the last four groups the flower and leaf characters are so nearly alike that the species can be distinguished with certainty only by the mature pods.

The seeds vary from 2 to 6 mm. (one-sixteenth to one-fourth inch) in length, and in the species here considered are yellow or greenish yellow in all but three species, *Medicago ciliaris* and *M. echinus* hav-

ing black seeds and *M. orbicularis* having yellowish brown seeds. In all but two species here considered the seeds are kidney shaped and smooth, the exceptions being *M. radiata*, in which they are oval in outline with a convoluted surface, and *M. orbicularis*, in which they are obovoid and the surface papillose.

Many of the species upon which these studies are based were originally obtained in Algeria by Mr. C. S. Scofield in 1901. *Medicago orbicularis*, S. P. I. No. 10725, is also from Algeria, secured in 1902 by Mr. T. H. Kearney. The others are mainly from botanical gardens, especially that at Madrid, Spain, and a few are from miscellaneous sources.

DISTRIBUTION AND DESCRIPTION OF SPECIES.

The genus *Medicago* is at present widely distributed over southern Europe, western Asia, northern Africa, and the adjacent islands. Its northern limit seems to be southern Scotland, Sweden, and Siberia. A few species have become naturalized in recent years in Abyssinia, South Africa, and Chile. In the United States about 60 species and subspecies have been introduced for experimental purposes since 1898 through the Office of Seed and Plant Introduction. Some of these importations may become naturalized. Prior to 1898 five species had become well established along the eastern, western, and southern coasts of the United States. These species and two others more recently introduced, are gradually working their way inland, but their progress is slow. At present but two species are established in the Central States north of Texas.

MEDICAGO RADIATA L.

(Pl. V, fig. 2.)

Stems decumbent, pubescent, 10 to 30 cm. (4 to 12 inches) long; leaflets obovate to cuneate, downy to villous on both sides, 2 to 6 mm. (one-sixteenth to three-sixteenths inch) wide, 3 to 10 mm. (one-eighth to three-eighths inch) long, rounded, and toothed at the apex, the base entire; leafstalks equaling or twice the length of the leaves, pubescent, the stalk of the terminal leaflet five times longer than the lateral; stipules awl shaped, pubescent, entire, 2 to 4 mm. (one-sixteenth to one-eighth inch) long; flowers usually axillary, in clusters of two, 2½ to 3 mm. (three thirty-seconds to one-eighth inch) long, the stigma not exposed when tripped, the peduncles and calyx pubescent; pods papery, brownish when ripe, sickle shaped to circular, 15 to 25 mm. (one-half to 1 inch) long, 7 to 10 mm. (one-fourth to three-eighths inch) wide, glabrous, netted veined, with a row of simple, sometimes forked spines about 1 mm. (one-sixteenth inch) in length along the outer side, and an irregularly toothed, membranous margin along the inner side, 5 to 6 seeded; seeds oval, flattened, light to yellowish brown, 2 to 2½ mm. (one-sixteenth to three thirty-seconds inch) long, surface convoluted, the radicle as long as the seed.

Distribution: Spain to Persia.

This species was received from Madrid, Spain, and Karlsruhe, Germany, under S. P. I. Nos. 9746 and 16266, respectively. It has been tested only at Chico, Cal. It makes little growth compared with toothed or spotted bur clover, and yields little seed.

MEDICAGO LUPULINA L. (YELLOW TREFOIL).

(Pl. VI. fig. 1.)

Stems four angled, pubescent to nearly glabrous, 10 to 80 cm. (4 to 32 inches) long, decumbent; leafstalks, 2 to 10 cm. (three-fourths to 4 inches) long, pubescent, the leaflets oval to broadly obovate or even obcordate, sometimes wedge shaped at the base, pubescent on both sides, 3 to 12 mm. (one-eighth to one-half inch) wide, 6 to 20 mm. (one-fourth to three-fourths inch) long, the base entire, stalk of the terminal leaflet 3 to 5 times longer than the lateral; stipules rather large, broad, and few toothed at the base; flowers very small, $1\frac{1}{2}$ to 2 mm. (one-sixteenth inch) long, in rather close, oval, or oblong heads of 10 to 40 flowers, the stigma not exposed when tripped; pod kidney shaped, about 2 mm. (one-sixteenth inch) in diameter, netted veined, minutely pubescent, blackish when mature, one seeded; seed $1\frac{1}{2}$ to 2 mm. (about one-sixteenth inch) long, yellow or greenish yellow.

Distribution: Spain to Scotland, east to Persia, and probably widely introduced into every civilized country.

This species is a semierect, leafy plant, usually biennial, but with annual and perennial forms. It occurs spontaneously both in the Pacific Coast States and in the Eastern States. It is hardy at least as far north as central New York and, in addition to its use as pasturage, is of promise as a green-manure crop. It is being tested in comparison with crimson clover in the Atlantic States, and while its actual yield of forage and green manure is not equal to crimson clover, the occasional high price of the seed of crimson clover makes this species potentially important. At the Arlington Experimental Farm, Va., it made a growth varying from 12 to 26 inches in height, depending on the character of the soil. It will grow on stiff clay soils somewhat too poor for the successful growth of alfalfa or red clover. It has been recommended as a constituent of lawn mixtures, since it remains green during rather severe drought. At Chico, Cal., it has been grown under F. C. I. No. 0268, seed received from the Botanical Gardens of Madrid, Spain, and also under S. P. I. No. 4340, from Naples, Italy. In hot weather it made considerably better growth than the other bur clovers under test. It is used to some extent in European pastures and is ordinarily regarded as being inferior to clover and alfalfa. Its use in the past to adulterate alfalfa and clover seed has caused it to be classed as a weed, but it is not troublesome in this respect, since it is readily eradicated by ordinary tillage. Its presence in uncultivated lands is not objectionable, but usually advantageous. Its short life makes it compare unfavorably with alfalfa, and its small size makes it less valuable than such plants as crimson clover or red clover, with which it must ordinarily compete in agricultural use.

MEDICAGO ORBICULARIS (L.) ALL. (BUTTON CLOVER).

(Pl. VII, fig. 1.)

Stems procumbent, 10 to 80 cm. (4 to 32 inches) long, sparingly pubescent; leaflets oval to obovate, sometimes truncate at the base, sparingly pubescent on both sides, up to 15 mm. (five-eighths inch) wide and 20 mm. (seven-

eighths inch) long, rounded at the apex, the margin toothed nearly to the base, the leafstalks 1 to 10 cm. (three-eighths to 4 inches) long; stipules with slender teeth about 2 to 3 mm. (one-sixteenth to one-eighth inch) long; flowers 4 to 5 mm. (about three-sixteenths inch) long, in pairs, on an axillary peduncle, the stigma slightly exposed when tripped; pods papery, straw colored, netted veined, 18 to 20 mm. (about three-fourths inch) in diameter, twisted spirally into 4 to 6 thin, flattened turns, the margin often recurved, the central winding largest, the others gradually decreasing in size; seed yellowish brown, obovoid, flattened, about $2\frac{1}{2}$ to 3 mm. (one-eighth inch) long, the surface minutely papillose, the radicle as long as the seed.

Distribution: France, Spain, and Algeria; thence east to Persia. In the United States it has been reported growing spontaneously only in Alabama and southern California.

This species was received from Algeria and from Brunswick, Germany, under S. P. I. Nos. 10725 and 16876, respectively. It has been tested most extensively at Chico and other places in California, but has also been tried in several localities in the South Atlantic and Gulf Coast States. It promises well for pastures in California, but has not been sufficiently tested in the Southern States to determine its value there. In general its growth is about like the spotted and toothed bur clovers, but in California it yields very much more seed than either of these species. Its large spineless burs and heavy yields of seed make it superior to common species for pasturage. It matures earlier and is affected much less by the clover-seed chalcis than the toothed or spotted bur clovers.

MEDICAGO ORBICULARIS MICROCARPA ROUY AND FOUC.

(Pl. VII, fig. 2.)

This subspecies differs from typical *Medicago orbicularis* only in having uniformly smaller pods, varying from 8 to 12 mm. (one-fourth to one-half inch) in diameter, having the same season of growth.

Distribution: Same as for the species.

This importation was from near Oued Smaar, Algeria, under S. P. I. No. 7738. Tested in California and in the Southern States in comparison with the species it shows no difference in agronomic value.

MEDICAGO ORBICULARIS MARGINATA (WILLD.) BENTH.

(Pl. VII, fig. 2.)

This subspecies differs from typical *Medicago orbicularis* in having pods with looser windings, all of the same diameter, and the margins always straight, never recurved.

Distribution: Same as for the species.

This importation was from Karlsruhe, Germany, under S. P. I. No. 16265, and has been tested at Chico, Cal. It makes less growth than the species proper, yields very much less, and therefore is of much less value.

MEDICAGO SCUTELLATA (L.) WILLD. (SNAIL CLOVER).

(Pl. VI, fig. 2.)

Plants densely glandular pubescent throughout; stems procumbent, 10 to 75 cm. (4 to 30 inches) long; leaves oval, oblong, or obovate, rarely broadly cuneate at the base; leaflets up to 15 mm. (five-eighths inch) wide, and 25 mm.



FIG. 1.—PODS AND SEEDS OF *MEDICAGO ORBICULARIS*, SHOWING VENATION AND WINDINGS OF PODS AND MARKINGS OF SEED COATS.

(Enlarged 2 diameters.)



FIG. 2.—PODS OF TWO SUBSPECIES OF *MEDICAGO ORBICULARIS*, *MARGINATA* (UPPER ROW) AND *MICROCARPA* (LOWER ROW), SHOWING VARIATION IN WINDINGS AND SIZE.

(Enlarged 2 diameters.)

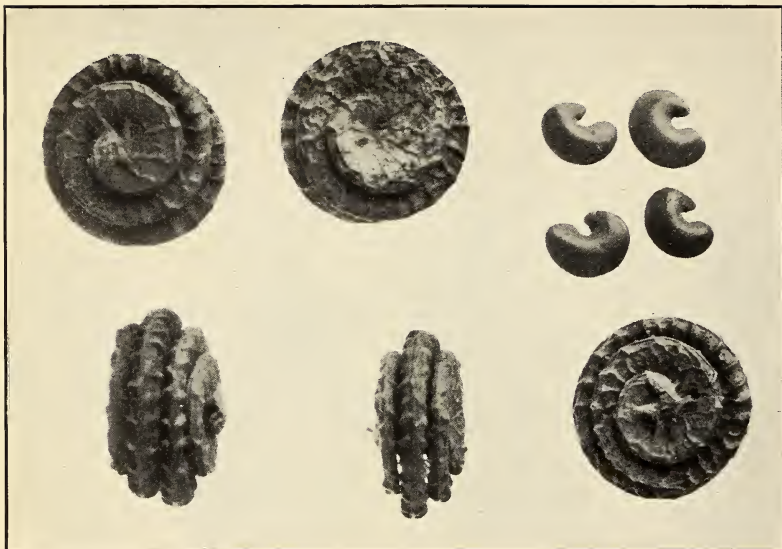


FIG. 1.—PODS AND SEEDS OF *MEDICAGO RUGOSA*, SHOWING VENATION AND WINDINGS OF PODS AND CHARACTERISTICALLY NOTCHED SEEDS.

(Enlarged 2 diameters.)

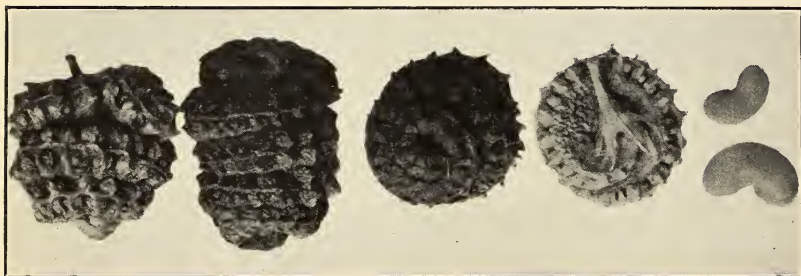


FIG. 2.—PODS AND SEEDS OF *MEDICAGO TUBERCOLATA*, SHOWING VARIATION OF WINDINGS AND SHORT TUBERCULAR SPINES OF PODS AND CHARACTERISTIC NOTCHES IN SEEDS.

(Enlarged 2 diameters.)

(1 inch) long, coarsely and sharply toothed nearly to the base, the apex obtuse to acute, the leafstalk rarely much longer than the leaf; stipules up to 4 mm. (three-sixteenths inch) wide, and 10 mm. (three-eighths inch) long, sparingly toothed; flowers about 7 mm. (one-fourth inch) long, in clusters of two, the stigma exposed when tripped; pods 12 to 15 mm. (one-half to five-eighths inch) in diameter, straw colored, netted veined, with 5 to 8 thin, spiral, cup-shaped windings; seed kidney shaped, yellow, 5 to 5½ mm. (about three-sixteenths inch) long, the radicle half the length of the seed.

Distribution: Spain and Algeria to Asia Minor.

This species was received under S. P. I. Nos. 9747 from Madrid, Spain; 16267 from Karlsruhe, Germany; and 16877 from Brunswick, Germany. It has been grown at Chico and other points in California and at several places in the Southern States. It matures earlier than any of the other species tested, and makes less growth than the common spotted and toothed bur clovers. In comparison with others it makes a heavy yield of seed under California conditions, but has done little in tests in the Southern States. On account of its large smooth burs, good yield of seed, and early maturity it is valuable for pasturage in California. The seeds are little attacked by the clover-seed chalcis.

MEDICAGO RUGOSA DESK.

(Pl. VIII, fig. 1.)

Plants sparingly glandular pubescent throughout, except on the upper surface of the leaves; stems decumbent, 10 to 60 cm. (4 to 24 inches) long; leaflets up to 15 mm. (five-eighths inch) wide and 20 mm. (seven-eighths inch) long, broadly truncate and entire at the base, the apex rounded or retuse, sharply toothed, the leafstalk up to 5 cm. (2 inches) long; flowers about 5 mm. (three-eighths inch) long, in clusters of two, the stigma slightly exposed when tripped; pods 7 to 8 mm. (one-fourth to five-sixteenths inch) in diameter, the windings 2½ to 4, somewhat inflated, with conspicuous, radiating, marginal striæ; seed kidney shaped, yellow, 3 to 4 mm. (about one-eighth inch) long.

Distribution: Syria, Mesopotamia, and Palestine.

This species was received from Madrid, Spain, under S. P. I. No. 19442. It has been tried only at Chico, Cal., makes much less growth than the spotted or toothed bur clovers, and yields considerably less seed. Its season is practically the same as the spotted or toothed bur clovers. It is little attacked by the clover-seed chalcis. The absence of spines makes it desirable for further testing.

MEDICAGO TUBERCULATA (RETZ.) WILLD.

(Pl. VIII, fig. 2.)

Stem procumbent, 10 to 60 cm. (4 to 24 inches) long, sparingly villous, with brownish hairs; leaflets pubescent on both sides, obovate to ovate, up to 15 mm. (five-eighths inch) wide, and 24 mm. (three-fourths inch) long, the apex rounded to acute, closely toothed, the base truncate, the terminal pedicels three to five times longer than the lateral; stipules not deeply toothed; flowers about 5 mm. (three-sixteenths inch) long, in clusters of 5, the stigma not exposed when tripped; pod 6 to 7½ (one-fourth to five-sixteenths inch) in diameter, twisted spirally into 4 to 5 turns, a few radiating veins near the center of the turn surrounded by a smooth band bordered by a vein parallel to the dorsal suture. The parallel vein and dorsal suture are connected by numerous radiating veins, these are usually swollen at the base when mature. Seed kidney shaped, yellow, about 4 mm. (one-eighth inch) long, radicle nearly half as long as the seed.

Distribution: France to Algeria; thence east to Syria.

This species was received from the Royal Botanic Gardens, Dublin, under F. C. I. No. 9229 and S. P. I. No. 17783. It has been grown only at Chico, Cal. Its season is practically the same as the spotted or toothed bur clovers, but it makes much less growth and yields little seed. It is worthy of further testing on account of its spineless burs.

MEDICAGO TURBINATA (L.) ALL.

(Pl. IX, fig. 1.)

Plant more or less densely pubescent throughout; stems procumbent, 10 to 60 cm. (4 to 24 inches) long; leaflets up to 16 mm. (five-eighths inch) wide and 25 mm. (1 inch) long, the leafstalk not much longer than the leaf, the stalk of the terminal leaflet five to eight times longer than the lateral; stipules not deeply toothed; flowers about 5 mm. (three-sixteenths inch) long, single, or rarely in clusters of two, the stigma exposed when tripped; pod 7 to 8 mm. (one-fourth to five-sixteenths inch) in diameter, twisted spirally into about 5 windings, which are smooth, woody, and sparingly covered with short, stiff, tubercular-pointed spines; seed kidney shaped, light yellow, 5 to 6 mm. (three-sixteenths to one-fourth inch) long. Pods without spines sometimes appear in dry seasons.

Distribution: Portugal and Algeria to Asia Minor.

This importation is represented by S. P. I. Nos. 19447 and 19449, both probably from the Madrid Botanical Gardens. It has been grown at Chico and other places in California. Its season of maturing is about the same as or a little later than toothed bur clover, but its growth is not as great, and its hard, woody, spiny pod makes it less desirable for pasture. It is little affected by the clover-seed chalcis.

MEDICAGO MURICATA (L.) ALL.

(Pl. IX, fig. 2.)

Plant pubescent throughout; stems procumbent, 10 to 50 cm. (4 to 20 inches) long; leaflets up to 14 mm. (nine-sixteenths inch) wide and 18 mm. (three-fourths inch) long, the leafstalks about as long as the leaves, the stalk of the terminal leaflet five to eight times longer than the lateral; stipules not deeply toothed; flowers in twos, about 5 mm. long, the stigma exposed when tripped; pod 6 to 7 mm. (about one-fourth inch) in diameter, spirally twisted into five to six windings, the lateral veins parallel to the dorsal suture, bearing nearly opposite, stiff, sharp spines as long as the diameter of the windings, the edges of the windings partly obscured by the slightly interlocking prickles; seed about 3 mm. (one-eighth inch) long, yellow, somewhat kidney shaped or angular along the back, the radicle half as long as the seed and the end turned up so as to form a small beak near the hilum.

Distribution: Canary Islands, both shores of the Mediterranean, and east to Syria and Egypt.

This species was received from Madrid, Spain, under S. P. I. No. 9743. It has been grown only at Chico, Cal. The season of maturing is the same as toothed bur clover, but it makes much less growth. Its yield of seed is light, and its hard burs, with sharp, heavy spines, make it undesirable for pasturage.

MEDICAGO MUREX (L.) ALL.

(Pl. X, fig. 1.)

Stems procumbent, glabrous, 10 to 50 cm. (4 to 20 inches) long; leaflets glabrous above, pubescent beneath, the leafstalk about as long as the leaf, the stalk of the terminal leaflet about 5 times longer than the lateral; stipules

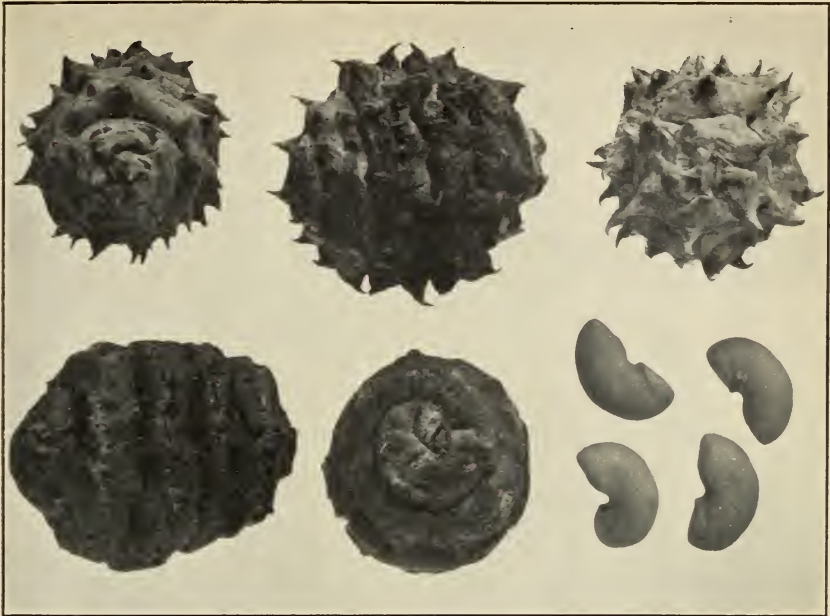


FIG. 1.—PODS AND SEEDS OF *MEDICAGO TURBINATA*, SHOWING WINDINGS OF PODS, SPINY AND SPINELESS PODS, AND SEEDS STRAIGHT AND NOTCHED ON THE UNDER SIDE.

(Enlarged 2 diameters.)

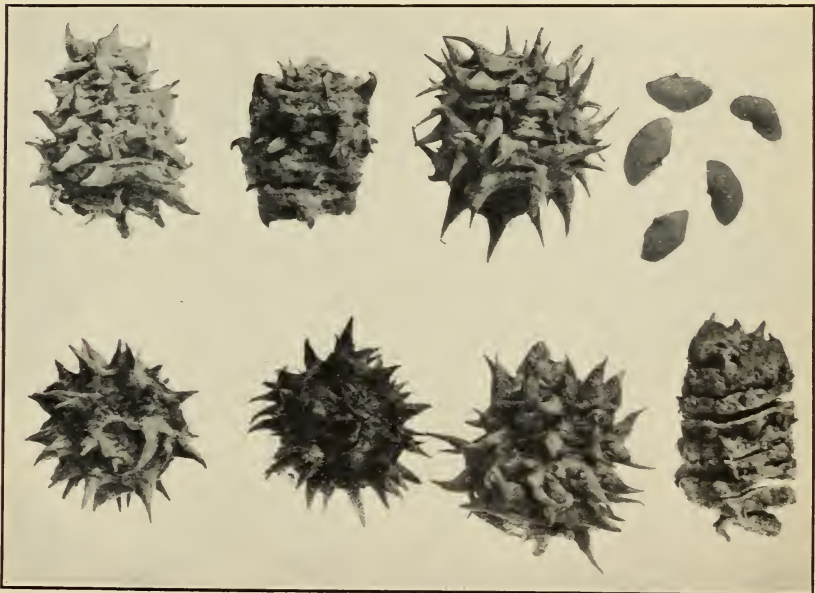


FIG. 2.—PODS AND SEEDS OF *MEDICAGO MURICATA*, SHOWING WINDINGS OF PODS, SPINY AND NEARLY SPINELESS PODS, AND ANGULAR SEEDS WITH PROMINENCE AT THE TIP OF THE RADICLE.

(Enlarged 2 diameters.)

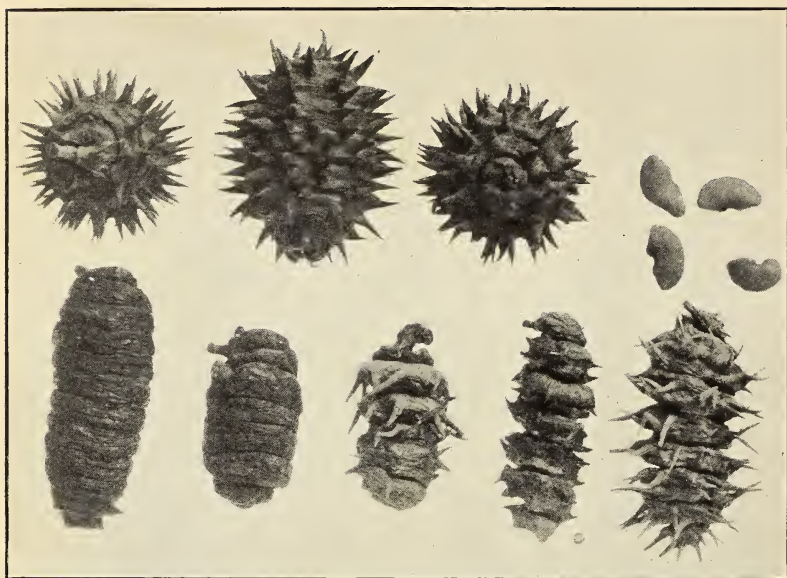


FIG. 1.—PODS AND SEEDS OF *MEDICAGO MUREX*, SHOWING VARIATION OF PODS OFTEN FOUND ON ONE PLANT.
(Enlarged 2 diameters.)

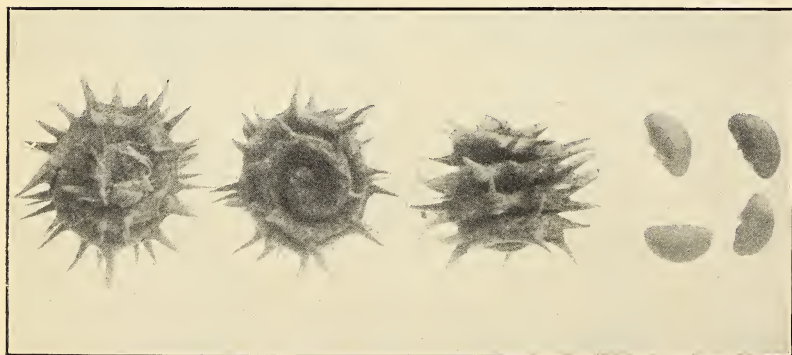


FIG. 2.—PODS AND SEEDS OF *MEDICAGO RIGIDULA*, SHOWING WINDINGS OF PODS, VENATION OF PODS HIDDEN BY PUBESCENCE, AND PROMINENCE AT THE TIP OF THE RADICLE.
(Enlarged 2 diameters.)

rather deeply toothed, the teeth 3 to 4 mm. (one-eighth inch) long; flowers in twos, about 4 mm. (three-sixteenths inch) long, the stigma not exposed when tripped. The pods are very similar in size and appearance to those of the preceding species, but have 7 to 9 turns, and the spines are more erect and do not interlock. Pods with few or no spines are produced in dry weather. The seeds are kidney shaped, about 3 to 4 mm. (one-eighth inch) long, and the radicle is nearly half the length of the seed.

Distribution: France, Italy, Turkey, and Algeria.

This species is represented by F. C. I. No. 0147, from Jamaica, and S. P. I. No. 16875, from Brunswick, Germany. It has been tested only at Chico, Cal. It has practically the same season as toothed bur clover, but makes much less growth. Its spiny burs make it objectionable for pasturage.

MEDICAGO RIGIDULA (L.) DESR.

(Pl. X, fig. 2.)

Plants pubescent throughout; stems procumbent, 10 to 50 cm. (4 to 20 inches) long; leaflets up to 12 mm. (one-half inch) wide and 24 mm. (1 inch) long, the leafstalk often equaling the leaves, but mostly shorter, the stalk of the terminal leaflet 3 to 4 times longer than the lateral; stipules not deeply toothed; flowers in twos, about 5 mm. (three-sixteenths inch) long, the stigma exposed when tripped; pods 7 to 8 mm. (about five-sixteenths inch) in diameter, similar to the preceding species, the windings not so thick and covered with a fine pubescence, the spines somewhat hooked at the tips; seed about 4 mm. (five thirty-seconds inch) long, yellow, kidney shaped, the radicle about half the length of the seed, the tips slightly raised.

Distribution: France and Spain; thence east to the Caucasus, Persia, and Egypt.

This species was received from Madrid, Spain, under F. C. I. Nos. 0373 and 0377, and from Strasburg, Germany, as S. P. I. No. 16288. It has been tested only at Chico, Cal. It makes much less growth than the toothed or spotted bur clovers and yields little seed. Its comparatively hard pod and stiff spines make it less desirable for pasturage.

MEDICAGO CILIARIS (L.) ALL.

(Pl. XI, fig. 1.)

Stems decumbent, glabrous, 10 to 100 cm. (4 to 40 inches) long; leaflets up to 17 mm. (five-eighths inch) wide and 30 mm. (1½ inches) long, pubescent beneath, the leafstalks slightly pubescent, about equaling the leaves, the stalk of the terminal leaflet 3 to 5 times longer than the lateral; stipules not deeply toothed; flowers about 7 mm. (five-sixteenths inch) long, in twos, the stigma exposed when tripped; pod pubescent, 7 to 12 mm. (five-sixteenths to one-half inch) in diameter, 10 to 22 mm. (three-eighths to seven-eighths inch) long, 7 to 10 spiral windings thickly covered with stiff, somewhat interlocking spines about 2 to 3 mm. (one-eighth inch) long; seed 5 to 6 mm. (three-sixteenths to one-fourth inch) long, kidney shaped, black.

Distribution: France to Madeira; thence east to Asia Minor and Mesopotamia.

This species includes S. P. I. Nos. 7742, from Oued Smaar, Algeria, and 9747 and 19435, from Madrid, Spain. It has been tested at Chico and other points in California. It has practically the same season as toothed or spotted bur clover and makes equally good growth. Its very spiny pods make it less desirable for pasturage, though it produces a comparatively good crop of seed.

MEDICAGO ECHINUS DC. (CALVARY CLOVER).¹

(Pl. XI, fig. 2.)

Stems procumbent, glabrous, 10 to 100 cm. (4 to 40 inches) long; leaflets up to 15 mm. (five-eighths inch) wide and 24 mm. (1 inch) long, pubescent beneath or only along the midrib, usually marked with a small reddish spot in the center of each leaflet, the leafstalk about as long as the leaf, the stalk of the terminal leaflet 3 to 5 times larger than the lateral; stipules not deeply toothed; flowers about 7 mm. (five-sixteenths inch) long, in clusters of 6, the stigma exposed when tripped; pod ovoid to spheroid, glabrous, 10 to 15 mm. (three-eighths to five-eighths inch) wide, 15 to 20 mm. (five-eighths to three-fourths inch) long, 7 to 9 spiral windings, thickly covered with slender, rigid, closely interlocking spines 5 to 7 mm. (about one-fourth inch) long; seed 5 to 6 mm. (three-sixteenths to one-fourth inch) long, kidney shaped, black.

Limited observation indicates that it is essential that the stigma be tripped as in alfalfa before the seed will set, and that crossing is advantageous to seed setting.²

Distribution: Spain and the Canary Islands; thence east to Italy and Algeria. This species was selected from S. P. I. No. 7742, from near Oued Smar, Algeria. It has been tested only at Chico, Cal. It has practically the same season as the toothed and spotted bur clovers and makes equally as good growth. Its very spiny pods make it less desirable for pasturage, though it produces a comparatively good crop of seed.

The subspecies *Medicago echinus variegata* (Urban) Ricker (*M. intertexta echinus variegata* Urban) differs from typical *M. echinus* in having a large, triangular, dark-reddish spot extending from the base to near the middle of the leaflet. The stems are less decumbent than those of the typical form, and the season of maturing is a little later. The name is a new trinomial.

Distribution: Same as for the species.

This importation was received from Brunswick, Germany, under S. P. I. No. 16874, and has the same agronomic value as the species. It perhaps can be used to advantage in California as an ornamental plant for winter border or bedding work.

MEDICAGO ARABICA (L.) ALL. (SPOTTED BUR CLOVER).

(Pl. XII, fig. 1.)

Stems procumbent, pubescent, 10 to 100 cm. (4 to 40 inches) long; leaflets up to 22 mm. (seven-eighths inch) wide, 27 mm. (1 $\frac{1}{8}$ inches) long, pubescent beneath, a dark-red spot in the center of each leaflet, the leafstalk often 4 to 5 times longer than the leaf, the stalk of the terminal leaflet not more than 2 to 3 times longer than the lateral; stipules not deeply toothed; flowers 4 to 5 mm. (about three-sixteenths inch) long, in clusters of 5 to 10; pods 3 $\frac{1}{2}$ to 5 mm. (one-eighth to three-sixteenths inch) in diameter, rather soft, twisted into 3 to 5 spiral windings, the edges bearing numerous interlocking grooved spines about as long as the width of a winding, the veins inconspicuous; seed about 2 $\frac{1}{2}$ mm. (three thirty-seconds inch) long, kidney shaped, the radicle somewhat

¹ Also called "crown of thorns," the name being derived from the suggested resemblance of one of the windings (Pl. XI, fig. 2).

² Proceedings, Cambridge Philosophical Society, vol. 8, 1894, pp. 142-143. Bulletins, Kansas Agricultural Experiment Station: No. 151, 1907, p. 101; No. 155, 1908, p. 319. Circular 24, Bureau of Plant Industry, 1909, p. 8.

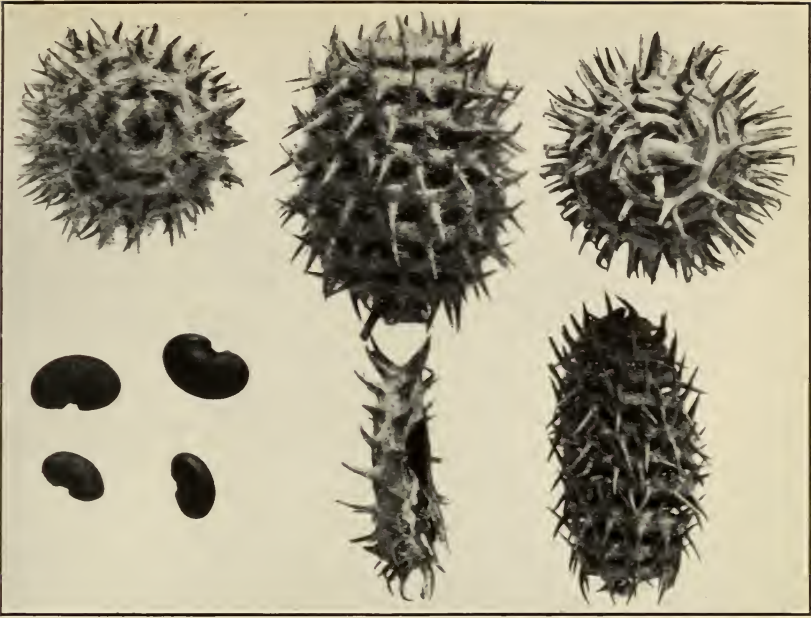


FIG. 1.—PODS AND SEEDS OF *MEDICAGO CILIARIS*, SHOWING VARIATION IN SHAPE OF PODS, CHARACTER OF WINDINGS, HAIRY SPINES, AND NOTCHED SEED.
(Enlarged 2 diameters.)



FIG. 2.—PODS AND SEEDS OF *MEDICAGO ECHINUS*, SHOWING INTERLOCKING SPINES, A SINGLE WINDING (LIKE A CROWN OF THORNS), AND NOTCHED SEED.
(Enlarged 2 diameters.)



FIG. 1.—PODS AND SEEDS OF *MEDICAGO ARABICA* (UPPER ROW) AND ITS SUBSPECIES *INERMIS* (LOWER ROW), SHOWING CHARACTER OF WINDINGS, LACK OF VENATION, AND PROMINENCE AT THE TIP OF THE RADICLE.

(Enlarged 2 diameters.)

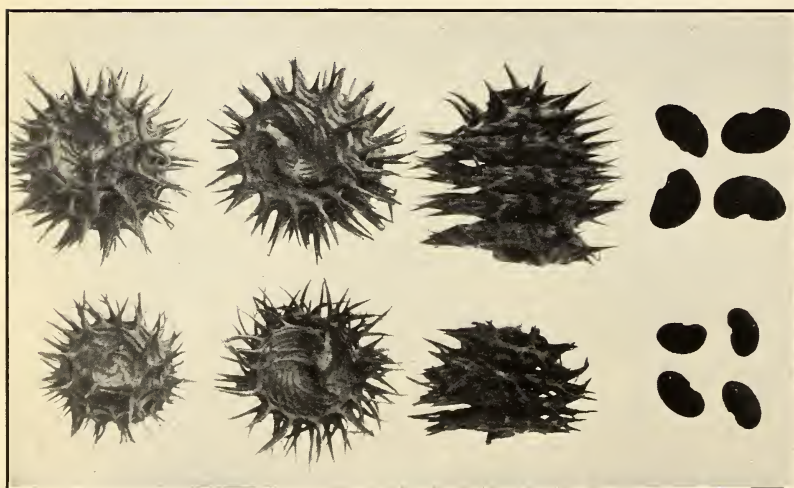


FIG. 2.—PODS AND SEEDS OF *MEDICAGO HISPIDA* (UPPER ROW) AND ITS SUBSPECIES *NIGRA* (LOWER ROW), SHOWING VENATION OF PODS, DIFFERENCE IN NUMBER OF WINDINGS, LENGTH OF SPINES, AND SHAPE AND SIZE OF SEEDS.

(Enlarged 2 diameters.)

more than half the length of the seed, the end slightly raised, forming a small beak near the hilum.

Distribution: Ireland to Algeria; thence east to Asia Minor. Established throughout the Atlantic, Gulf, and California coasts and extending rapidly into the interior States. It is reported from Colorado.

This has been extensively tested in the South Atlantic and Gulf Coast States under S. P. I. Nos. 16213, 21550, 23661, and 25878, all from American sources. It is common throughout this region, and on account of its hardiness has proved the best bur clover for the region designated. It also does well in California, where the spiny form is common. Its season for maturing is medium as compared with other species. It is usually in bloom from early until late spring. Wherever it does well it affords a large amount of pasturage both in the green and the dry state.

MEDICAGO ARABICA INERMIS RICKER (NEW SUBSPECIES).

(Pl. XII, fig. 1.)

This subspecies differs from typical *Medicago arabica* only in the absence of spines on the pod. Many seeds of this subspecies have been plan'ed at Chico, Cal. In every instance they have produced pods true to type and without spines.

Distribution: Seed received without definite statement of locality (S. P. I. No. 23284) from Mr. José D. Husbands, of Santiago, Chile. The type specimen grown from these seeds and collected by Mr. Roland McKee at Chico, Cal., June 1, 1910, has been deposited in the United States National Herbarium and a duplicate in the Economic Herbarium of the United States Department of Agriculture.

This importation has been grown only at Chico, Cal. In growth and season it is the same as typical *Medicago arabica*. On account of its spineless pods it gives promise of being especially serviceable in the Middle Atlantic and Gulf Coast States, where spotted bur clover in particular does well.

MEDICAGO HISPIDA GAERTN. (TOOTHED BUR CLOVER).

(Synonym, *M. hispida lappacea* (Desr.) Urban.)

(Pl. XII, fig. 2.)

Stems decumbent, glabrous, 10 to 110 cm. (4 to 44 inches) long, and up to 3 mm. (one-eighth inch) in diameter; leaflets broadly obovate to obcordate, glabrous above, sparingly pubescent beneath, up to 22 mm. (seven-eighths inch) wide and 28 mm. (1½ inches) long, often containing very small scattered whitish and dark-red spots, which disappear with age or drying, the apex finely toothed and emarginate, the base interruptedly toothed to entire, the stalk of the lateral leaflets very short, the terminal leaflet about five times longer than the lateral; stipules with linear teeth up to 3 mm. (one-eighth inch) long; flowers 4 to 5 mm. (one-eighth to three-sixteenths inch) long, in loose clusters of 6 to 9 on axillary peduncles, the stigma not exposed when tripped; pods netted veined, 7 to 10 mm. (one-fourth to three-eighths inch) in diameter, twisted spirally into 1½ to 4 windings with a conspicuous vein on each side of the winding parallel to the dorsal suture, and a double row of nearly opposite, stiff, erect, or slightly divergent spines connecting the dorsal suture and its parallel vein, the length of the spines being from one-half to full width of the windings; seed from light to brownish yellow, about 3 mm. (one-eighth inch) long, kidney shaped, the radicle half the length of the seed.

Distribution: The species and all its subspecies are natives of the northern Mediterranean regions, and are now found throughout the region from Spain to southern Germany and east to Central Asia and India. The species has been introduced extensively in Chile and Argentina and is becoming widely distributed in California.

This species was received under F. C. I. No. 0301 from Cambridge, England, and under S. P. I. No. 9736 from Madrid, Spain. It occurs commonly in California, and has been grown in comparative tests at Chico and other places in that State. It makes a good growth and is one of the best of the bur clovers in that respect. Its season for maturing is medium as compared with the other species, being in bloom in California from March until June, though in damp places it is found in bloom throughout the year. It is one of the forms of toothed bur clover already discussed (p. 8). Where it does well it affords a large amount of pasturage, either green or dry. The seed of this species and all its subspecies are badly attacked by the clover-seed chalcis. On account of its spiny burs it is less desirable than the spineless forms for pasturage.

MEDICAGO HISPIDA CONFINIS (KOCH) BURNAT.

(Pl. XIII, fig. 1.)

This subspecies differs from typical *Medicago hispida* in the general absence of leaf markings, in having rarely a small spot at the base of the leaf, and in having $1\frac{1}{2}$ to $3\frac{1}{2}$ windings and no spines. Short veins connecting the dorsal suture and lateral veins replace the spines.

Distribution: Same as for the species.

This importation was received under F. C. I. No. 0309 from Berlin, Germany, and under S. P. I. No. 9737 from Madrid, Spain. It has been tested at Chico and other places in California and in several localities in the Southern States. It has the same season as the species proper. It makes a good growth and is one of the best of the bur clovers in this respect. Its pods are spineless and, for this reason, it is especially desirable for pasturage. This form of the toothed bur clover is more fully discussed elsewhere (p. 20).

MEDICAGO HISPIDA RETICULATA (BENTH.) URBAN.

(Pl. XIII, fig. 1.)

This subspecies differs from *Medicago hispida confinis* only in having a pod with five windings. It has been occasionally found as a mixture with other species tested at Chico, Cal. Its growth and season are the same as the typical *M. hispida*. On account of its spineless bur it is desirable for pasturage.

Distribution: Same as for the species proper.

MEDICAGO HISPIDA APICULATA (WILLD.) URBAN.

(Pl. XIII, fig. 1.)

This subspecies differs from *Medicago hispida reticulata* only in the presence of short spines about as long as the thickness of the windings of the pod. It was received under F. C. I. Nos. 0266 and 0372 from Madrid, Spain, and under S. P. I. Nos. 16873 from Brunswick, Germany, and 19431 and 19434 from Madrid, Spain. It has been tested at Chico and other places in California. Its growth and season are the same as the species. It is preferable for pasturage to the more spiny form.

Distribution: Same as for the species proper.

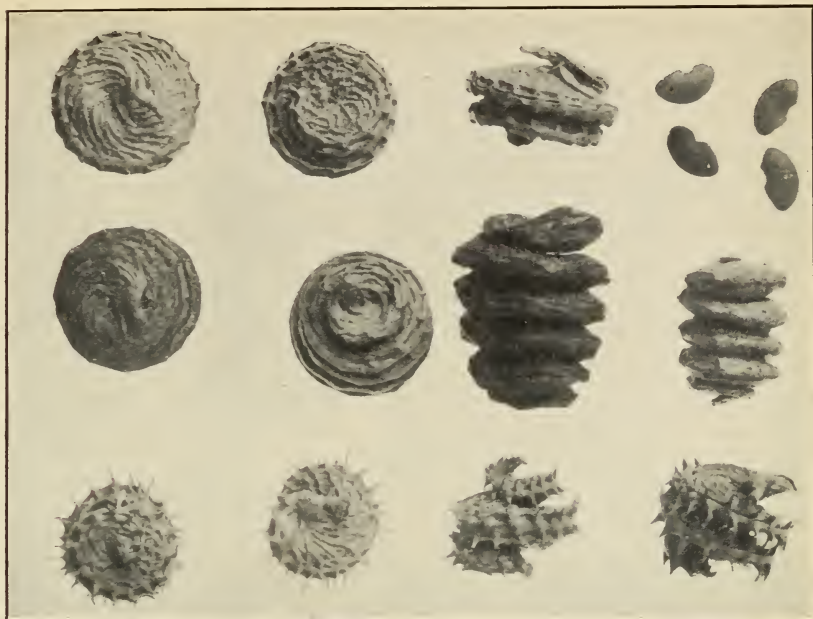


FIG. 1.—PODS OF THREE SUBSPECIES OF *MEDICAGO HISPIDA*, SHOWING DIFFERENCES IN WINDINGS, VENATION, ABSENCE OF SPINES, ETC.; ALSO SLIGHTLY NOTCHED SEEDS OF ONE SUBSPECIES.

Upper row, *M. hispida confinis*; middle row, *M. hispida reticulata*; lower row, *M. hispida apiculata*. (Enlarged 2 diameters.)



FIG. 2.—PODS AND SEEDS OF TWO SUBSPECIES OF *MEDICAGO HISPIDA*, SHOWING DIFFERENCES IN WINDINGS, IN LENGTH OF SPINES, AND IN SIZE AND SHAPE OF SEEDS.

Upper row, *M. hispida denticulata*; lower row, *M. hispida terebellum*. (Enlarged 2 diameters.)



MEDICAGO HISPIDA DENTICULATA (WILLD.) URBAN.

(Pl. XIII, fig. 2.)

This subspecies differs from *Medicago hispida apiculata* in having longer spines, about as long as half the width of the windings of the pod. This form has been received from various sources under F. C. I. Nos. 0149, 0151, 0262, 0271, 0272, 0273, 0280, 0374, 0382, 0894, and S. P. I. Nos. 19444, 19450, 19452, 19453, 19455, 20715, 22649, 24596.

This form is the most common of the toothed bur clovers already discussed. Its growth and season are the same as the species. On account of its spiny burs it is less desirable for pasturage than the spineless forms.

Distribution: New Brunswick to Florida; thence west to California and Washington.

MEDICAGO HISPIDA NIGRA (WILLD.) BURNAT.

(Pl. XII, fig. 2.)

This subspecies differs from typical *Medicago hispida* in having 4 to 6 windings of the pod and stout rigid spines equaling or exceeding the width of the windings.

Distribution: Same as for the species.

This form was received under F. C. I. Nos. 0264, 0269, 0379, and S. P. I. Nos. 9739, 19439, 19448, 26072. All were originally from the Botanic Gardens at Madrid, Spain.

This importation has been tested at Chico and other places in California and at several localities in the Southern States. Its growth and season are the same as for the species. On account of its very spiny burs it is less desirable for pasturage than the spineless forms.

MEDICAGO HISPIDA TEREPELLUM (WILLD.) URBAN.

(Pl. XIII, fig. 2.)

This subspecies differs from *Medicago hispida nigra* in having pods with more compact windings, the spines being absent or reduced to rudiments. The pod is comparatively large and somewhat harder than in the other subspecies. It was received under F. C. I. No. 0274 from Madrid, Spain, and under S. P. I. No. 16879 from Brunswick, Germany, and under Nos. 19446 and 19456, probably also from Madrid. It has been tested at Chico and other places in California and at several localities in the Southern States. Its growth and season are the same as for the species proper. On account of the large size of the pod and the absence of spines, this form is desirable for pasturage. Nos. 0274 and 19446 have matured earlier than the other numbers tested and may be of greater value, as in a dry season late-maturing varieties do not yield as well.

Distribution: Same as for the species.

FURTHER WORK PLANNED.

The comparative testing of the bur clovers is being continued with the species discussed in this bulletin, together with a number of others more recently introduced. The newer introductions will be tested at various stations throughout the bur-clover sections of

the United States, to determine their relative agronomic value in comparison with the spotted and toothed bur clovers.

It is the intention to bring together as complete a collection of species as possible. Species and subspecies not discussed in this bulletin are shown in the list that follows. Species marked with a star (*) have been recently introduced for this work. Attempts are being made to obtain the others.

List of nonperennial species and subspecies of Medicago not discussed in this bulletin.

- | | |
|---|---|
| * <i>Medicago aschersoniana</i> Urban. | <i>M. orbicularis applanata</i> (Willd.) A. and Gr. |
| * <i>M. blancheana</i> Boiss. | <i>M. orbicularis biancae</i> (Tod.) Urban. |
| <i>M. bonarotiana</i> Arcang. | <i>M. orbicularis canescens</i> Urban. |
| * <i>M. carstiensis</i> Wulf. | <i>M. orbicularis glandulosa</i> Urban. |
| * <i>M. coronata</i> (L.) Desr. | <i>M. pironae</i> Visiani. |
| <i>M. daghestanica</i> Rupr. | * <i>M. praecox</i> DC. |
| * <i>M. disciformis</i> DC. | <i>M. rigidula cinerascens</i> (Jord.) Urban. |
| <i>M. galilaea</i> Bois. | <i>M. rigidula eriocarpa</i> Rouy and Fouc. |
| <i>M. globosa</i> Presl. | <i>M. rigidula morisiana</i> (Jord.) Rouy and Fouc. |
| <i>M. granatensis</i> Willd. | <i>M. rigidula timeroyi</i> Boreau. |
| <i>M. hispida microdon</i> (Ehrenb.) | * <i>M. rotata</i> Boiss. |
| * <i>M. hispida reticulata</i> (Benth.) Urban. | <i>M. rugosa incisa</i> (Moris) Urban. |
| * <i>M. intertexta</i> (L.) Mill. | * <i>M. soleirolii</i> Duby. |
| <i>M. intertexta decandollei</i> (Trin.) Urban. | <i>M. tenoreana</i> Ser. |
| <i>M. intertexta panormitana</i> (Trin.) Urban. | * <i>M. tuberculata</i> (Moris) Urban. |
| * <i>M. laciniata</i> (L.) Mill. | <i>M. tuberculata aculeata</i> Moris. |
| * <i>M. litoralis</i> Rhode. | <i>M. tuberculata apiculata</i> (Bast.) Urban. |
| <i>M. litoralis breviseta</i> DC. | <i>M. tuberculata chiotica</i> Urban. |
| <i>M. litoralis pentacycla</i> Urban. | <i>M. turbinata inermis</i> Aschers. |
| <i>M. litoralis tricycla</i> (DC.) Urban. | <i>M. turbinata neglecta</i> (Guss.) Urban. |
| * <i>M. minima</i> (L.) Grufb. | <i>M. turbinata olivaeformis</i> (Guss.) Urban. |
| * <i>M. mureæ sorrentini</i> (Tin.) Urban. | <i>M. truncatula</i> Gaertn. |
| <i>M. muricoleptis</i> Tineo. | <i>M. truncatula breviaculeata</i> (Moris) Urban. |
| <i>M. nocana</i> Boiss. | <i>M. truncatula longeaucleata</i> (Moris) Urban. |
| <i>M. obscura</i> Retz. | <i>M. truncatula tentaculata</i> (Willd.) Urban. |
| * <i>M. obscura helix</i> (Willd.) Urban. | |
| <i>M. obscura lenticularis</i> (Desr.) Urban. | |
| <i>M. obscura muricata</i> (Willd.) Urban. | |
| <i>M. obscura tornata</i> (Willd.) Urban. | |
| <i>M. orbicularioides</i> Cand. | |

SUMMARY.

The nonperennial species of *Medicago* consist principally of bur clovers, mostly annual plants native to the Mediterranean region.

Spotted bur clover (*Medicago arabica*), toothed bur clover (*M. hispida denticulata*), and yellow trefoil (*M. lupulina*) are the only species now widely distributed in the United States.

Spotted bur clover is the species best suited to and most commonly grown in the Middle Atlantic and Gulf Coast States.

Toothed bur clover is the most common bur clover in California, but spotted bur clover does equally well there.

Yellow trefoil is quite generally distributed throughout the United States and makes good growth in practically all sections in which it occurs.

Yellow trefoil promises to be of value for green manuring, not only in sections of the eastern United States where crimson clover is grown, but especially farther north.

The bur clovers are adapted for general use only in sections having a very mild winter climate, such as the Southern and Pacific Coast States.

Toothed bur clover, spotted bur clover, and yellow trefoil are suited to varied conditions with regard to soil and moisture.

The stronger growing bur clovers make good pasturage and green-manuring crops.

The bur clovers sometimes cause bloat in cattle when fed in the green state.

Yellow trefoil, toothed bur clover, and spotted bur clover seem to be somewhat unpalatable to stock not used to them.

The feeding value of bur clovers is good, as indicated by general experience and also by chemical analyses.

Bur clovers without spines are the most desirable for pasturage.

Medicago hispida confinis is a spineless form of toothed bur clover that is especially desirable for this reason.

Medicago orbicularis is one of the more recently introduced species that has large spineless burs and is very promising for pasturage in California.

Medicago arabica inermis is a new subspecies that has a spineless bur and is promising for use in sections where spotted bur clover does well.

Fall seeding of bur clover is necessary for the best results in all sections having mild winters.

In the Southeastern and Gulf Coast States the first of September is usually about the right time for seeding.

In California seeding may be done any time during September or October, but if the land is irrigated before sowing October is best.

In the Eastern and Gulf Coast States it is necessary for the best results to inoculate the soil in which bur clover is grown for the first time, but in the Pacific Coast States inoculation is not necessary.

One hundred pounds of burs of either spotted or toothed bur clover contain 25 to 30 pounds of seed.

In seeding any of the species of bur clover 15 pounds of seed (hulled) per acre should be sown when a thick stand is desired, either in pastures or cultivated fields.

To handle bur clovers as a seed crop is somewhat expensive, but not impracticable.

The farm machinery used in harvesting grain and hay crops, although not suited for handling bur clover, can be used to some extent.

Most bur clover seed on the market at the present time is obtained as a waste product from woolen mills, where it has been carried in the wool, and from screenings of small grains, with which it grows as a weed in California.

Twenty-three species and subspecies of bur clover have been studied in connection with the results here presented.

The plants of the various species are very similar in habit of growth and appearance of stems and leaves.

The burs of the species differ more or less, and their botanical classification is based largely on these differences.

Most of the species and subspecies studied are made up of definite types or forms which may be selected and grown as pure strains.

Environmental conditions may cause a wide variation in the burs of an individual plant, and must be taken into consideration in the identification of species.

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