LIFE HISTORY STUDIES AS RELATED TO WEED CONTROL IN THE NORTHEAST

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7 — COMMON PURSLANE

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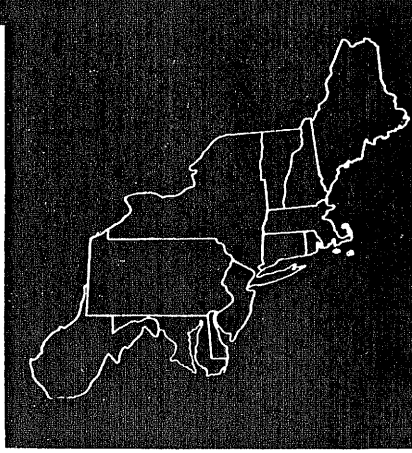

This bulletin is one of a series that pertains to life history studies of weeds that are important in the Northeastern states.

This series of bulletins is being published by the Northeast Regional Weed Control Technical Committee (NE-42).

Bulletins previously published pertain to the following weeds:
nutgrass (Rhode Island Agr. Expt. Sta. Bul. 364, 1962),
quackgrass (Rhode Island Agr. Expt. Sta. Bul. 365, 1962),
horse nettle (Rhode Island Agr. Expt. Sta. Bul. 368, 1962),
yellow foxtail and giant foxtail (Rhode Island Agr. Expt. Sta. Bul. 369, 1963),
barnyardgrass (Delaware Agr. Expt. Sta. Bul. 368, 1968), and
large and small crabgrass (Storrs [Connecticut] Agr. Expt. Sta. Bul. 415, 1971).

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INTRODUCTION

The genus *Portulaca*, comprising about 100 species, is characterized by conspicuously fleshy sessile leaves. Common purslane *(Portulaca oleracea* L.) is probably a native of western Asia but is now a widely distributed weed throughout temperate and tropical lands of the earth (26). It was known in the Mediterranean region and central Europe since ancient times (49). Common purslane was imported into the United States from southern Europe. In the United States it is most abundant in the Northeastern States, least common in the Pacific Northwest (46, Fig. 1).

Common purslane is an annual weed, troublesome in fertile gardens, muck lands, ornamental crops, cotton fields, and lawns in some southern states. It occurs also in waste areas, waysides, barren driveways, eroded slopes, and bluffs from sea level to 8,500 ft. Due to the short life cycle and rather high temperature needed for germination and growth, common purslane in maritime European provinces is usually common in warmer vineyard areas; in continental climate regions this plant can grow well even where winter temperatures drop to -30 C (26). Muenscher (30) indicates that common purslane seedlings usually do not appear until the weather is warm, or after most other weeds have been destroyed by cultivation. The short growing season and continuous large production of small seeds makes purslane a persistent troublesome annual broadleaved weed. On the other hand, some naturalists (8) consider this weed as a pioneer plant whose roots may open up soil for crop roots, so the crop roots can go deeper into the ground and obtain more water or plant nutrients. A recent survey indicates that this weed is spreading in the Northeastern region (45).

Ecologically, common purslane is a typical plant in plant associations with galinsoga *(Galinsoga* spp.) and *Amaranthus* spp. (26). Common purslane is known as a drought resistant plant. Thick succulent leaves, stems and roots are able to absorb and store water and thus this weed easily withstands soil conditions of dry hot weather. Seeds germinate rather fast and the life cycle is completed in a short amount of time. Cole and Holch (9) indicate that dry range pastures reddened after a period of showers by a thick growth of common purslane. It is reasonable to assume that its competition under water stress in soil should be effective.

The literature concerning this plant is very limited, although a taxonomical monograph on this genus recognizing 104 species was prepared by von Poellnitz (49), a German botanist. More than 20 species are recognized for the North American continent (52). In southern Europe and Mediterranean countries purslane is used as a vegetable (6, 39, 49).

Seeds have been received from France and Germany that produce a larger, more succulent type, *Portulaca oleracea* var. *sativa*, which is used as a culinary delicacy in these countries (54).

Lack of thorough understanding of growth habits of different weed species is limiting the effectiveness of weed control. Present research is limited more by the lack of knowledge of the growth habits of weed species than by any other single factor. Basic information of the life cycle of weeds is needed to develop control methods which could destroy weeds at the most vulnerable point of their growth. With this in mind a regional study beginning in July 1966 by the Northeast Regional Weed Control Technical Committee (NE-42) was initiated. The state experiment stations of Massachusetts and New Hampshire cooperated in this study.

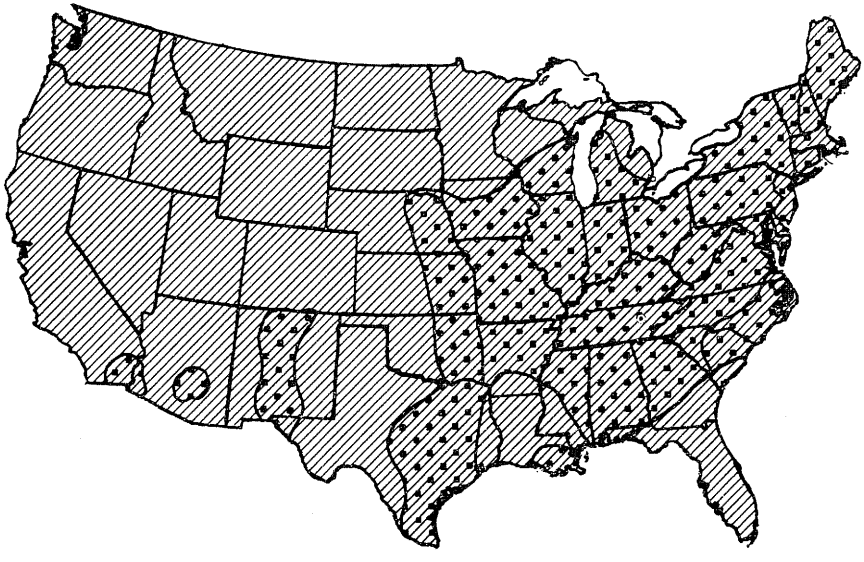

Figure 1. Distribution of common purslane in the U.S.A. [from Selected Weeds of the United States, U.S. Department of Agriculture, Agricultural Research Service, Agricultural Handbook No. 366, 1970 (46)].

CHARACTERISTICS OF COMMON PURSLANE

Morphology

Stems—glabrous, succulent, fleshy, purplish-red in color and arising from a taproot, often forming mats, freely branched 10-56 cm long (30, 46). The shoots are erect when young, but usually becoming prostrate with age (Fig. 2).

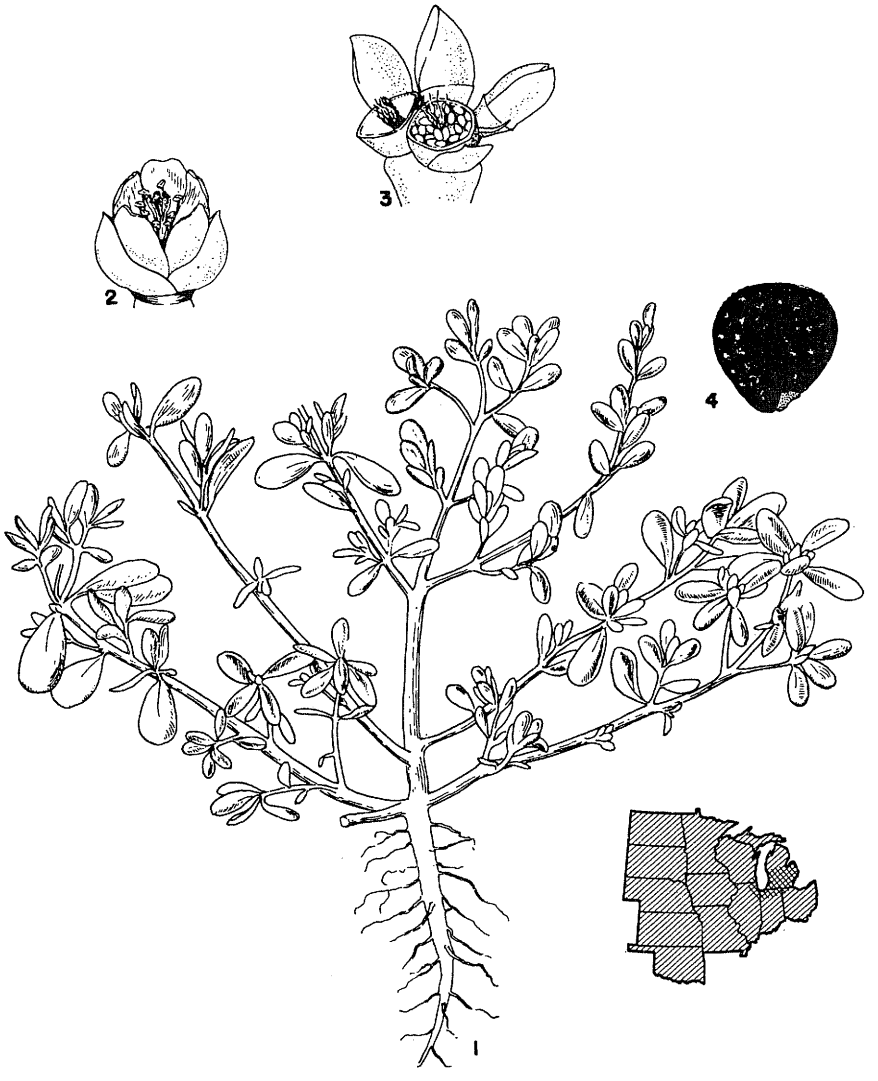

Figure 2. Purslane, Pusley *(Portulaca oleracea)*. 1, entire plant showing fleshy stems, prostrate growth habit; 2, flower; 3, pods; 4, seeds [from Weeds of the North Central States, North Central Regional Publication No. 36, 1954].

Leaves—alternate or nearly opposite, usually in clusters at the ends of the branches, succulent, thickened, sessile, margins smooth and broad rounded tips, 4-28 mm long, 2-13 mm broad, occasionally larger, rounded or nearly truncate at the apex. Stipules are reduced to small bristles.

Flowers—sessile solitary in the leaf axils or several together in the leaf clusters at the end of the branches, 3-10 mm broad, including the 5 pale yellow petals which open only on sunny mornings, fugacious, 3-4.6 mm long, 1.8-3 mm broad; style lobes 4-6. Calyx is the lower portion fused with the ovary, the upper part with 2 free sepals, pointed at the tip and 3-4 mm long. Petals and the 6-12 stamens appear to be inserted on the calyx.

Fruit—a globular capsule, many seeded, 4-9 mm long, opening by a lid at the middle with the upper part of the calyx attached; seeds nearly oval, only about 0.5-0.8 mm in diameter, flattened, broadly ovate, with a yellowish scar and small concave area at the smaller end, edges rounded, roughened by curved rows of minute rounded tubercles, slightly glossy, black.

Common purslane normally flowers and fruits from June or July until frost; in hot regions from April to June, disappearing in the hottest period, reappearing in late summer, and continuing until frost.

Common purslane has a rather thick, much branched, fleshy taproot with many fibrous side secondary roots (Fig. 3). The upper ones are usually spreading close to the soil surface around the main taproot

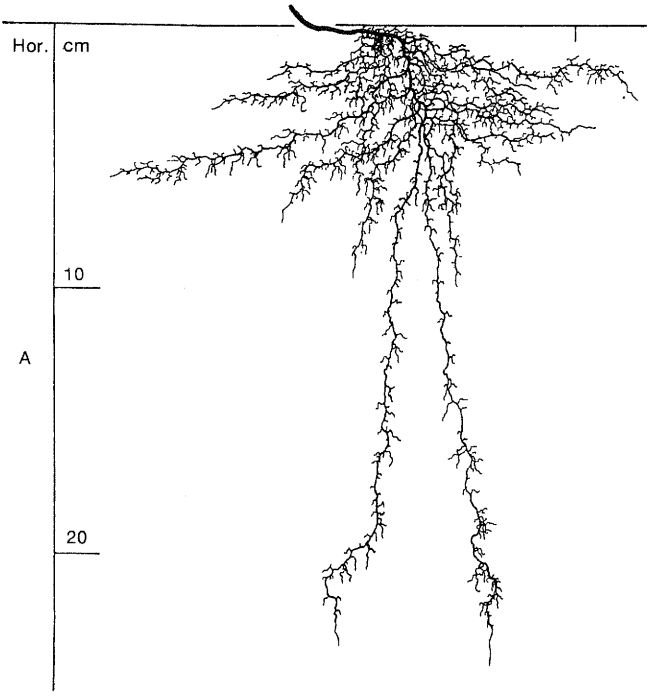

Figure 3. Distribution of common purslane roots in soil [from Kutschera (26)].

and may reach 153 cm in diameter, as in Nebraska according to Cole and Holch (9). The thickness of the taproot at the crown measured 8 mm in diameter. Kutschera in Austria (26) found taproot thickness at the crown to be 2 mm and the root horizontal expansion reached 20 cm in diameter only. Apparently under warm Nebraska climatical conditions much lusher and larger purslane plants can be expected. According to Kutschera (26) the lower common purslane roots branch less than upper ones. Generally roots are shallow and reach 24-33 cm depth (9, 26). Roots are white-yellow or light yellow in color.

According to Zimmerman (54) growth of common purslane is basically monopodial although often appear to be growing in a radial manner with all major stems originating from one single point. This illusion is due to the fact that primary and secondary shoots (branches) grow as long or longer than the main stem and the completely prostrate habit of the plant. Purslane branches develop in the most orderly fashion in acropetal direction. Because leaves and therefore members of a branch pair are seldom developed exactly across from one another, or at precisely the same time, the plant must be referred to as basically alternate-leaved. The second pair of primary shoots is normally the longest (Fig. 4).

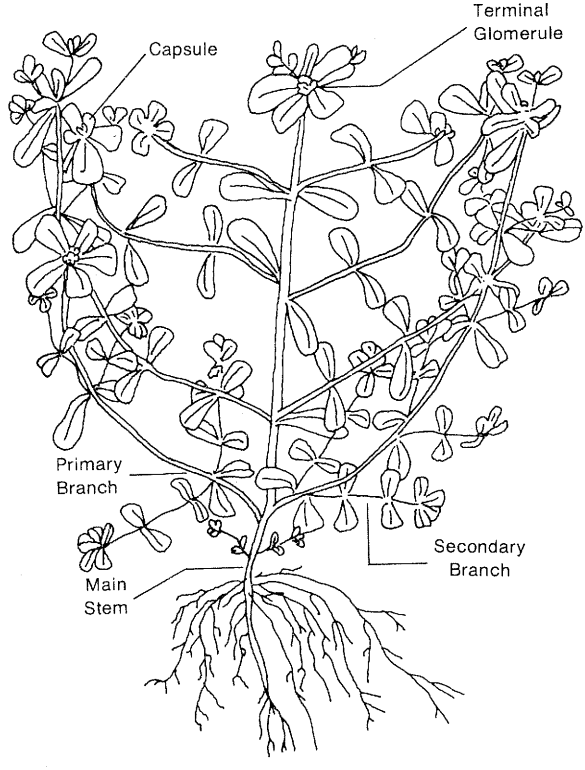

Figure 4. Growth pattern of common purslane. Primary and secondary branches grow long or longer than the main stem [from Zimmerman (54)].

Branching in common purslane proceeds through the fifth order (54). By far the greatest amount of vegetative growth takes place in primary and secondary shoots. Tertiary through fifth order branches serving mostly for production of capsules. The major part of growth in each branch is finished at the time mature seeds are produced. Toward the end of the growing season, growth wanes and gradual decline of the plant takes place. In the Northeast usually freezing temperatures terminate the life cycle before physiological death.

Seed Production and Maturation

According to Zimmerman (54) common purslane is both non-apomictic and self-compatible. Self-compatability always allows for some outcrossing and this appears to be sufficient in giving these populations necessary variability. Common purslane flowers are open, on the average, about 4 hrs. a day. Flowers are sensitive to both low light intensity and temperatures below 21 C. In Michigan (54) on bright, hot days in June, flowers open by 10:00 a.m. and close by 2:00 p.m. They last but a single day. During July, opening and closing takes place 1 hr. earlier. On cool, cloudy days no unfolding occurs and flowers ready for fertilization on that particular day are self-fertilized without ever opening. Common purslane shows a great degree of cleistogamy. Cross-pollination is primarily by wind as few insects have been observed visiting common purslane flowers. Development of seeds from flowering or from date of possible flowering in the case of cleistogamous capsules, required 7 days for common purslane.

Materials and Methods

In New Hampshire (16) early in July young common purslane plants were collected from gardens, transplanted to plastic pots filled with moist vermiculate to which fertilizer had been added, and placed in the greenhouse. After 1 month of growth, the plants were examined to determine the number of seed capsules per plant and the number of seeds per capsule. These same plants also were observed to determine the time required for the maturation process from flowering to seed.

Results and Discussion

The number of capsules per plant and the number of seeds per capsule varied widely (Table 1), but the common purslane plant that averaged about 28 cm in diameter produced approximately 6,700 seeds per plant.

Table 1. Size and seed production of 25 common purslane plants after 5 to 6 weeks' growth.

Numerical values	Diameter of plant (cm)	Seed capsules per plant	Seeds per capsule	Seeds per plant
Range	23-34	54-143	36-107	—
Average	28.5	93.5	71.9	6,723

Previous observations have shown that the common purslane plant blooms and sets seeds many times during the growing season; over one growing season the plant may produce many times this number of

seeds. Both numbers of capsules and seeds were positively correlated with plant size. In tests conducted by Zimmerman (54) common purslane produced from 101,625 to 242,540 seeds per plant.

It had been observed previously that the small yellow flowers would open in the morning and close tightly by noon. It also seemed that the flowers were fertilized at that time and did not open again. To substantiate these observations, 10 flowers on each of the 25 plants were tagged when they came into bloom. The plants were examined every day for maturity of seeds. Since the seeds are located within a capsule which dehisces when the seeds are mature, the maturity of the seeds was determined when the capsule began to dehisce. Of the total 250 labelled flowers, 63 matured in 14 days, 82 in 15 days, 90 in 16 days, and 15 in more than 16 days.

Of the three or four flower buds which were borne at each node, all did not bloom at the same time. Usually one or two, at the most, bloomed at one time; the remaining buds did not bloom for several days. The flowers on the main branches of the plant matured first, and capsules on the secondary branches matured later. Therefore, common purslane has a sequential maturation and distribution of seeds throughout the growing season. Seeds tend to mature first near the center of the growing rosette, and the blooming periods vary so that seed production occurs from spring until late summer. Since the flowers are so inconspicuous and seed production occurs soon after flower opening, seed collection was accomplished by spreading sheets of white paper around the potted plants in the greenhouse and under the spreading branches. From these sheets the small black seeds were easily gathered.

These observations support recommendations that weed control measures should be started while the plants are very small to prevent seed formation. The large number of seeds produced per plant partly account for the persistence of this species.

Anatomy

Connard and Zimmerman (10) indicated that the stem in common purslane is surrounded by a single though occasionally double layer of epidermal cells. Periderm may occur through wounding but it is normally produced. Within the epidermis are two to three layers of collenchyma cells with heavy cellulose walls. There are four to six more layers or cortical cells before reaching the endodermis or starch sheath. Immediately within the endodermis, outside of the vascular bundles, are groups of bast fibers.

The stem of common purslane (10) is herbaceous type but with discreet bundles. The primary vascular system consists of four or five main bundles which divide, forming traces for leaves and branches. These branch traces appear only in sections near a node, i.e. where they leave the stem. As soon as one set of leaf traces leaves the stem the main bundles start branching to form those for the leaf directly above so that the leaf traces are seen throughout the internodes. In any internode there are present the main bundles alternating with groups of from one to three leaf traces, making from 10 to 20 bundles in the stem. As the stem grows older some secondary tissues develop from the fascicular or interfascicular cambiums. The activity of cambiums is largely con-

fined to the formation of small bundles which run more or less obliquely connecting two bundles, generally a main bundle and a leaf trace.

Materials and Methods

At the University of Massachusetts some aspects of common purslane anatomy were studied by T. C. Chang.

Plant samples were collected at various stages of development. Plants were killed and fixed either in buffered aldehyde or Crafts solution (34, 38). They were dehydrated and embedded in paraffin according to the method described by Johansen (24). Tissues were sectioned at 12-14 μ and were stained with safranin and fast green. Stomata were counted using thin layer film technique (53). Cellulose acetate solution was painted on the leaf surfaces and the dried film stripped off and the number of stomata were determined.

Results and Discussion

Leaf mesophyll consists of one layer of palisade parenchyma indiscriminately scattered, and spongy parenchyma cells. The palisade cells are regular in shape in cotyledons and in young true leaves. As the leaves grow older, the palisade cells become less regular in shape with large irregular shaped air spaces between them.

The epidermis is composed of irregular shaped cells, bulliform cells, guard cells and subsidiary cells. Bulliform cells, the thin-walled large parenchyma cells, are found on the margin of the epidermis and in the spongy parenchyma just beneath the lower epidermis. These bulliform cells are motor cells and according to Esau (17) probably play a role in the opening and closing movements of the leaves.

Stomata are located on both the upper and lower epidermis. It was observed that plants grown in the growth room had a similar pattern of stomata distribution as those in the field. The stomata distribution on the upper epidermis of young leaves is of a higher density than on the lower epidermis (Table 2). It appears that the maturation of stomata on the upper epidermis occurs earlier than on the lower epidermis. As the leaf matures and expands, the epidermal cells enlarge and the number of stomata remain constant. Therefore, the number of stomata per sq. mm. decreases.

Table 2. Stomata distribution in common purslane leaves.

	Number of mature stomata per sq. mm.	
Leaf stage	Upper epidermis	Lower epidermis
Young leaves	113	76
Middle size leaves	55	46
Fully developed leaves	36	35

Using dodecane diffusion method (1) for examination of the opening and closing of the stomata, it was found that the stomata opened during the day and closed during the night which is different from other succulent plants (23, 25, 27, 31). Since only 100% of dodecane penetrated the stomata during the day, this experiment also proved the size of the stomata to be relatively small (1).

The primary structure of the stem contains epidermis, cortex, vascular system and pith. The ground tissues, cortex and pith are thin-walled parenchyma which are considered as water storage cells.

Physiological Remarks

Common purslane is both a stem and leaf succulent. Succulent plants have a property to store water in their tissues during short rainy periods. They usually are not rooted especially deep, but short roots can quickly pick up water during and after rain. In order to store water, succulent plants have specialized water tissues formed from different groups of cells in plants. It may be one or more layers of epidermis or centrally located parenchymatic tissues (28). Water tissues usually have big cells with cellulose walls and no chloroplasts. Cells of water tissues are usually poliploidal (16n, 32n, 64n) due to endomithosis. Especially in the *Portulacaceae* family the poliploidal cells in epidermis were observed (43). Members of the genus *Portulaca* vary greatly in chromosome size (42), and the evidence indicates that the evolution of the genus has involved chromosomal aberations such as duplications and deficiencies concurrent with poliploidy. Microsporogenesis and macrosporogenesis in this plant have been studied by Cooper (11, 12).

Succulents have a very small surface area: mass ratio. It diminishes transpiration markedly. These plants usually have a thick cuticle and a small number of deeply placed stomata which can close very tightly. Briggs and Shantz (4) show that common purslane is exceptionally efficient in water utilization:

Plants	Water requirements based on dry matter
Common purslane *(Portulaca oleracea)*	292 ± 11
Redroot pigweed *(Amaranthus retroflexus)*	297 ± 4
Lambsquarters *(Chenopodium album)*	801 ± 41
Ragweed *(Ambrosia artemisiifolia)*	948 ± 66
Alfalfa, Grimm *(Medicago sativa)*	844 ± 8
Beans, Navy *(Phaseolus vulgaris)*	682 ± 4

Chemical Composition

According to the data presented by Pammel and King (32) chemical percent composition of fresh common purslane plants is as follows:

Water	Ash	Protein	Fiber	Nitrogen free extract	Fat
92.61	1.56	2.24	1.03	2.16	0.40

Well-developed common purslane plants with some seeds already and collected in potato fields in Massachusetts (47) and analyzed on air-dry matter basis had the following percentages:

N	P	K	Ca	Mg
2.80 ± 0.21	0.58 ± 0.15	6.77 ± 0.12	1.05 ± 0.18	0.40 ± 0.17

Common purslane had the highest content of potassium (K) of all investigated common weeds in Massachusetts.

SEED INVESTIGATIONS

Germination

The chief items of literature on seed germination of common purslane have been reviewed by Andersen (2). Most observers agree that the seeds of this species are sensitive to light. Cross (13) reported that germination was increased by abrasion of the seeds. Light also stimulated germination but could be supplanted by other agents. Alternating temperatures were more effective than constant conditions. Everson (18) also found light to increase germination over darkness. Povilaitis (35) found germination increased with dry storage of seeds, and that light and higher temperatures (30°C, or 20-30°C) promoted germination. In trials by Hopen (20) purslane had a higher emergence rate and produced more foliage at 32°C than at 27°or 21°C soil temperatures. The experiments of Chepil (7) showed that purslane seeds required periods of high temperature and relatively low moisture content of the soil for best germination. Seeds continued to germinate well in soil after three years' time. They may have a long dormancy period, exceeding three years. Peak germination in any one season may occur from May 31 to August 31. Land once infested with seeds may be expected to remain infested for many years, even under clean cultivation. Young common purslane plants cannot compete successfully with spring grain crops, whose early, quick growth may choke them out. However, common purslane plants may mature late in the season, which increases their chances of survival. Muenscher (30) states that purslane seeds may pass digestive systems of swine and sheep and germinate. Zimmerman (54) found that purslane seeds passed sparrows digestive tract were viable from 27.4 to 73.5%.

Light Quality Effects on Germaintion

At Durham, New Hampshire a series of investigations was conducted on the germination of common purslane seeds as influenced by light intensity.

Materials and Methods

In one experiment four different kinds of mercury vapor lamps were used. The lamps were Sylvania high intensity types as designated in Part A of Table 3. They were set to provide a light intensity of 800μw /cm^2 for 16 hrs. daily, with 8 hrs. of darkness. The temperature was kept at 70 F during the light period, and 60°F during darkness. The seed was of New Hampshire origin. Twenty-five seeds were placed on a double layer of moist filter paper in each of four glass petri dishes for any given light treatment. All treatments were replicated twice. Distilled water was the moistening agent for the filter paper unless otherwise indicated. Germination counts were taken every 2 days for 14 days, and the tabulated data represented accumulated means for this period. The seeds given a dark treatment were placed with their containers in the same location as the other seeds, but were covered with black cloth, and so had the same temperature conditions. This general procedure was followed for all of the New Hampshire germination tests presented

in this bulletin, except for modifications in the moistening agent, or other chemical treatments and kinds of light.

Results and Discussion

The data show (Table 3) that the common purslane seeds germinated significantly better under all of the light treatments than in darkness. Germination for Standard Clear was significantly greater than for Silver White, but the values for Gold and Color Improved did not differ significantly from each other and from each of the other two lamps.

The fluorescent lamps used were Sylvania 48 in. T-12 VHO, in red, blue, green, yellow, and cool white. Their spectral energy distribution curves are given in the paper by Dunn *et al.* (15). The results of seed germination under these lamps appear with distilled water as the moistening agent in Section B (Table 3), and with 0.2% KNO as the moistening agent in Section C (Table 3). In both sets of data yellow light produced the highest germination, which could have been due to the complete lack of blue light in the spectral emission of the yellow lamps. In Section B (Table 3), the germination in darkness was significantly lower than that for any of the lights. In Section C, with dilute KNO there was more of a scattering of significant differences. Germination with blue light was consistently low in both sets of data.

Table 3. Light quality effects on purslane seed germination.

Percent Germination

A. Kind of Mercury Vapor Lamp

Moistening Agent—Distilled H_2O

Dark	Silver white	Gold	Color improved	Standard clear
24.0	83.0	89.0	92.0	95.0

B. Kind of Fluorescent Lamp

Moistening Agent—Distilled H_2O

Dark	Blue	White	Green	Red	Yellow
32.2	71.6	71.8	81.5	86.8	90.8

C. Kind of Fluorescent Lamp

Moistening Agent—0.2% KNO_3 Solution

White	Blue	Red	Dark	Green	Yellow
70.0	78.0	84.0	87.6	88.4	91.2

Effects of Light and DMSO Moistening Agent

Experiments were conducted at Durham, New Hampshire with New Hampshire common purslane seed. In preliminary tests the only moistening agent to show increasing germination with increasing concentration was DMSO (dimethyl sulfoxide). The moistening agent solution was applied to the filter paper upon which the seeds were placed in petri dishes. Ten ml. of solution per dish was used. Distilled water was added as needed to keep the filter paper well moistened. Seed planted on filter paper with distilled water served as control in both light

and darkness. Light was provided by cool white fluorescent lamps. Germination percentages for all three light treatments (Table 4) were significantly greater than those for two of the dark treatments. Only for darkness with 5% DMSO was there overlapping of significance. The lower concentration of DMSO gave highest germination in light, while the reverse was true for darkness.

Scarification

Two experiments were performed in New Hampshire in studying concentrated sulfuric acid effects on common purslane seed germination (Table 5). There it is shown that relatively short lengths of time are best, giving fairly high germination for times varying from 0.5 to 1.5 minutes.

Table 4. Light and DMSO effects on common purslane seed germination.

Dark DMSO	Dark Control	Dark DMSO	Light Control	Light DMSO	Light DMSO
1%		5%		5%	1%
63	68	73	89	92	93

Means not underscored by the same line are significantly different at the 5% level.

Table 5. Sulfuric acid effects on common purslane seed germination.

			Length of treatment (min.)	
Experiment 1	Control	1	5	10
Percent germination	5	70	33	2
			Length of treatment (min.)	
Experiment 2	Control	0.5	1.5	2
Percent germination	8	66	81	40

Light and Temperature

Materials and Methods

Tests were carried out in the seed laboratory, University of Massachusetts, using petri dishes with double blotter paper moistened with tap water. Supply of 1966 common purslane seed was used. Seeds were sterilized with 10% commercial Chlorox for 0.5 hrs. In each case 4 x 100 seeds were germinated. Temperature and light were variables in these tests. Tests were started June 27, 1968 and continued for a period of 22 days until July 19. Treatments dark/light indicate that seeds were kept for 16 hrs. in darkness and 8 hrs. in light. Alternating temperatures indicate that seeds under lower temperatures were kept 16 hrs. and under higher temperatures for 8 hrs. Only those germinated seeds which developed at least 5 mm seedlings with normal looking roots were counted. Germination countings were done daily and germinated seeds were removed from blotters each time. Thus all treatments were exposed to light every day for a few minutes. This general procedure was followed for all of the Massachusetts germination tests presented in

this bulletin, except for modifications indicated when discussing separate experiments.

Germination vigor ratings (44) which estimate speed as well as extent of germination were calculated as follows: the number of normal seedlings per 100 seed counted each day was multiplied by the reciprocal of time in days in the germinator. The values for each day were then totalled when germination was complete (44).

Results and Discussion

The best germination was obtained when temperatures in germinators were between 25° and 40° C, i.e. when temperatures were higher than 20° C (Table 6). Under these conditions germination was between 73% and 90%. The data do not indicate any clear-cut effect of light or alternation of dark/light on the results of germination. Zimmerman (54) found that common purslane seeds germinated better in light than in dark. Also, alternating temperatures apparently did not influence significantly percentage of germination.

The greatest germination vigor (speed) was under continuous temperatures between 30°-40° C. Temperatures below 30° C decreased germination vigor considerably. In any case, when germination tests were conducted with temperatures 18° C, or above, the apparently viable healthy common purslane seeds in these tests germinated in 3 to 8 days. This indicates rather speedy purslane seed germination.

Seed Age

Materials and Methods

In these tests 14 (1952), 7 (1959), 1 (1965) and 0.2 year-old common purslane seeds collected from plants grown on Brooks Farm, University of Massachusetts were used. Seeds were kept in paper bags and stored in waste containers in an unheated barn. For each treatment 4 x 100 seeds in petri dishes containing agar were seeded. These germination tests were carried out in growth chambers under 12 hr. photoperiod and 21/27° C temperature, i.e. 12 hr. light and 27° C, and 12 hr. dark and 21° C. Tests started August 1 and continued for 25 days until August 26, 1966. Germination countings were done every 3 days and germinated seeds were removed each time. Average germination results are presented in Table 7.

Results and Discussion

Results indicate (Table 7) that common purslane seeds can survive in storage for many years without losing viability appreciably. The best germination and germination vigor (44) was obtained from seeds 1 year old. Freshly harvested seeds (0.2 year old) germinated 39% compared with 78% of 1 year-old seeds. This indicates that freshly harvested common purslane seeds physiologically-biochemically are not ripe and may need some after-harvest ripening period to break dormancy. On the other hand, 39% germination of freshly harvested common purslane seeds show that under Massachusetts climatic conditions in the field this weed can produce two generations in one growing season. Zimmerman (54) found also that common purslane seeds may germinate immediately after ripening, i.e. no after-ripening needed and he in-

Table 6. Temperature and light effects on germination of common purslane seeds.

	Treatment	Percent germination	Germination vigor
1.	4°C, dark	0	—
2.	15°C, dark	36	4.7
3.	18°C, dark	61	11.3
4.	20°C, dark	62	12.4
5.	25°C, dark	79	24.0
6.	25°C, light	86	23.4
7.	25°C, dark/light	80	23.6
8.	30°C, dark	78	36.4
9.	30°C, light	83	35.3
10.	30°C, dark/light	88	39.4
11.	35°C, dark	86	42.7
12.	35°C, light	84	40.1
13.	35°C, dark/light	82	40.4
14.	40°C, dark	82	36.5
15.	40°C, dark/light	84	40.8
16.	25/35°C, dark	90	36.0
17.	25/35°C, light	85	24.3
18.	25/35°C, dark/light	85	30.7
19.	20/30°C, dark	85	22.7
20.	20/30°C, dark/light	89	21.7
21.	15/25°C, dark	73	13.1
22.	15/25°C, dark/light	83	15.7
23.	8/10°C, dark	0	—

Table 7. Seed age effects on germination.

Seed age	(Year)	Percent germination	Germination vigor
14	year-old (1952)	59b[1]	7.7b
7	year-old (1959)	59b	11.7b
1	year-old (1965)	78a	20.3a
0.2	year-old (1966)	39c	4.5c

[1]Means within columns followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

dicates that three generations are usually produced during a single Michigan growing season.

Planting Depth

Materials and Methods

In studying the effect of seed planting depth on common purslane emergence two experiments were conducted at Amherst, Massachusetts. In both experiments plastic 5-inch pots and sterilized fine sandy loam soil were used. In each pot 100 seeds were seeded. Four replicates were

used. Needed moisture was supplied by subirrigation. In both experiments treatments were included with seeds left on soil surface uncovered, covered 1/4 cm, 1/2 cm, 1 cm, 2 cm, 4 cm and 8 cm deep. In Experiment I some of these treatment pots were covered with aluminum foil and kept in the dark. Parallel treatments were exposed to natural Amherst day/night periods. In this experiment germination-emergence tests were started August 18, and terminated 15 days later on September 2, 1966. Experiment II tests were carried out in the growth room under 16 hr. photoperiod and 24/27° C temperature, i.e. 16 hr. light and 27° C, and 8 hr. dark and 24° C. These tests were started August 28, 1967 and terminated 15 days later when new seeds ceased to emerge. Results of these two experiments are presented in Table 8.

Results and Discussion

Germination-emergence was highest for seeds left uncovered on the soil surface (Table 8). Under natural field conditions uncovered soaked and sprouted seeds may dry easily and thus small seedlings may be killed. In our field tests with subirrigation water supply was continuous. Under dark conditions emergence was significantly lower than under normal day/night or 16 hr. photoperiod in the growth room (Table 8). The deeper seeds were seeded in the soil the lower was the emergence obtained. In both experiments seeds planted 4 cm deep or deeper did not emerge at all. Hopen (20) also found that the greatest emergence of common purslane occurred with seed placed on the soil surface. Emergence progressively decreased as placement depth increased. Smooth, finely prepared seedbed favored the emergence of the small-seeded common purslane.

Table 8. Common purslane emergence from various depths of planting.

Data of Experiment I and Experiment II.

Depth of planting in cm	Experiment I Percent emergence		Experiment II Percent emergence
	Light	Dark[1]	
0	71	24	74
1/4	43	17	34
1/2	21	12	24
1	10	—	23
2	8	—	9
4	0	—	0
8	0	—	0

[1]No parallel "dark" treatments were carried out for seeds covered 1 cm or deeper.

Seed Production of Uprooted Plants

Uprooted common purslane plants can remain relatively succulent for a long period of time without completely drying out. In one case well-developed uprooted plants were put in paper bags and kept in the laboratory at 22-23 C temperature and 40-45% relative humidity. Under

these conditions it took 30 days for common purslane to become air-dry. On a well-developed common purslane plant one can observe mature shedding seeds, just ripened seedheads, not yet fully ripe seedheads, flowering blossoms and new vegetative branching and growth at the same time. Therefore, it is reasonable to assume that in uprooted plants physiological-biochemical processes may proceed for some time, and e.g. plant nutrients can be translocated to underdeveloped seeds which thus become fully developed and ripen on uprooted plants. To investigate seed production of uprooted common purslane plants special tests were conducted at Amherst, Massachusetts.

Materials and Methods

On August 5, 1966 well-developed common purslane plants were cut at ground level. Eight, as uniform as possible, 500g samples were weighed. From four of these samples seedheads with some leaves present were picked off, i.e. all stems, branches and other vegetative parts in these samples were cut off. It was postulated that in these samples immature seeds would receive much less plant nutrients than needed for normal development and thus these samples finally would produce less well-developed mature seeds as compared with 500g plant samples where the whole plants were left intact. These eight samples were scattered separately on 4 x 8 ft plywood boards and kept in the greenhouse until all samples became dry. Dried samples were threshed by hand and the amount of common purslane seed determined. All seeds which did not pass through Fairbanks No. 31 sieve were considered as normal well-developed common purslane seeds. Smaller underdeveloped seeds were discarded.

Analogous tests were also done in 1967. Plant samples taken were each 500g large and were prepared as in 1966, but were kept in a rather dark basement laboratory room until they were dried out.

Results and Discussion

Results of 1966 and 1967 tests are presented in Table 9. Differences in the amount of seed obtained are clear-cut and statistically significant. Generally the seed amount obtained from 500g uprooted common purslane plants in 1967 was much greater than in 1966. On the other hand, 1967 differences in seed production between intact plants and those picked off was not as great as in 1966. These differences could be caused by (a) different plant developmental stage of plants and (b) darkness of the room in 1967.

Table 9. Seed production by 500g fresh uprooted common purslane plants.

	Seed amount (g)	
	1966	1967
Intact plants	4.9a[1]	11.3a
Vegetative parts cut off	1.9b	8.5b

[1]Means within columns not followed by the same letter are significantly different at the 5% level according to Duncan's Multiple Range Test.

VEGETATIVE REPRODUCTION

Muenscher, in his well-known text on weeds (30), writes that common purslane plants that have blossomed should be removed from the soil and burned or composted, otherwise the fleshy stems will take root again and mature seeds. A recent U.S. Department of Agriculture publication (46) states that common purslane is an "annual herb, reproducing by seeds and stem fragments on moist soil." Connard and Zimmerman (10) studied the origin of adventitious roots in cuttings of common purslane and found that a single stem cutting may produce as many as 100 adventitious roots. These roots generally arise in the rays adjacent to primary vascular bundles. The manner of emergence of the roots is peculiar. In most plants adventitious roots grow more or less perpendicular to the axis of the stem and emerge through the epidermis or periderm. In common purslane the roots emerge through the cut surface and parallel to the main axis of the stem. Those nearest the center assume this longitudinal direction from the start. The majority of the adventitious roots start out radially as in other plants but, when about half the cortex has been penetrated, they turn downward and proceed longitudinally until they can make their way through the surface. In the normal purslane stem very little, if any, cell division takes place in the cambium. In the cuttings no callus is formed although occasional cell division occur in the pith or cortex. The formation of the adventitious roots is the most essential feature of the interfasicular cambium (10).

The main objective of our studies was to investigate the possibilities of vegetative reproduction of common purslane.

Materials and Methods

Well-developed common purslane shoots were selected for this study. From the base and from the top of these shoots stem cuttings 12 cm long were taken and planted in 5-inch diameter plastic pots. In each pot three shoot cuttings were planted. Some of these cuttings were treated with rooting hormone Hormodin No. 2. In these rooting studies, treatments were included with intact common purslane shoots bent to the adjacent filled pots and covered with soil about 0.5-1.0 cm deep. Fine sandy loam was used in these tests. All treatments were replicated four times. Trials were conducted in growth chambers at 12.5 hr. photoperiod, at 24/19°C temperature and 80% relative humidity. Water was supplied by subirrigation. The trials were started on March 1, 1967 and continued for 37 days until April 7 when plants were pulled out, roots washed, rooting investigated and the whole fresh weights of plants were determined.

Results and Discussion

Results are presented in Table 10. Cuttings taken from the tops of shoots, i.e. from younger stem parts, produced roots only if treated with the rooting hormone. Contrary to this, well-developed stem cuttings from the base of shoots produced roots whether treated or not with rooting hormone (Fig. 5). In short, uprooted and cut pieces of common purslane shoots, especially basical parts of them, are able to produce adventitious roots and thus vegetatively propagate. Close observations

indicated rooting pattern to be the same as Connard and Zimmerman (10) found. Differences in rooting of young cuttings (from shoot tips) as compared with older ones could be of morphological-physiological nature. Botanists do not agree entirely as to the exact internal origin of adventitious roots from stem cuttings (10, 37). It is thought that roots in young portions of stems originate in different tissues as compared with older stems. Rooting hormone effects indicate physiological-biochemical importance also. It is surprisingly interesting to find out that healthy common purslane shoots which were not wounded and kept in continuous contact with moist soil did not produce roots. This indicates that common purslane practically does not reproduce or spread vegetatively.

Table 10. Rooting of common purslane shoots.

Treatment	Fresh weight (g/plant)	Remarks
(1) Shoot tops	0.3c[1]	No roots, wilted, dead
(2) Shoot tops plus hormone	29.5b	Well-developed roots, plants growing well, branching
(3) Shoot bases	47.8a	Well-developed roots, plants growing well, branching
(4) Shoot bases plus hormone	44.2a	Well-developed roots, Plants growing well, branching
(5) Intact shoots covered with soil	—	No roots from stems in contact with soil were produced

[1]Means within columns not followed by the same letter are significantly different at the 5% level according to Duncan's Multiple Range Test.

Figure 5. Vegetative reproduction of common purslane. A. Piece of shoot from the top of a branch did not produce any roots and died. C. Piece of shoot from the base of the same branch produced roots and grew normally.

INFLUENCE OF ENVIRONMENTAL FACTORS

Light, temperature, moisture, soil and plant nutrients are important environmental factors affecting plant growth and development. In the course of light effect studies on common purslane development, photoperiod, light quality and light intensity were investigated.

Plant Nutrients

Materials and Methods

Response of common purslane to nitrogen (N), phosphorus (P), and potassium (K) was studied by Hopen (20) at the University of Illinois in quartz sand subirrigated with Hoagland's solution (19). Nutrient solutions were maintained in sand Monday through Friday. Distilled water was used as a flush on Saturday and Sunday. The liquid was removed from the pots for 30 to 45 min. for aeration during each 24-hr. period. The studies were carried out from January to April with a 9 to 13-hr. light period. Three replicates were used.

Results and Discussion

Nutrient level is important for common purslane growth as evidenced by greater growth at full strength Hoagland's solution than at nutrient levels less than full strength (Table 11).

Table 11. Nitrogen, phosphorus, and potassium levels in quartz sand culture as influencing the fresh weight (g/plant) of common purslane (1966 trials).

Strength of		48-day old plants		70-day old plants	
Hoagland's solution	Height (cm)	Foliage	Roots	Foliage	Roots
Full	14.9	5.48	0.40	29.3	0.98
1/2 Full	12.4	5.43	0.31	17.8	0.50
1/4 Full	6.6	2.13	0.13	5.3	0.18
Full—N	5.3	1.31	0.07	4.3	0.19
Full—P	1.0	0.05	0.01	0.8	0.07
Full—K	3.8	0.33	0.04	1.8	0.22

Elimination of phosphorus caused the greatest reductions of fresh weight of common purslane. Increased weight of common purslane was recorded when phosphorus levels increased (Table 12). Based on the positive response of common purslane to phosphorus in quartz sand and the build up of phosphorus in vegetable crop soils where this weed is a problem, soil phosphorus appears to be a significant factor in common purslane establishment. Zimmerman (54) indicates that common purslane for optimum growth needs a high nitrogen level in soil.

Common purslane is well adapted to survive dry soil conditions but on the other hand responds well to good moisture supply and generally this weed is not observed growing on poor, sandy soils which generally have low moisture content (54).

Table 12. Fresh weight (g/plant) of 35-day old common purslane as influenced by level of phosphorus in the nutrient culture (1968 trials).

Phosphorus[1] concentration (ppm)	Foliage	Roots
0	0.9	0.05
6	7.3	0.80
20	15.3	4.20
30	20.4	4.38
60	18.1	5.60

[1] The level of phosphorus was varied in otherwise full strength Hoagland's solution.

Photoperiod

Zimmerman (54) found that common purslane is rather neutral to photoperiod because plants produce some flowers at both short and long day cycles. In his tests even 4-hr. photoperiod evoked capsule production. The largest increase occurred between photoperiods of 4 and 8 hrs., demonstrating that 4 hrs. of light were barely able to maintain reproduction.

Materials and Methods

Five-inch diameter plastic pots were filled with a soil consisting of two parts of compost plus one part of washed sand and one part of peat moss. Before seeding common purslane seeds were sterilized with chlorox as indicated previously. After emergence two purslane seedlings were left in each pot. Plants were grown under 12-hr. and 16-hr. photoperiod at 22/18° C temperature in growth chambers. Eight replicates were used and the entire experiment run twice in 1966 at the University of Massachusetts. Summarized average data are presented in Table 13 and Fig. 6.

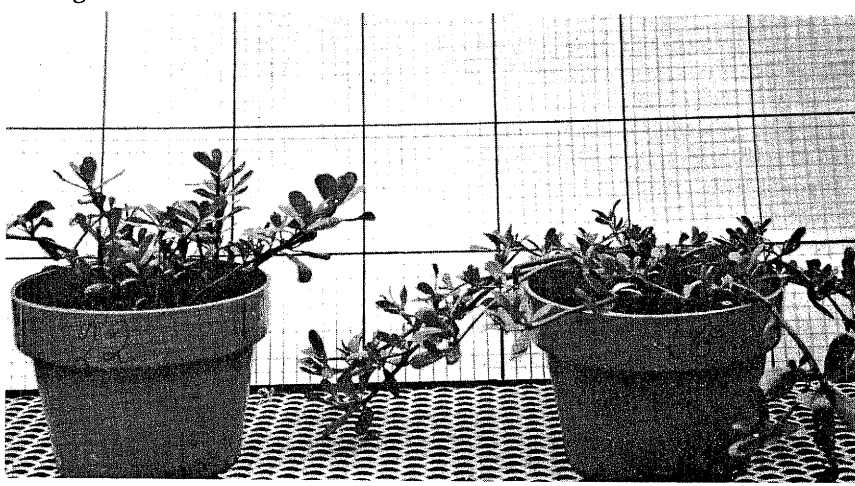

Figure 6. Common purslane growth patterns as influenced by day length. Left (22) 16-hr. photoperiod, right (26) 12-hr. photoperiod.

Results and Discussion

Long day (16 hr.) photoperiod common purslane plants were slower in developing but grew taller and finally produced greater fresh matter yields than short day plants (Table 13). Contrary to this, 12 hr. day plants grew and developed faster and produced more seedheads and seeds per plant. Long day photoperiod stimulates more vegetative plant growth while short day photoperiod stimulates more reproductive development in common purslane.

Table 13. Photoperiod effects on growth and development of common purslane.

Observations	Photoperiod 12 hr.	Photoperiod 16 hr.
(1) Emerged, days after seeding	4.0 a	4.0 a[1]
(2) First heads, days after emerging	25.0 a	43.0 b
(3) First ripe seeds, days after emerging	39.0 a	54.0 b
(4) Diameter of rosette (cm), 55 days after emerging	34.7 a	35.6 a
(5) Height of rosette (cm), 55 days after emerging	6.1 a	19.0 b
(6) Weight (g/plant), 55 days after emerging	53.2 a	89.5 b
(7) Number of seedheads per plant, 10 days after first seeds ripen	242.2 a	163.7 b
(8) Seeds (g/plant), 68 days after emerging	0.95 a	0.50 b
(9) Plant growth habit	Prostrate growth, shoots and leaves greenish	Upright growth, shoots and leaves reddish

[1]Means within rows followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Light Quality, Intensity and Temperature

Materials and Methods

A preliminary experiment was started to determine the factors necessary for good growth of common purslane under controlled conditions. Chambers were set on a 14-hr. photoperiod with alternating day/night temperatures of 21 and 15.5° C, respectively, and light intensity of 400 or 700 μw/sq. cm. During several weeks of exposure to these conditions, growth and development were very slow. These results led to the hypothesis that lower than optimum temperature and light intensities were responsible for the poor growth observed. The resulting stunted plants transferred to a greenhouse for 12 weeks did not recover.

In subsequent trials cultural conditions were altered. Seeds were germinated in a flat of vermiculate. When seedlings were well developed, they were transplanted into 0.7-liter plastic pots containing a mixture of peat moss, vermiculate, and a small amount of fertilizer in the bottom half, a layer of 5-10-10 fertilizer in the middle, and moist vermiculate in the top half. Nutrients were added at 2-week intervals. The light sources were 48-inch Sylvania VHO fluorescent lamps in cool white, red, green, yellow (gold) and blue. The spectral emission curves were described previously (15). Photoperiod of 16 hr. and a temperature of 26.7 C alternating with a dark period of 8 hr. and 22.2 C was established. Light intensities used were 740 and 1200 μw/sq. cm.

After a few days in the greenhouse, the plants were well established and then were transferred to the growth chamber. After about 3 weeks in the growth chamber the plants became infested with flea beetles. These insects were effectively controlled by applying a pyrethum spray, but this treatment also caused slight injury to the plants and some slowing of their growth. Nevertheless, harvest data were recorded at maturity.

A second set of plants was grown under similar conditions except that seeds were germinated and the plants maintained in the growth chamber without exposure to greenhouse conditions. The growth chamber was heat-treated between crops to eliminate insects and their eggs.

A third set of plants was grown under a single light intensity of 680 μw/sq. cm. with a temperature of 26.7 C during the light period and 15.5 C during darkness. Most of these plants grew rather upright, so height of plants and fresh and dry weights were taken at maturity. All data were analyzed with a modified Duncan's Multiple Range Test.

Results and Discussion

Experiments under higher light intensity produced greater fresh and dry weight yields than those at low intensity (Table 14). The plants grown under high light intensities also appeared more healthy and vigorous than those grown under low light intensities. The fresh and dry weights of plants under cool white light were high for both intensities and were significantly greater than those for all other light qualities at low light intensity. On the other hand, the fresh and dry weights were least for yellow light. The only exception was at low intensity in the second test (Table 14). The effect of yellow light was very detrimental, not only to flowering but to vegetative growth as well. In this respect, the response of common purslane differed from that of barnyardgrass (15) which had good yields but late flowering with yellow light. The adverse effects of yellow light, particularly on flowering, may be due to lack of any blue radiation in the spectral emission of these lamps (15). The yield of common purslane under red light did not differ significantly from the yields under green or blue light. In contrast, the yields for barnyardgrass and crabgrass (15) were significantly greater under red than green or blue light.

The growth habit of the plants varied with light intensity. Plants under red and green light were somewhat upright and highly branched. Those under yellow light were upright and showed little or no branching. Common purslane grown under yellow light also was very succulent and small in size, and a few plants died before the end of the exposure. This size response was obtained most frequently at the high light intensity. Plants under blue light were intermediate in size, and the stunting effect of this spectral region on grass weeds (15) was not apparent with common purslane.

Attempts to study flowering in the growth chamber were unsuccessful. Occasionally a flower was observed in some treatments but was never seen in others. An occasional open flower was seen in plants at the high intensity of blue, green, red, and white light. No open flowers were observed under yellow light at either intensity nor under other lights at the low intensity. However, seeds were observed on all plants

Table 14. Fresh and dry weights of common purslane plants grown under five light qualities and two starting schemes with temperatures of 26.7°C and 22.2°C during light and dark periods, respectively.[1]

Light intensity (μw/sq. cm.)	Color of light	Started in greenhouse		Started in growth chamber	
		Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
740	White	28.79a[2]	2.23a	14.24a	1.16a
	Green	19.34b	1.33b	1.24b	0.10b
	Blue	18.49b	1.33b	4.13b	0.27b
	Red	15.11b	1.15b	2.23b	0.14b
	Yellow	0.49c	0.05c	0.19b	0.02b
1200	White	40.61a	3.83a	38.71a	3.28a
	Green	36.77a	3.06a	21.06a	1.74a
	Blue	36.04a	2.97a	14.80a	1.20a
	Red	40.11a	3.48a	20.86a	1.78a
	Yellow	5.20b	0.28b	0.24b	0.01b

[1]Means of six subsamples and two replicates per treatment.

[2]Means within columns followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

except those under yellow light. Fertilization apparently occurs even if the flower is closed. Perhaps a higher light intensity is required for most of the flowers to open.

The results of the third experiment are summarized in Table 15. The temperature during the dark period was set 6.6 C lower than before. The low yields in this experiment probably were a result of the low light intensity (680 μw/sq. cm.). Significantly greater yields and heights were obtained with plants grown under green light than were obtained with those grown under white and yellow light. The high yields under green light and the low yield for white light apparently were caused by the cool temperature during darkness. Yields for yellow light again were lowest of all. The values for height of plants followed about the same size order as those for fresh and dry weights.

Table 15. Fresh and dry weights and heights of common purslane grown under five light qualities at 680 μw/sq. cm. intensity with temperatures of 26.7°C and 15.5°C during light and dark periods, respectively.[1]

Color of light	Fresh weight (g)	Dry weight (g)	Height (cm)
Green	15.61a[2]	1.80 a	20.0a
Blue	8.86a	0.77 a	12.0ab
Red	4.14ab	0.35 b	12.7ab
White	0.79b	0.06 b	6.8b
Yellow	0.14b	0.012b	5.2b

[1]Means of six subsamples and two replicates per treatment.

[2]Means within columns followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Common purslane plants are very adaptable. The conditions under which the highest yields occurred in the last experiment (green light at relatively low intensity and low night temperature) are similar to conditions in late summer under shade of large corn (*Zea mays* L.) plants, where most of the spectrum other than green light is either absorbed or reflected by the crop foliage. Cool nights are prevalent at this time of year. Common purslane thrives in thinly planted corn fields during late summer.

Date of Planting

Common purslane seeds can emerge throughout the growing season when temperature, moisture and other growing conditions are favorable. Growth, development and competitiveness of a weed can vary considerably due to the differences in time of emergence. Knowledge about these biological factors of weeds is limited. The main objective of our studies at the University of Massachusetts was to obtain specific information on growth and development of common purslane emerging at various dates in Massachusetts.

Materials and Methods

Field trials were conducted in 1967 at Brooks Farm and in 1968 and 1969 at the South Deerfield Farm, University of Massachusetts. In both locations the soil was fine sandy loam with only fair drainage. Each year the seedbed was prepared by liming to approximately pH 6.2 and fertilizing with 1120 kg/ha of 10-10-10. Common purslane was seeded in one 4.6m long row plots at 15-day intervals starting May 15. Three replicates were used. Rows in the blocks representing various seeding dates were 1.2m apart. After emergence, seedlings of common purslane were thinned out, leaving plants in the row 15cm. apart. Time of emergence, heading, maturity and diameter of rosettes were observed and recorded. During the latter part of the 1969 growing season, common purslane plants became infested with aphids and some unidentified fun-

Table 16. Growth and development of common purslane emerging at various dates during the growing season in Massachusetts

Date of seeding	Days to emergence	Days to heading after emergence	Days to maturity after emergence	Yields of fresh matter (g/plant)	Diameter of rosette (cm)
5/1	14	35	57	850	103
5/16	13	30	55	713	97
6/1	6	27	52	592	89
6/16	6	25	44	422	83
7/1	5	24	39	234	59
7/16	4	21	39	98	48
8/3	4	15	42	8	19
8 /16	7	18	—	+[2]	6
9/2	7	21[1]	—	+	3

[1] Heads were produced in 1968 only.

[2] Weighs less than 1g.

gus disease. These pests were successfully controlled with repeated applications of malathion (O-O-dimethyl phosphorodithioate of diethyl mercaptosuccinate) and zineb (zinc ethylene bisdithiocarbamate). Plots were harvested and fresh matter yields as well as size of rosettes were determined, usually early in September before the killing frost. For this purpose, in each plot 1.8m row, 12 plants were clipped and weighed. Results are presented in Table 16.

In Table 17 average climatological data for 1967, 1968 and 1969 growing seasons at Amherst, Massachusetts are presented.

Table 17. Monthly average air temperatures (°C) and precipitation (in mm) at Amherst, Massachusetts.

	Temperature				Precipitation			
Month	1967	1968	1969	Normal	1967	1968	1969	Normal
May	10.5	13.3	14.1	14.3	160	77	70	96
June	20.8	18.9	19.7	19.3	92	183	89	103
July	22.5	22.5	21.0	22.0	133	18	175	97
August	21.0	20.8	22.1	20.9	96	28	132	98
September	16.3	17.8	17.4	16.6	54	67	75	110
Total					535	373	541	504

Results and Discussion

Observations and analysis of data showed little variation from season to season in growth, development or maturity of common purslane. Growth and development pattern was similar in 1967, 1968 and 1969. Data of three years was combined and are presented in Table 16.

During the warm June-August summer season common purslane in Massachusetts emerged 4 to 6 days after seeding. Early in the fall and especially in May it took up to 2 weeks for seeds to emerge. It is apparent that temperature is an important factor in germination of common purslane seeds. These field trials under natural conditions verified our common purslane germination data obtained in germinators under controlled conditions (Table 6). In May in Massachusetts weather is much cooler than in September (Table 17) and close observations and tests showed that common purslane in September, before the killing frost, emerge much more readily than in early May.

Common purslane seeded mid-July or later formed seedheads sooner than those seeded in May or June. It is reasonable to assume that changes in the reproductive stage was caused by differences in photoperiod. Days toward the fall season are shorter and could be influential in reproductive development of the plant. Although it is difficult under field conditions, using various seeding dates, to separate clearly light, temperature or photoperiod effects on common purslane development, our tests discussed earlier (Table 13) indicate the importance of photoperiod in inducing the reproductive stage in common purslane.

The length of time required for common purslane seeds to ripen was from 39 to 57 days after emergence. The maturity was determined arbitrarily. Plants were assumed to be mature when the first dark nor-

mally developed seeds were observed. Again, photoperiod and probably total light were influential. Under favorable conditions, common purslane plants emerging as late as August may produce normally developed and mature seeds. Seedheads were produced by plants emerged as late as during the first 10 days of September. These plants did not produce any mature seeds before the first frost which usually kills this weed. In one case common purslane emerged on August 24, formed heads and after harvesting before the killing frost, uprooted plants were transferred to the greenhouse and kept in paper bags. Within a month or so these produced some normally developed mature and viable seeds.

The highest fresh matter yields were produced by common purslane plants emerging in May-June. Longer growing period and longer exposure to light helps to accumulate a greater amount of dry matter (54). The yields sharply dropped for plants emerging in July or later. The yields and size of rosettes are directly correlated. These growth and development characteristics have a direct bearing on the competitiveness of common purslane. For example, it is important to control this weed until mid-July. There is no practical need to apply control measures later in the season since seedlings emerging after mid-July have only about one-tenth as much growth as those seedlings which emerge in May or June. This reduction in growth of late emerging plants is brought about by the marked sensitiveness of common purslane to photoperiod. As the days become shorter reproductive rather than vegetative growth will occur so that, almost regardless of the date of emergence, seedheads are formed even in September.

Common purslane is a short prostrate plant characterized by matted growth. Its competitiveness should be great early in spring and especially in crops which develop slowly and do not provide shade. Thus it is likely to become a much more serious pest in crops such as table beets or onions than in soybeans or sweet corn.

Although growth and development of common purslane seeded at various dates all 3 years were alike, the appearance in 1968 was better and healthier, yields slightly higher and diameter of rosettes greater than those of 1969 plants. Close observations indicate that most probably the cause for this was climatical conditions. The 1968 growing season was rather dry (Table 17). Being a succulent fleshy plant, common purslane withstands not only dry soil and weather conditions well but apparently ecologically is well adapted and feels "at home" under such conditions. Also, Kutschera (26) found larger and better developed common purslane plants in the more arid Nebraska environment than in the more rainy Austria environment.

Outdoor Light Intensity

In competition between various plants water and light are most important factors (33, 50). Common purslane is a low-growing prostrate weed and, therefore, it can not compete effectively for light in taller-growing crop plants. Contrary to this, growth and development of common purslane should be affected by taller-growing companion cultural plants. It has been shown (3) that shading may affect weedy plants' growth and development considerably. Recently, Zimmerman

(54) found that common purslane is tolerant to low light intensities and produced capsules outdoors at 41% of total solar radiation. In growth chambers some capsules were produced at all light levels, including that of 220 foot-candles.

The main objective of our investigations was to find out how much growth and development of common purslane emerging at various dates is affected by outdoor light intensity.

Materials and Methods

In 1968 and 1969 field experiments were conducted at the South Deerfield Farm, University of Massachusetts. Commercially available SARAN shade material was used over post and wire structures high enough to allow workers to move freely underneath. Due to this shading outdoor light intensities were decreased 30, 51 and 76%. Soil was fine sandy loam with only fair drainage. Each year the seedbed was prepared by liming and fertilizing with commercial 10-10-10 fertilizer at a rate of 1120 kg/ha. Common purslane seedings were started mid-May and continued semi-monthly until August. The plot consisted of a row 2.5m long and 1m apart. Three replicates were used. After emergence common purslane seedlings were thinned out and plants left 15 cm apart. Dates of emergence and ripening were observed and recorded. Mid-September in each plot a middle 1.8m long section (12 plants) was clipped and fresh matter yields determined.

Under heavy 76% shading emergence of common purslane was slower but generally shading did not affect time of emergence significantly (Table 18). Although no data was recorded, close observations showed clearly that seed emergence under 76% shading was always significantly poorer than in check plots or in comparison with two other lighter shading treatments. Micro-climate was not investigated in these variously shaded tents and it is possible that purslane seed emergence was not only directly affected by different light intensities but also by differences in temperature, humidity or CO_2. Shading 51% or more delayed plant change to the reproductive phase of development. Plants under heavier shadings headed and matured later than those shaded 30% or not shaded at all. These trials verified earlier results (Table 16) that photoperiod is an important factor in plant development and played a role in change to the reproductive stage. Plants seeded later in July or August headed and matured in a shorter period of time after emergence than those emerging in May or June.

The earlier plants emerge the higher the yields produced (Table 16, 18). The best developed and heaviest common purslane plants were growing under full outdoor light intensity. The heavier shading the lower the yields that were obtained. These trials clearly indicate that common purslane is susceptible to shading and, therefore, this weed in faster and taller-growing crop plants should not be a strong competitor. Yields and size of rosettes are directly correlated.

Consistently in both years 30% shading was beneficial to common purslane plants emerging late July and early August (Table 18). This period is the warmest in Massachusetts (Table 17) and apparently slight shading creates microclimatical conditions favorable to the growth and development of common purslane.

Table 18. The effect of light intensity on growth and development of common purslane. Averages of 1968 and 1969.

Seeding date	Shaded percent	Emerged in days	Heading days after emergence	Ripe seeds days after emergence	Fresh matter yields (g/plant)	Rosette diameter (cm)
5/15	0	11	29	58	812.8	113
	30	11	31	62	596.1	99
	51	11	32	64	268.0	80
	76	12	56	82	26.6	17
5/31	0	7	25	53	675.6	103
	30	6	31	59	540.1	98
	51	6	33	61	223.5	69
	76	7	49	89	27.8	17
6/17	0	6	24	44	447.5	94
	30	6	24	44	331.4	82
	51	6	25	50	184.5	62
	76	8	32	69	22.3	14
7/2	0	5	22	37	296.6	65
	30	5	26	37	190.0	58
	51	6	26	42	108.6	36
	76	7	27	73	7.6	12
7/16	0	4	21	34	186.7	57
	30	4	21	34	227.5	64
	51	4	24	53	69.2	47
	76	4	27	80	1.1	5
8/3	0	4	14	42	11.7	18
	30	4	21	44	11.8	18
	51	4	29	57	3.4	12
	76	6	32	—	0.2	2

COMPETITION STUDIES

In the field, if space is available, common purslane will branch out, form a matted growth and fill all bare spots around. Being a low-growing prostrate weed, common purslane should not be able to compete effectively with taller-growing and liberally fertilized cultural plants. Generally, more severe crop yield reductions could be expected from weeds which overlap or seriously shade the cultural companion crop (14). Much less is known about yield losses resulting from low-growing prostrate weeds such as common purslane. At the University of Massachusetts competitiveness of common purslane with table beets, snap beans and sweet corn was studied (48).

Materials and Methods

Experiments with table beets (*Beta vulgaris* L., var. Detroit Red) and snap beans (*Phaseolus vulgaris* L., var. Eastern Butter) were conducted in 1967 and 1968 at Amherst, Massachusetts. Competition studies between common purslane and sweet corn (*Zea mays* L., var. Early Golden Giant) were carried out at Amherst in 1968 and at the South Deerfield Experiment Station farms in 1969. At Amherst the soil is fine sandy loam with only fair drainage while at the South Deerfield farm the soil is a sandy loam with excellent drainage. In all cases the seedbed was prepared by liming to pH 6.2 to 6.4 and fertilizing with 1120 kg/ha of 10-10-10 commercial fertilizer. Randomized complete block designs, with four replicates, were used. Beets, beans and corn were planted in rows 45, 60 and 90 cm apart, respectively. After emergence of beets, beans and corn, plots 4.6 to 7.6m long each containing three or four rows were established. Plant rows were used as border lines of plots and two or three middle rows made up a net plot. Randomized complete block designs with four replicates were used. Although from year to year experiments varied slightly, beets, beans and corn were planted in these competition trials between June 11 and July 1. At Amherst the experimental areas were uniformly infested with common purslane. In 1969 the experimental area at South Deerfield was rather free of weeds. In preparing the seedbed 1.1 kg/ha of common purslane seed was seeded and mixed in 10 to 15 cm deep. At planting time with all experimental areas the prepared seedbed was overseeded with weed seed at the rate of 1.7 kg/ha each year. Weed stands in all experiments were uniform and averaged 300 to 350 seedlings per square meter. All experimental areas were kept free from other weeds by continuous hand-weeding.

Beets, beans and corn were kept weed-free by frequent hand-weeding for 0, 2, 4 and 6 weeks after emergence. One plot was kept weed-free until harvest. Treaments were included in which common purslane was allowed to grow undisturbed for 0, 2, 4 and 6 weeks, and until harvest. At the end of the prescribed periods of weed competition, the common purslane was removed with as little disturbance to the crops as possible, and common purslane yields were determined. The weed-free condition was maintained until harvest by periodic hand-weeding.

Results and Discussion

The lowest yields with all crops were obtained in plots where common purslane was not controlled during the entire growing season (Ta-

ble 19, 20). Common purslane control was most important in the first 2 weeks after beet, bean or corn emergence. Control of common purslane for more than 2 weeks did not increase tested crop yields. This demonstrated that it is important to eradicate the first crop of common purslane seedlings. When common purslane control was stopped as early as 2 weeks after beet, bean or corn emergence, the weed was not able to establish a vigorous, competitive stand. Weak beet or other companion crop seedlings continued to grow and were not affected by the newly emerging common purslane seedlings. Common purslane seeds germinate very well if they are within 1 cm or so of the seedbed surface and are under proper moisture and temperature conditions. A thick stand of common purslane seedlings indicated that conditions were satisfactory for germination in the upper layer of the seedbed. When common purslane control was stopped in any treatment, few common purslane seedlings emerged and stands, as yields indicate, were poor (Table 19, 20).

Table 19. Yields of beets, beans and common purslane as influenced by length of weed-free period after emergence.[1] Average data of 1967 and 1968.

Treatment	Beets			Beans		
	Roots	Roots and tops	Common purslane	Pods	Pods and foliage	Common purslane
Check, no control	2.1a[2]	5.9a	26.6b	9.4a	18.7a	19.4c
Weed-free 2 weeks	13.3b	28.4b	1.4a	11.5b	23.0b	5.5b
Weed-free 4 weeks	13.0b	27.6b	0.5a	11.2b	22.8b	1.0a
Weed-free 6 weeks	13.4b	28.4b	+[3]	11.6b	21.9b	+
Weed-free all season	13.5b	28.4b	0	11.9b	23.8b	0

[1]Fresh matter yields in kg/plot.

[2]Numbers within columns not followed by the same letter are significantly different at the 5% level according to Duncan's Multiple Range Test.

[3]Yields less than 0.1 kg/plot.

Table 20. Yields of sweet corn and common purslane as influenced by length of weed-free period after emergence.[1] Average data of 1968 and 1969.

Treatment	Market corn		Whole corn plant		Common purslane	
	1968	1969	1968	1969	1968	1969
Check, no control	16.5a[2]	9.8a	35.5a	27.3a	32.9c	35.8c
Weed-free 2 weeks	20.8b	19.9b	45.2b	49.7b	7.9b	6.8b
Weed-free 4 weeks	21.0b	20.0b	44.0b	47.8b	2.3a	1.4a
Weed-free 6 weeks	20.9b	20.3b	44.3b	49.8b	0.9a	0.3a
Weed-free all season	19.7b	19.4b	43.1b	48.8b	0	0

[1]Fresh matter yields in kg/plot.

[2]Numbers within columns not followed by the same letter are significantly different at the 5% level according to Duncan's Multiple Range Test.

The longer common purslane was allowed to compete after beet, bean or corn emergence, the more crop yields were decreased (Table 21, 22). Four weeks of competition decreased beet, bean and corn yields by 52%, 4% and 7%, respectively. Just 2 weeks of competition were needed to decrease beet yields significantly while more than 4 weeks of competition were needed to decrease bean or corn yields significantly. Common purslane is a strong competitor in table beets. It is a poorer competitor in snap beans or sweet corn than in table beets. Beans or corn grow rapidly and soon after emergence develop larger leaves and are able to compete with the small-leaved, slowly developing common purslane seedlings. Beans and especially corn were taller than common purslane, but beets were smaller than common purslane when growing competitively (Table 23, 24). Dawson (14) demonstrated that annual weeds which do not overtop beans do not affect yields significantly. Common purslane was at least a poor competitor with beans and corn for light. Good moisture conditions in the lowland Amherst experimental area and liberal fertilization apparently were able to provide both water and plant nutrients satisfactorily for both crop and weeds. However, beets, which develop more slowly than beans or corn, were affected strongly by the competing common purslane for light, water or plant nutrients (33).

Competitiveness of common purslane was much greater in 1969 than in 1968. This could be explained by different moisture conditions.

Table 21. Yields of beets, beans and common purslane as influenced by common purslane competition for indicated periods after which beets and beans grew alone.[1] Average data of 1967 and 1968.

	Beets			Beans		
Treatment	Roots	Roots and tops	Common purslane	Pods	Pods and foliage	Common purslane
No competition	13.5a[2]	28.4a	0	11.9a	23.8a	0
Competition 2 weeks	9.1b	19.9b	11.0a	10.9a	22.2a	4.9a
Competition 4 weeks	6.5c	14.5c	18.2b	11.4a	22.6a	14.0b
Competition 6 weeks	3.1d	7.9d	25.7c	8.9b	18.2b	18.7c
Competition all season	2.1d	5.9d	26.6c	9.4b	18.7b	19.4c

[1]Fresh matter yields in kg/plot.

[2]Numbers within columns not followed by the same letter are significantly different at the 5% level according to Duncan's Multiple Range Test.

Table 22. Yields of sweet corn and common purslane as influenced by common purslane competition for indicated periods after which sweet corn grew alone.[1] Average data of 1968 and 1969.

	Market corn		Whole corn plant		Common purslane	
Treatment	1968	1969	1968	1969	1968	1969
No competition	19.7b[2]	19.4c	43.1b	48.8c	0	0
Competition 2 weeks	19.0b	20.0c	41.1b	49.5c	5.2a	10.2a
Competition 4 weeks	19.0b	17.4b	40.0b	37.2b	32.4b	32.0b
Competition 6 weeks	17.4a	11.5a	37.6a	29.4a	34.3b	37.9c
Competition all season	16.5a	9.8a	35.5a	27.3a	32.9b	35.8c

[1]Fresh matter yields in kg/plot.

[2]Numbers within columns not followed by the same letter are significantly different at the 5% level according to Duncan's Multiple Range Test.

At the South Deerfield experimental area, because of lighter soil texture, excellent drainage and high elevation, competition for water had to be stronger than in 1968 at Amherst on poorly drained bottomland soil conditions. Apparently competition for water was the most important factor affecting yields of sweet corn in these studies. Also, the possibilities were greater for nutrients leaching at the South Deerfield experimental area. Weise and Vandivier (50) found that some weeds are stronger competitors under wet and some under dry soil moisture conditions. Being a succulent plant, common purslane can easily withstand dry soil or weather conditions, and it is reasonable to assume that its competition under water stress in soil should be rather effective. Market corn yields in 1968 and 1969 were decreased due to common purslane competition for 6 weeks after corn emergence by 12% and 40%, respectively.

Removal of common purslane growing in close association with table beets, snap beans or sweet corn possibly produced a "shock effect" on the beets, beans and corn plants, which could not be ascertained from yield data. This can be noted especially by the greater bean yield reductions in plots where competition lasted 6 weeks than in plots where competition lasted for the entire growing season (Table 21).

Table 23. Beet, bean and common purslane heights (in cm) at various dates during the 1968 growing season.

		Beets with common purslane			Beans with common purslane	
Date	Beets alone	Beets	Common purslane	Beans alone	Beans	Common purslane
7/9	—	—	—	20.6	20.3	5.6
7/14	3.3	3.6	3.6	24.1	22.9	14.2
7/22	10.2	11.2	14.2	38.6	38.6	25.9
7/29	18.8	20.8	30.2	40.4	43.7	36.6
8/5	22.9	22.9	29.0	45.2	45.5	39.9
8/12	31.8	28.2	35.8	44.2	44.9	36.1
8/19	42.7	33.3	37.8	43.9	43.9	40.4
8/26	37.3	30.2	35.6	—	—	—

Table 24. Sweet corn and common purslane heights (in cm) at various dates during the growing season. Average data of 1968 and 1969.

		Sweet corn with common purslane	
Date	Sweet corn alone	Sweet corn	Common purslane
7/ 2	26.4	26.2	4.1
7/ 9	37.6	37.8	9.4
7/17	57.9	58.9	22.1
7/24	97.8	86.9	28.7
7/31	126.0	120.1	35.0
8/ 7	160.0	152.1	36.3
8/14	166.1	161.0	48.0
8/22	173.7	171.2	44.7

EFFECT OF DICAMBA ON COMMON PURSLANE

The main objective was to study the response of common purslane to dicamba (3, 6-dichloro-*o*-anisic acid) treatment with consideration of morphological and physiological effects on the weed and to examine the absorption, translocation and metabolism of the herbicide in the treated plants. Also, an attempt was made to compare the physiological action of ethylene and dicamba in purslane and to explore their interaction (41).

Growth and Development

The purslane seeds were sown on sand in plastic pots, subirrigated with Hoagland solution (19) and kept in the growth room under controlled light and temperature conditions. At the age of 4 weeks purslane plants were treated with various rates of dicamba applied to the foliage as measured droplets, or to the roots in nutrient solution. The morphological effects of dicamba on purslane was followed visually and plant height and yields recorded.

The symptoms of dicamba injury invariably started with leaf epinasty. With foliar application this response could be seen after 4 hrs. with 10 ug of dicamba per plant. Younger leaves were more strongly affected than the older ones. In the case of root application the epinasty developed slower and mainly at the top of the branches. Normally common purslane leaves change their position half an hour before the dark period from more or less perpendicular to the stem in the daytime into an upright, close to the stem position at night. On the treated plants the leaves stayed perpendicular or bent downward. The growth of treated plants was visibly impaired at dicamba rates above 0.5 μg per plant. New leaves were very small, twisted, elongated. There was a proliferation of growth of small young branches from the lateral buds in the leaf axils which normally remain dormant.

Another early symptom of dicamba action was bending of the stems. The bending of young purslane plants treated with 1 ug of dicamba or less was reversible, but at higher rates the whole plants eventually died. The lethal responses started with the treated leaf which usually became yellowish, developed necrotic spots at the base and abscissed. Often the defoliation was so complete that only the stems remained. The stems were abnormally swollen in the upper portions and the apex produced a cluster of yellow callous intumescence. Zimmerman (54) found that leaf abscission occurs also in response to low soil moisture content; under severe conditions almost all leaves disappear, leaving but a tuft at the apex of each branch.

The lethal dose of dicamba was 5 ug for a 4 week-old, 20 ug for 10 week-old purslane applied through foliage or roots. These respective doses killed the plants within two weeks.

The stunting of purslane growth treated with dicamba was apparent (Table 25). The strongest effect was achieved by the highest rates of dicamba with both foliar and root applications. The difference between the foliar and root application was not significant except at the lowest rate of dicamba, with root application being notably less effective than foliar.

There was significant reduction in fresh weight yields of purslane treated with dicamba (Table 25). The yields decreased proportionally to the rate of dicamba treatment.

Table 25. Main stem length and fresh matter yields of common purslane treated with dicamba 4 weeks after emergence.

Treatment site	Dicamba µg/plant	25 days after treatment	
		Main Stem length (cm)	Yields g/pot
Check	0	26.8a	69.7a[1]
Root	0.5	22.9b	40.8b
Root	5.0	17.7cd	17.4cd
Foliar	0.5	17.4cd	36.3bc
Foliar	5.0	14.0d	11.6d

[1]Means within columns followed by the same letter do not differ significantly at the 5% level according to Duncan's Multiple Range Test.

Cell Membrane Permeability

Dicamba applications caused bending of purslane stems. It was of interest to measure changes in cell membrane permeability in the regions of stem bending. After 6 hours when the bending response occurred in plants treated with 5 µg of dicamba, 1-cm stem sections were excised from the bending region and efflux of electrolytes was measured (51).

The permeability of leaf tissues was examined by feeding rubidium ions and then following their efflux into demineralized water. Plants were treated with dicamba as well as with ethylene and rubidium ion content was determined (29).

The efflux of electrolytes from bending zone of stems of treated purslane was greater than from parallel checks and increased with increased rates of dicamba (Table 26). It indicates that certain changes in permeability of stem tissues occurred soon after treatment, and that this could be responsible for the bending effect. Both dicamba and ethylene increased the permeability of purslane leaves. The check leaves practically did not lose any rubidium during the experiment, while ethylene and dicamba treated leaves showed a significant loss of this ion.

Table 26. Efflux of electrolytes from purslane stem sections after dicamba treatment (in percent of total content of electrolytes).

Dicamba treatment µg/plant	Efflux %
Check	12.2a[1]
0.5	19.8c
5.0	25.9

[1]Means followed by the same letter do not differ significantly at the 5% level according to Duncan's Multiple Range Test.

Protein Synthesis

Two systems were used to determine effects of dicamba on protein synthesis in common purslane leaves. These were the incorporation of

labeled phenylalanines and the activity of nitrate reductase, which is known to turnover rapidly in plant material (40). Both procedures were used to check dicamba effects on protein synthesis in purslane (41).

Nitrate reductase activity was not affected until 2 days after the treatment (Table 27). It was not a "first response" as opposed to visible morphological changes. The drop in activity occurred when the leaves were already in epinasty and the stems were bent.

Table 27. Nitrate reductase activity in leaves of purslane treated with dicamba.

Time after application	Nitrate reductase activity μmoles NO_2^-/mg protein/hr.		
	Check	Treated	Ratio %
0	.154	—	100
1 day	.225	.214	84
2 days	.165	.038	23

Total protein synthesis in purslane leaves as measured by phenlalanine incorporation decreased on the third day after its application (Table 28), and the incorporation continued to diminish during the following days.

Table 28. Phenylalanine-^{14}C incorporation into protein in leaves of purslane plants treated with 10 μg dicamba.

Days after treatment	Percent of check
0	100
1	107
2	106
3	53
4	31

The inhibition of total protein synthesis was so delayed that it must be considered as a secondary effect of dicamba, possibly mediated through earlier changes. Nevertheless, it is the one which can greatly contribute to death of the leaves, as protein synthesis is reduced 69% four days after treatment.

Ethylene Effects and Production

Many of the responses of purslane to dicamba were similar to well known ethylene effects in other plants (5, 36). Therefore, a study was undertaken to determine the response of purslane to various ethylene concentrations and the production of ethylene by dicamba treated purslane plants (41).

The pots with purslane plants were enclosed in desiccator jars and ethylene was injected through a rubber vaccine stopper. Other plants, treated with dicamba or left untreated, were enclosed in a similar way and the samples of air were withdrawn and analyzed by gas chromatography for ethylene.

Common purslane proved to be very sensitive when submitted to ethylene fumigation in the range of 0.5 to 100 ppm. Within 4 to 6 hours after application of 20 to 100 ppm of ethylene, rapid epinasty of all the leaves occurred and abscission was initiated. After 24 hours defoliation was complete. With decreasing ethylene concentration the time of appearance of the first response was delayed and abscission occurred at a slower rate. Still, 5 to 10 ppm of ethylene produced nearly complete defoliation within 24 hours. The youngest leaves remained attached but they were chlorotic. It was also noticed that the few remaining leaves lost their ability to close at night. This response became first noticeable in the plants treated with 0.5 and 1.0 ppm of ethylene.

The application of dicamba multiplied normal ethylene production of purslane (Table 29). Ethylene production increased roughly proportionally to the dicamba concentration. The noticeable increase in ethylene production occurred in less than 4 hours after the herbicide application. Even 5 μg of dicamba increased the ethylene production about tenfold (41).

Table 29. Ethylene production in common purslane after dicamba treatment (100 μg/pot) expressed in ppm of ethylene in a 10-liter jar.

Hours after treatment	Ethylene concentration	
	Check	Treated •
24	0.05	0.50
48	0.10	1.00

The following scheme of mode of action of the dicamba in purslane is proposed. The herbicide influences the ethylene producing system within the very first hours of its action. The high level of ethylene in the tissues is maintained for a long time and causes further physiological changes. It could influence the observed increase in the permeability of leaf tissues indicating the changes in cell membranes. In the course of 2 to 3 days it could account for the inhibition of protein synthesis in the leaves. The produced level of ethylene is high enough to cause epinasty, defoliation and final lethal effects of dicamba in common purslane plants.

Absorption, Translocation and Metabolism

In these studies tagged dicamba and thin layer chromatography on silica gel were used (41).

Dicamba moved into plants rather slowly (Table 30) but translocation of absorbed dicamba inside the plant proceeded rapidly (Table 31). Common purslane absorbed only a minute amount of the applied dose of dicamba, but it caused very marked lethal changes. The herbicide once absorbed was quickly translocated into the stem and then young parts, leaves and roots. Young parts clearly accumulated dicamba but it was later redistributed more uniformly into the leaves and roots. The translocation follows assimilate pattern. At the end of the experiment about one third of the herbicide was probably immobilized in the dying leaves. A considerable leakage of dicamba occurred from the roots into the nutrient medium.

Table 30. Absorption on dicamba-^{14}C in purslane expressed as percent of the applied dose.

Time after treatment	Percent of applied dose
1 hr.	0.5
1 day	8.6
8 days	10.4

Table 31. Distribution of dicamba-^{14}C in purslane as expressed in percent of the absorbed amount.

	Percent radioactivity					
Time after treatment	Treated leaf	Young parts	Leaves	Stems	Roots	Medium
1 hr.	66.0	11.0	8.4	11.9	2.7	—[1]
1 day	14.4	52.4	8.9	23.9	0.2	0.2
8 days	10.0	31.0	39.5	12.5	2.6	4.3

1 — denotes no radioactivity was detected.

The low rate of dicamba absorption could be explained by contact lethal changes in the treated leaves. Necrotic spot which formed around the place of application could prevent further absorption. The herbicide was not metabolized in common purslane and after 8 days it remained in unchanged form of dicamba.

COMMON PURSLANE CONTROL

Cultural Practices

Competition studies at the University of Massachusetts demonstrated that it is important to eradicate the first crop of common purslane seedlings. When purslane control was stopped as early as 2 weeks after beet, bean or corn emergence, the weed was not able to establish a vigorous, competitive stand. This could be explained by the fact that even freshly shed purslane seeds are viable and germinate if they are within 1 cm or so of the seedbed surface. Therefore, destroying common purslane seedlings by hoeing or cultivation can be a very effective controlling means. Companion cultural crop seedlings continue to grow, shade soil surface and as trials showed no vigorous competitive new stands of purslane developed.

Uprooted, especially more advanced, common purslane plants should be carried away from the field after hoeing or cultivation. Succulent habit prevents quick wilting and depending upon the weather, plants may remain inactive for several weeks and subsequently reroot and continue to grow.

Chemicals

There are many herbicides which are toxic to common purslane, especially when in contact with the germinating seed or emerging young seedlings. There are also many herbicides which are effective in post-emergent treatments. In each case it is of first importance to select a chemical which will kill common purslane but will not effect the companion cultural crop growing in the same field.

Common purslane needs higher soil and air temperatures to germinate and usually emerges when suitable climatic conditions prevail. In early planted crops, applied preemergence herbicides can be dissipated by the time purslane germinates and thus the weed may escape these treatments. At the time the herbicide was active the seeds of purslane were dormant and were not affected by the herbicide. Therefore, it is important to select a herbicide or combinations which would be active to hit germinating seeds or immediately afterwards. Hopen (20) found that alachlor (2-chloro-2', 6'-diethyl-N-(methoxymethyl) acetanilide) or DCPA (dimethyl tetrachloroterephthalate) did a good job in controlling early emerging weeds in horseradish but for later emerging common purslane it was necessary to add nitrofen (2, 4-dichlorophenyl p-nitrophenyl ether) to get effective control.

Some of the common herbicides which, if properly used, can be effective in purslane control are presented below:

1. Benefin (N-butyl-N-ethyl, a, a, a-trifluoro-2, 6-dinitro-p-toluidine)
2. CDAA (N,N-diallyl-2-chloroacetamide)
3. CDEC (2-chloroallyl diethyldithiocarbamate)
4. Chlorpropham (isopropyl-m-chlorocarbanilate)
5. Dichlobenil (2, 6-dichlorobenzonitrile)

6. Dinoseb (2-sec-butyl-4, 6-dinitrophenol)
7. EPTC (S-ethyl dipropylthiocarbamate)
8. Pyrazon (5-amino-4-chloro-2-phenyl-3 (2H)-pyridazinone)
9. Sesone (2-(2, 4-dichlorophenoxy) ethyl sodium sulfate)

Many more widely used herbicides could be included in this list. For specific research information refer to literature available in the proceedings of several regional weed conferences and in Weed Science, Journal of the Weed Science Society of America.

Dicamba, mecoprop (2-((4-chloro-o-tolyl) oxy) propionic acid) as well as silvex (2-[2, 4, 5-trichlorophenoxy] propionic acid) can be used to control emerged common purslane in turfgrasses (21, 22). Observations at the University of Massachusetts indicate that common purslane is sensitive to diuron (3-(3, 4-dichlorophenyl)-1, 1-dimethylurea) postemergent applications.

Biological Control

Common purslane has its own natural pests and there is some hope of biological control of this weed. Purslane sawfly (*Sofus pilicornis*) is a natural pest of common purslane in some Illinois commercial fields.[1]

[1] Hopen, H. J., University of Illinois, Urbana, Illinois. Personal communication.

SUMMARY

This study consisted of many experiments covering various phases in the life cycle of common purslane (*Portulaca oleracea* L.). The experiments were conducted between 1966 and 1970 cooperatively by Massachusetts and New Hampshire Agricultural Experiment Stations.

Anatomical and morphological characteristics of common purslane plants were studied. Seed studies included light, light quality, temperature, moistening agent, scarification and age of seed effects on germination. Also, seeding depth of common purslane and seed emergence were studied. Seed production on uprooted plants as well as vegetative reproduction of common purslane were explored. Environmental factors, such as day length, light quality, date of emergence and light intensity were investigated. Competitiveness of common purslane with table beets, snap beans and sweet corn were studied. Response of purslane to dicamba treatments was investigated.

As a result of these experiments, the following observations and conclusions were made:

1. Stomata are located on both the upper and lower leaf epidermis. In the fully developed leaves the number of stomata on both sides of the epidermis are very close, about 36 per sq. mm. Stomata open during the day and close during the night.

2. Common purslane flowers open in the morning and close by noon. Seeds matured in 14 to 16 days after flowering. Common purslane has sequential maturation and distribution of seeds throughout the growing season. Seeds tend to mature first near the center of the growing rosette, and the blooming periods vary so that seed production occurs from spring until late summer. Under greenhouse conditions plants that averaged 28 cm in diameter produced approximately 6,700 seeds per plant. During one growing season the plant may produce many times this number of seeds.

3. Common purslane seeds germinated significantly better under all of the light treatments than in darkness. Germination with blue light was consistently low. Yellow light produced the highest germination.

4. Common purslane seed treatments with concentrated sulfuric acid increased germination. Treatments for 0.5 to 1.5 minutes were best. Dimethyl sulfoxide (DMSO) as a moistening agent increased seed germination.

5. The best common purslane seed germination in Massachusetts tests were obtained when temperature in germinators were between 25 and 40 C. The greatest germination vigor (speed) was under continuous temperatures between 30 to 40° C. In any case in germination tests between 18 and 40° C all apparently viable seeds germinated in 3 to 8 days. This indicates rather speedy common purslane seed germination.

6. In storage common purslane seeds can survive for 14 years without losing viability appreciably, but the best germination was obtained from seeds 1 year old. Freshly harvested seeds germinated 39% as compared with 78% of 1 year old ones.

7. Emergence was higher for seeds left uncovered on the soil surface. The deeper that seeds were planted, the lower the emergence that was obtained. Seeds planted 4 cm deep or deeper did not emerge at all.

8. Growth of common purslane was greater at elevated nutrient levels and was dependent on adequate phosphorus in the nutrient media.

9. Long day (16 hr.) photoperiod stimulated vegetative purslane growth, while short day (12 hr.) photoperiod stimulated reproductive development.

10. Massachusetts trials indicate that common purslane seeds not fully developed can become fully developed and ripen on uprooted plants.

11. Cut pieces of common purslane shoots, especially basical parts, are able to produce adventitious roots and thus vegetatively propagate. Healthy purslane shoots not cut or wounded kept in continuous contact with moist soil did not produce roots.

12. Under natural field conditions during the warm June-August summer time in Massachusetts common purslane emerged in 4 to 6 days after seeding. Early in the fall, and especially in May, it took up to 2 weeks for seeds to emerge.

13. Common purslane seeded in July, or later, formed heads quicker than those seeded in May or June. Common purslane required a period of 39 to 57 days after emergence for seeds to ripen. Apparently photoperiod was influential in stimulating changes from vegetative growth to reproductive stages of development. In Massachusetts, under favorable conditions, common purslane plants emerging as late as August 7 may produce normally developed and mature seeds.

14. The highest fresh matter yields were produced by common purslane plants emerging May-June. The yields dropped sharply for plants emerging in July or later. The yields and size of rosettes are directly correlated. The diameter in cm of purslane plants emerged on the first of May, June, July and August were 103, 89, 59 and 19, respectively.

15. Seed emergence under 76% decreased outdoor light intensity was significantly poorer (lower) than in full light plots. Shading 51% or more delayed plant change to the reproductive phase of development. Plants under heavier shadings headed and matured later than those shaded 30% or not shaded at all. The heaviest purslane plants were growing under full outdoor light intensity. The heavier the shading the lower the yields that were obtained.

16. Competition studies showed common purslane control was most critical during the first 2 weeks after table beet, snap bean or sweet corn emergence. Weed control for longer than 2 weeks did not increase beet, bean or corn yields. The longer purslane was allowed to compete after beet, bean or corn emergence, the more yields were decreased. Common purslane was a stronger competitor in beets than in beans or corn. Common purslane was a stronger competitor under less favorable growing conditions.

17. The visual response of common purslane to dicamba and ethylene was similar and included swelling of stems, epinasty and defoliation of leaves, necrosis. Dicamba caused ethylene increase in purslane and it is

possible that ethylene may be responsible for some observed dicamba effects. Dicamba increased permeability of cell membranes and reduced protein synthesis in common purslane. Dicamba was absorbed slowly but translocation to young tissues and buds was fast. There was no indication of dicamba metabolism in common purslane.

Figure 7. Common purslane *(Portulaca oleracea* L.). A, habit; B, flowers and capsules; C, flower open; D, seeds [from Selected Weeds of the United States, U. S. Department of Agriculture, Agricultural Research Service, Agricultural Handbook No. 366, 1970 (46)].

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