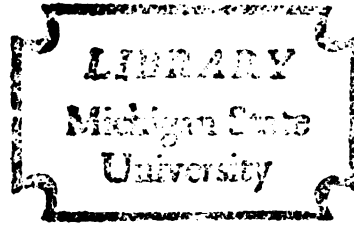


GROWTH AND DEVELOPMENT OF COMMON PURSLANE
(*Portulaca oleracea* L.) AND ITS COMPETITIVE
INFLUENCE WITH ONIONS ON MUCK SOILS

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ABSTRACT

GROWTH AND DEVELOPMENT OF COMMON PURSLANE
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By

Nancy Elaine Adams

Both ethylene and light were essential for the germination of dormant, freshly harvested common purslane (Portulaca oleracea L.) seed. The seed failed to germinate when light or ethylene were removed from the seed environment, and exogenously supplied ethylene as gas or ethephon (2-chloroethylphosphonic acid) increased germination 2 to 4 fold that of the air controls. Increased rainfall, planting depth, and decreased temperatures caused a decline in common purslane germination.

In field competition experiments, early season common purslane densities of 58 plants/m² for 40 days after planting did not decrease onion yields. Common purslane densities of 153 and 463 plants/m² could be tolerated for only 30 and 20 days respectively without decreasing yields. Onion plots which remained weed-free for 10 or more days prior to common purslane establishment produced bulb yields equal to weed-free controls. Low densities of common purslane stimulated onion growth during early stages of development and produced an apparant yield increase in the field experiments.

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TABLE OF CONTENTS

	Page
LIST OF TABLES.....	iv
CHAPTER 1: GENERAL LITERATURE REVIEW.....	1
CHAPTER 2: FACTORS INFLUENCING THE GERMINATION OF COMMON PURSLANE SEED.....	7
Abstract.....	7
Introduction.....	8
Methods and Materials.....	10
Results and Discussion.....	14
Literature Cited.....	22
CHAPTER 3: THE COMPETITIVE INFLUENCE OF COMMON PURSLANE WITH ONIONS ON MUCK SOILS.....	24
Abstract.....	24
Introduction.....	26
Methods and Materials.....	28
Results and Discussion.....	32
Literature Cited.....	44
APPENDIX: WEED SPECIES LOCATED IN UNDISTURBED 0.1 m ² PLOTS.....	45
LIST OF REFERENCES.....	46

LIST OF TABLES

	Page
 CHAPTER 2	
1. Common purslane germination in Houghton muck soil at various planting depths	14
2. Common purslane germination with varying rainfall on two soils	15
3. Gas concentrations in a Houghton muck soil as influenced by simulated rainfall	16
4. Gas concentration in a Bellefontaine loamy sand soil as influenced by simulated rainfall	17
5. Germination of common purslane seed as influenced by different temperatures	18
6. Emergence and growth of common purslane as influenced by four environments	19
7. Ethylene stimulation of dormant common purslane seed germination	20
8. Influence of Ethephon on germination of dormant common purslane seed	20
 CHAPTER 3	
1. Dry weight of onion plants grown with five densities and three durations of common purslane	32
2. Quantity of common purslane produced per hectare as influenced by density	34
3. Onion bulb yield (MT/ha) as influenced by early competition with several densities and durations of common purslane	35
4. Onion weight per bulb (g) as influenced by early competition with several densities and durations of common purslane	36

	Page
5. Onion bulb yield (MT/ha) as influenced by later season competition with several densities and durations of common purslane	37
6. Onion weight per bulb (g) as influenced by later season competition with several densities and durations of common purslane	38
7. Growth of onion as influenced by duration of common purslane competition	40
8. Light meter readings ($\mu\text{w}/\text{cm}^2$) beneath various purslane canopies	41
9. Onion seedling growth as influenced by common purslane seedlings and activated charcoal in aerated water	42
10. Common purslane seedling growth as influenced by onion seedlings and activated charcoal in aerated water	43

CHAPTER 1

GENERAL LITERATURE REVIEW

Introduction.

Common purslane (Portulaca oleracea L.), a plant naturalized from Europe, is a member of the Portulacaceae Family (41). This plant is considered a problem weed throughout the United States, particularly in intensively cropped situations. In determining the degree of weediness of a plant species, Zimmerman listed five characteristics: (A) weeds are colonizers of disturbed habitats and appear in early, successional stages. (B) weeds are introduced, not natural members of the original plant community. (C) weeds are abundant in local areas. (D) weeds are noxious, destructive, and/or troublesome organisms. (E) weeds are economically of little or no value (41). If the above definitions are accepted for describing a weed species, common purslane adequately fits into that category.

Factors which allow for rapid colonization include seed longevity, rapid plant maturation with prolific seed production, and seed germination under a variety of environmental conditions. The survival of an annual species in its habitat depends largely upon a viable seed population from year to year. Common purslane plants may produce as many as 101,625 to 242,540 seeds per plant (41). Since seed germination and dormancy factors are so important in plant establishment, a review of previous studies on these processes may provide an understanding of

why common purslane germinates and grows successfully in both competitive and noncompetitive situations.

Factors Affecting Seed Germination.

Germination experiments conducted on freshly harvested common purslane seed demonstrated its high sensitivity to both photoperiod and temperature (34). A 4 hour light exposure induced only 3% seed germination while seeds given 24 hours of light attained up to 51% germination. As temperatures were increased from 10°C to 30°C, germination increased from a low of 16% to a high of 92% respectively (43). Gutterman experimented with various light quality and photoperiodic effects on the mother plant and subsequent seed (18). Germination was dependent upon the last eight days of seed maturation. Seed dormancy has also been related to seed maturation on the mother plant, with dormant, mature black seed remaining longer on the parent plant than less dormant, immature, brown seed (11). Most experimentors agree upon the need for light in the germination of newly formed common purslane seed (1, 34, 40). Singh obtained optimum germination with alternating light and dark regimes (34). Polysome formation in common purslane seed was shown to increase in the presence of light, a factor which may be responsible for light-controlled dormancy (29). As seed age increases in the dark, light requirements diminish and percent germination increases (34).

Germination of common purslane is influenced by temperature. As temperatures are increased from 10 to 40°C, less time is necessary to reach maximum germination, and total percent germination is increased

(33). Singh noted little seed damage to a cold (-15°C) exposure of 5 days (33). Viability studies of 40 years indicate that common purslane seed is capable of remaining dormant and viable for long periods of time (8). Hopen's study demonstrated the disadvantage of smooth seedbed preparation, with plant number and fresh weight doubled when common purslane was seeded on a smooth vs a rough seedbed.

Another major factor influencing seed germination is the gaseous condition of the ambient air. Three germinating processes reported by Kato and Esashi are believed to apply to all dicot seed (24):

(A) passive water uptake; (B) anaerobic thrust (confirmed in earlier studies by Ballard which showed increased clover germination with low oxygen levels following imbibition)(2); (C) aerobic thrust, the energy from which is needed to break the seed coat. The three major gases responsible for these processes are oxygen (O_2), carbon dioxide (CO_2), and ethylene (C_2H_4). Their interactions are extremely important in the germination of both dormant and non-dormant seed. CO_2 and C_2H_4 have both been found to increase germination in subterranean clover (Trifolium subterraneum L.) and peanut (Arachis hypogaea L.) seeds, yet the gases control independent actions (14, 26). In dormant cocklebur seeds, the after-ripening effect was an activation process of the aerobic C_2H_4 producing system (17). Dormant seed contained a quasi-anaerobic C_2H_4 production system while non-dormant seed employed an additional aerobic ethylene production to stimulate seed germination. Other relationships exist between gases, but they vary among plant species (36).

Various techniques have been devised to obtain gas samples from the soil environment. The American Society of Agronomy recognizes two main methods of obtaining samples from the soil atmosphere (3). The mass flow technique samples the air by direct insertions of a hypodermic needle into the soil. Error can occur if large soil samples are removed, since the exact depth of measurements is in doubt, due to the large influx of air from the surrounding soil. The diffusion method allows for equilibrium to be reached between a fixed column and the soil atmosphere. Tackett suggested two techniques to obtain the gases by the diffusion method (37). The first was a chamber or well placed in the soil either by force or in a predrilled hole. The second method involved the insertion of a capillary gas sample probe into the soil. Most sampling techniques are modifications of the above methods. Small quantities of air removed from the soil environment can quantitatively be measured for CO₂, O₂, and other gases with the aid of gas chromatography. With knowledge of the gaseous concentrations in soils under various conditions, estimates of their effect on seed germination and dormancy can be made.

A noted success in controlling weed seed germination has resulted from treating soil with exogenous ethylene to stimulate witchweed (Striga lutea Lour.) seed germination prior to emergence of its host (12, 13). This noxious parasitic weed has been effectively controlled with this method. Olatoye and Hall (28) screened other weed species to observe the effects of ethylene on dormant seed germination. Results indicated a diversity of response between species with some seed stimulated, others inhibited, and others unaltered. No results are

available on the effects of various gas levels on common purslane seed germination. Since common purslane germinates throughout the growing season on muckland soils, a study of regulation of seed germination could provide a new management strategy for this pest.

Factors Affecting Common Purslane Growth and Development.

Studies of common purslane have included experiments on nutrient removal from the soil (21, 40, 43), chemical composition of purslane in cultivated fields (39), water requirements (4), and the effects temperature and photoperiod exert upon fresh and dry weight production (40, 43). Common purslane is considered an efficient (C-4) plant (4). As such, increased light intensities promote increased photosynthesis. The CO_2 -photosynthetic threshold value is considerably higher than for non-efficient plants. This efficiency is reflected in the low water requirement necessary to produce 1 g of dry matter. Common purslane requires 281 g of water while selected non-efficient crop plants demand up to 714 g of water to produce 1 g of dry matter (4). The mean percentage composition (air-dry basis) of common purslane indicates twice the N, P, Ca, 4 times the K, and 7 times as much Mg as a comparably grown onion plant (39). In nutrient culture, an increase in phosphorus from 0 to 60 ppm considerably increased foliage and root growth (21). The adverse effects on plant growth from the absence of phosphorus from the nutrient solution was more dramatic than removal of either nitrogen or potassium. The high nutrient content of this plant, and its palatability suggests its desirable characteristics for use as a green vegetable (31). Common purslane is completely

neutral to photoperiod for its flowering response. With longer daylengths, the quantity of dry matter produced is greater. Although rate of dry matter production increases with temperature, active plant growth occurs over a wide range of temperatures, exhibiting common purslane's great adaptability to variations in the environment (21, 34, 43).

Competitive Influence of Common Purslane with Crops.

A major concern agronomically is the competitive influence of common purslane on crop plants after establishment has occurred. Ample research is available on the competitive effects various annual weed species exert upon onion yields (5, 7, 19, 20, 22, 30, 32, 41, 42), however no data are present examining the competitive relationship between common purslane and onions (Allium cepa L.), and little data are available from muck soil studies. Common purslane has been studied in competitive situations with table beets (Beta vulgaris L.), snap beans (Phaseolus vulgaris L.), and corn (Zea mays L.) (38, 40). Results indicated common purslane control was most important during the first 2 weeks following corn, beet, and bean emergence. Control after this initial 2 week period did not increase yields. The longer that competition occurred after bean, beet, and corn emergence, the more crop yields were decreased. Common purslane was a stronger competitor in beets than in the taller, faster growing corn and bean plants. This was attributed to these crop's superior ability to compete for light, water, and/or plant nutrients.

CHAPTER 2

FACTORS INFLUENCING THE GERMINATION OF COMMON PURSLANE SEED

ABSTRACT

Freshly harvested common purslane (Portulaca oleracea L.) seed did not germinate in the dark or at planting depths of .63 cm or deeper. Two-year old seed did germinate in the dark; however, few seedlings emerged when planted deeper than 2.5 cm. As temperatures were raised from 10°C to 35°C, seed germination increased. At the higher temperatures, seedlings emerged and obtained their first true leaf in fewer days than at the lower temperatures. Germination of dormant common purslane seed stored for 2.5 months at 45°C occurred in the dark while seeds stored from 1 to 10°C did not germinate in the dark. With increasing rainfall, common purslane germination declined, CO₂ concentrations increased, and O₂ levels decreased on sandy soils. Muck soils provided similiar results, except O₂ concentrations remained relatively constant. Removal of endogenous ethylene from the seed atmosphere prevented germination, while exogenously supplied ethylene significantly stimulated common purslane germination over that of the air control. Ethephon (2-chloroethylphosphonic acid) applied to common purslane seed in petri dishes significantly increased germination; however, no stimulation occurred when seeds were treated in muck soils.

INTRODUCTION

The requirements to break seed dormancy are complex and numerous. Weed species vary in their individual needs for germination and this difference is reflected throughout plant ecosystems. Dormancy factors include seed depth, gaseous conditions, moisture and light levels, temperature and seed age. Each interacts together to allow initiation of growth.

Katoh and Esashi recognized three germinating phases for cocklebur (Xanthium pennsylvanicum Wallr.) seed, which they felt were applicable to all germinating dicot seeds (11). (A) passive water uptake, (B) anaerobic thrust, (C) aerobic thrust which provides needed energy to break the seed coat. Gases which are inextricably involved in these phases include oxygen (O_2), carbon dioxide (CO_2), and ethylene (C_2H_4). Ethylene has been shown to be directly related to seed dormancy and germination for a number of crop and weed species (6, 7, 12, 13). In Spergula arvensis L., both light and ethylene were required to germinate newly produced dormant seeds. It appeared that "light stimulated the phytochrome system and ethylene removed some inhibition to the expression of the phytochrome response"(17). Low concentrations of CO_2 stimulated small-seeded legume germination (2, 7), while interactions between O_2 , CO_2 , and C_2H_4 in cocklebur seeds remain highly temperature dependent (8, 11). Each species retains its own set of germination variables, conditions which are determined only through experimentation. An understanding of the role both exogenous and

and endogenous gases play in the germinating seed will better enable scientists to manipulate weed seed germination. Success has occurred in the case of witchweed (Stiga lutea Lour.), a problem parasitic weed throughout the Carolina's. Ethylene applied to the soil in the spring stimulated seed germination sufficiently for adequate control prior to emergence of the host crop plants (5, 6).

Dormant seeds of common purslane are known to require light for germination (1, 4, 16, 19). Egley found dormancy variations are due in part to both seed age and water content (5), while others report the necessity of high temperatures for optimum germination (1, 4, 9, 15, 16, 19).

The object of this research was to develop a more full understanding of the role ethylene exerts upon common purslane seed, and to elucidate various conditions which influence seed dormancy and germination.

METHODS AND MATERIALS

Influence of Light and Depth of Seeding. It has been previously reported that common purslane seed requires light for germination (1, 4, 16, 19). The following experiments were conducted to provide comparisons between seed harvested 2.5 years ago in August of 1974 and seed harvested in August of 1976. The 1974 seed was obtained from H. J. Hopen at the University of Illinois, while the 1976 seed was collected at the Michigan State University Muck Farm.

1976 seed was placed in 10.2 cm styrofoam pots (10/pot) containing Houghton muck soils and seeded to depths of 0, 0.6, 1.3, 1.9, 2.5, and 3.2 cm below the soil surface. The pots were then watered, covered, with plastic bags, and the seed allowed to germinate. The experiment contained three replicates of each treatment.

A similar experiment was conducted with the Illinois seed, except two additional depths of 4.4 and 5.1 cm were included in the above treatments. Both experiments were placed in a greenhouse with supplemental fluorescent lighting of 850 f.c. and a photoperiod of 16 hours. The night temperature was maintained at 15°C, and day temperatures varied from 15-30°C. Germination data were obtained 10 days after seeding.

Influence of Rainfall. Soil moisture levels are also important in controlling seed germination and the response varies with soil types. Ten common purslane seeds were covered with 0.3 cm of either Houghton muck or Bellefontaine loamy sand soils in 10.2 cm styrofoam pots. Four

rainfall treatments were imposed; 0.6, 1.3, 1.9, and 2.5 cm. The single water application was applied by a three nozzle boom sprayer fixed to an overhead motored chain. This spray unit allowed the simulated rainfall to be applied slowly by multiple passes thus preventing soil erosion and seed disturbance associated with single drench applications. The pots were subsequently covered with plastic bags to retain moisture and no further watering occurred. They were placed in the greenhouse as described previously. Germination was recorded nine days following treatment.

Gas concentrations generally follow the trend of increasing CO₂ and decreasing O₂ with increasing soil depth (10). This relationship with rainfall was examined by inserting a 2 cc syringe to either a 1.3 or 2.5 cm depth and removing a gas sample. It was analyzed for CO₂ and O₂ by injection into a gas chromatograph as described by Brenner and Cieplinski (3). Three replicate samples were obtained for each treatment.

Temperature. To determine the influence of temperature upon the germination of common purslane seed, 25 seeds were placed on wetted blotter paper, rolled, and inserted into glass tubes. The tubes were closed with rubber stoppers, and placed into water baths at various temperatures; 10, 12.8, 18.3, 23.8, 29.4, and 35°C. These temperatures were monitored continuously, and heaters utilized when necessary to maintain constant temperatures. There were two replicates. Radicle emergence was the criterion for germination.

Since temperature conditions are variable throughout the season,

controlled environmental chambers were used to simulate these differences in the following experiment. Common purslane was seeded into pots containing sterilized Houghton muck soil, and placed into one of four chambers: (A) 10-15°C (night-day temperatures respectively); (B) 15-20°C; (C) 20-25°C; and (D) 25-30°C. Each chamber maintained a 16 hour photoperiod with a light intensity of 1200 f.c. 51 cm below the light source. Measurements were recorded for number of days to emergence and appearance of the first true leaf. There were six pots within each chamber and two experimental trials.

Ethylene. Because ethylene is present in the soil environment and is implicated as a factor in germination, exogenous ethylene was applied to common purslane seed of both 1974 (Illinois) and 1976 (Michigan). Three treatments: air, with ethylene, and without ethylene, were used throughout the various experimental trials. Ethylene was removed by the addition of 3 purifill crystals per tube while treatments containing exogenous ethylene were supplied with ethylene gas in sufficient quantity to obtain the desired level of 1 ppm. Concentrations of CO_2 , O_2 , and C_2H_4 were monitored 24 hours later by removing a 2 cc sample and inserting it into a gas chromatograph to measure CO_2 , O_2 , and ethylene as reported by Brenner (3). Germination of the seed was also recorded at this time. This process was conducted in both the light and dark. The lighted chamber was maintained at a constant 25.5°C with 1000 f.c. of luminescence while the dark chamber was maintained at 25.5°C and contained a green lamp during preparation to prevent light stimulation of the seed.

Ethephon. Two experiments were conducted to determine if ethephon (2-chloroethylphosphonic acid), a chemical whose breakdown product is ethylene, would enhance germination of Michigan purslane seed. Concentrations varied from .01 to 1000 ppm. Seven milliliters of solution were added to petri dishes containing blotter paper and 25 purslane seeds. The dishes were maintained under light (1000f.c.) at a temperature of 25°C. Germination data were recorded after 5 days.

The above experiment was modified in that 25 seeds were sown on the surface of Houghton muck soil and drenched with the various concentrations of ethephon. The pots were covered with plastic bags to prevent moisture loss, and placed in a greenhouse with growth conditions as previously described.

RESULTS AND DISCUSSION

Influence of Light and Depth of Seeding. The new Michigan (1976) seed germinated only when placed on the soil surface (Table 1). At a depth of only 0.6 cm, no germination occurred. Light meter readings (Plant Growth Photometer) indicated that no light penetrated beneath 1 cm of muck soil. This indicates a light requirement in the germinating process of freshly harvested dormant purslane seed. The aged Illinois seed, however, did demonstrate limited germination at the deeper planting depths. Below the depth of 2.5 cm, little germination occurred. Hopen

Table 1.--Common Purslane Germination in Houghton Muck Soil at Various Planting Depths.

Depth (cm)	<u>% Germination</u>	
	Michigan 1976	Illinois 1974
0	100	-
0.6	0	50 bc
1.3	0	35 abc
1.9	0	30 abc
2.5	0	70 c
3.2	0	5 a
4.4	-	0 a
5.1	-	0 a

and Vengris also found few common purslane seeds germinating below 2.5 cm, indicating that a basic requirement for germination is lacking in that environment (9,18). This may involve a critical concentration of gases. The 1974 seed did lose its requirement for light stimulation, a fact also observed by previous investigators (16,18). The explanation for this phenomenon is unknown, but it appears that some light induced pathway necessary for new common purslane seed germination is bypassed as the seed ages, or is no longer necessary for germination.

Influence of Rainfall. Muck soils are characterized by a high water holding capacity, and can retain small quantities of rainfall in the uppermost layer of the soil. Sandy soils, however, are coarse textured and allow downward movement of water more rapidly. While a single application of simulated rainfall (0.6 cm) was inadequate to germinate common purslane seed on sand, it was optimal for seed germination on muck soil (Table 2). Percent germination decreased on muck soil with

Table 2.--Common Purslane Germination with Varying Rainfalls on Two Soils.

Rainfall (cm)	<u>% Purslane Germination</u>	
	Houghton Muck	Belefontaine Sand
.64	95 b	0 a
1.3	75 ab	80 b
1.9	58 a	73 b
2.5	48 a	10 a

a corresponding increase in rainfall, while optimum germination occurred at 1.3 cm rainfall on sand and declined with additional water. The decline in germination may have been due to limiting gas levels with increasing water levels. Water saturated soils may have created an oxygen deficient environment, a condition which would inhibit seed germination.

At a soil depth of 2.5 cm, CO₂ concentrations increased with added amounts of rainfall (Table 3 and 4) on both sandy and muck soils. There was no significant difference in CO₂ in muck soils at the depth of 1.3 cm for any quantity of rainfall, but CO₂ levels at 2.5 cm increased with increasing rainfall. Measurements from sandy soils at 1.3 cm showed a significant increase in percent CO₂ from 0 to 0.6 cm rainfall and a

Table 3.--Gas Concentrations in a Houghton Muck Soil as Influenced by Simulated Rainfall.

<u>Rainfall</u> (cm)	<u>Gas Concentration</u> (%)			
	CO ₂		O ₂	
	<u>Soil depth (cm)</u>		<u>Soil depth (cm)</u>	
	1.3	2.5	1.3	2.5
Air Standard	.05		22.2	
0	.08	.04	20.4	18.3
0.6	.05	.05	18.1	18.2
1.3	.07	.08	15.9	18.2
1.9	.08	.13	17.9	18.6
2.5	.07	.15	18.5	18.6

Table 4.--Gas Concentration in a Bellefontaine Loamy Sand Soil as Influenced by Simulated Rainfall.

<u>Rainfall</u> (cm)	<u>Gas Concentration</u> (%)			
	<u>CO₂</u>		<u>O₂</u>	
	<u>Soil depth (cm)</u>		<u>Soil depth (cm)</u>	
	1.3	2.5	1.3	2.5
Air Standard	.05 a		22.2 f	
0	.05 a	.05 a	21.9 ef	21.1 de
0.6	.28 c	.28 c	20.4 d	19.3 c
1.3	.13 b	.41 d	10.2 a	15.5 b

decline from 0.6 to 1.3 cm. Oxygen levels remained relatively constant throughout the muck soil experiment. However, in sandy soils there was a significant decrease in percent O₂ with increasing rainfall for either sampling depth.

The differences between soil types are reflected in the rapidity with which water movement through the soil occurs. Sandy soils allow for rapid vertical water movement which fills available pore spaces to a greater depth than muck soils which can retain small quantities of rainfall in the uppermost layer of the soils. This may account for the noticeable increase in CO₂ and decrease in O₂ associated with the sandy soil and comparably minor differences experienced on muck soil. The various gaseous conditions described here may affect purslane seed germination, with higher levels of CO₂ and lower levels of O₂ depressing germination.

Temperature. Increasing the temperature resulted in increased common purslane seed germination from a low of 24% at 10°C to a high of 78% at 35°C (Table 5). Germination was not only favored by higher temperatures, but seedlings also manifested a more rapid growth rate (Table 6). Seedlings emerged and obtained their first true leaf in fewer days with higher temperatures than did seeds grown at colder temperatures. This

Table 5.--Germination of Common Purslane Seed as Influenced by Different Temperatures.

<u>Water Temperature</u> (°C)	<u>Germination</u>
10	24 a
13	32 ab
18	56 bc
24	52 abc
30	76 c
35	78 c

suggested that common purslane will emerge early in the spring when temperatures are low (10-15°C), but that growth is favored during warm summer months (25-30°C). This data confirms Singh's and Zimmerman's earlier experiments which demonstrated increased common purslane seed emergence with increasing temperatures (16,19). Research conducted in Massachusetts showed this same trend of accelerated germination later in the season which corresponds with higher temperatures (18).

Table 6.--Emergence and Growth of Common Purslane as Influenced by Four Environments.

<u>Night/Day Temperature</u> (°C)	<u>Number of Days</u>	
	Emergence	First True Leaf
10-15	8	26
15-20	7	22
20-25	3	8
25-30	2	6

Ethylene. Freshly harvested common purslane seed did not germinate in the dark in any of the three treatments. This concurs with previous experiments demonstrating the need for light in the germinating process (4,16,19).

The absence of ethylene prevented seed germination while exogenously supplied ethylene nearly doubled germination over that of the air control (Table 7). The larger number of germinating seedlings may account for the increased CO₂ concentration in test tubes containing supplied ethylene. With respiration a primary process in seed germination, a rise in the byproduct, CO₂, would naturally occur. The concentration of CO₂ in the treatment without ethylene is comparable to levels found in the atmosphere, so the response shown is due to the absence of ethylene, not the level of CO₂. Oxygen levels, however, remained constant throughout the various treatments. This experiment clearly illustrates the need for ethylene for optimum germination of dormant common purslane seed. Common purslane can now be included among the

list of several weed species stimulated by ethylene's presence (13).

Table 7.--Ethylene Stimulation of Dormant Common Purslane Seed Germination.

<u>Treatment</u>	<u>Gaseous Concentration</u>			<u>Germination (%)</u>
	CO ₂ (%)	O ₂ (%)	C ₂ H ₄ (ppm)	
Without Ethylene	.04 a	21.6 a	0 a	0 a
Air	.15 b	21.6 a	.04 b	58 b
With Ethylene	.25 c	21.6 a	.43 c	95 c

Ethephon. Ethephon concentrations above .01 ppm significantly increased germination of common purslane seed in petri dishes (Table 8). However, this was not shown when seeds were germinated in muck soil. Muck soils

Table 8.--Influence of Ethephon on Germination of Dormant Common Purslane Seed.

<u>Ethephon Concentration</u> (ppm)	<u>Germination (%)</u>	
	Petri Dish	Muck Soil
0	23 a	33 a
.01	25 a	13 a
.1	47 b	34 a
1.0	59 b	37 a
10	87 c	44 a
1000	-	41 a

possess a high organic matter content which can adsorb and deactivate many chemical compounds. Such may be the case with ethephon applied as a drench to the soil surface. Although ethephon did not stimulate common purslane germination in muck soils, seedlings emerging from treatments containing 1000 ppm ethephon were stunted and deformed, indicative of severe ethylene injury. Ethephon may prove useful for producing other growth suppressing effects in undesirable weed species.

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CHAPTER 3

THE COMPETITIVE INFLUENCE OF COMMON PURSLANE WITH ONIONS ON MUCK SOILS

ABSTRACT

Although common purslane (Portulaca oleracea L.) occurs widely on muck soils of Michigan, the competitive influence of various densities has not been determined. Two common purslane competition studies were conducted during the summer of 1976 with seeded onion on Houghton muck soils. Three common purslane densities were established in the early competition experiment; 58, 153, and 463 per m². Durations of competition were 0, 10, 20, 30, and 40 days with common purslane, after which the plots were kept weed-free. The late competition experiments imposed densities of 44, 95, and 115 /m², and five durations: weedy throughout the season, and 10, 20, 30, or 40 days weed-free after which the common purslane populations were allowed to become established.

A high density (463/m²) early in the season could be tolerated for a period of only 20 days without decreasing onion yields. Durations of 30 days with a common purslane density of 153/m² and 40 days at the low density of 58/m² also reduced yields. If onions were kept weed-free for a period of 10 days before common purslane was allowed to emerge, no decrease in onion yields occurred from competition within the 40 day period studied. However, onion yields were significantly decreased for all common purslane densities when

the weed was left in the plots for the entire season. Common purslane height increased with a corresponding increase in density, and taller plants decreased light penetration to the soil surface. Evidence suggested an enhancement of onion growth when onion and common purslane plants are grown together at early stages.

INTRODUCTION

Common purslane (*Portulaca oleracea* L.) is a problem annual weed in onion (*Allium cepa* L.) fields in muck soils throughout Michigan. It was noted by Vengris in 1953 to be the second most important weed in onions grown throughout the U.S. (8). Common purslane is included among Blacks list of efficient plants (1). In terms of photosynthesis, this implies an increase in carbon fixation with increasing temperature or light. It has an extremely low CO₂ compensation point and has been classified as a C-4 plant (1). When examining water requirements, common purslane requires only 291 g of water to produce 1 g of dry matter, a quantity half that of many C-3 plants (1). Common purslane has also been found to accumulate 2 to 7 times the amount of N, P, K, Ca, and Mg (% dry weight composition) when compared with onion plants at bulb maturity (8). All these factors point to an excellent competitor, one which will exert a strong influence upon crop species. These findings, along with Zimmerman's (12) which show purslane to grow rapidly at varying temperatures, light regimes, and moisture levels, indicate that common purslane should be a formidable competitor on muck soils.

Various onion-weed competition studies have been conducted over the past twenty years to determine the effect of several weed species on yield. Some experimenters indicate that fields must be maintained weed-free for the total season to maximize yields (7, 10, 21). This contrasts with research by Hewson and Roberst which indicates a "critical period" 6 to 8 weeks following 50% onion emergence at which

time the crop must be kept weed-free (4). Weeds may be allowed to grow on either end of this "critical period" without adversely affecting yields. It appeared that early competition was detrimental to onion yields in experiments conducted by Shadbolt et.al. (2, 3, 8). Since onion growth is slow initially, this may explain the above findings (5). Early competition causes early bulb formation which inhibits further leaf formation (7). Hewson and Roberts found that onion plants must be kept weed-free during the development of the third true leaf to obtain maximum yields (4). Perhaps the detrimental effect which weeds exert upon onion plants early in the season involves some important physiological process that occurs during the development of the third true leaf. For instance, this may be the crucial time for bulb development processes which will ultimately determine yield.

Since common purslane is a problem weed in onions, and no competition data are available from muck soils, the following experiments were conducted to determine the effects different densities of common purslane and removal dates exert in this crop ecosystem.

MATERIALS AND METHODS

Greenhouse Competition Experiment. A preliminary greenhouse onion-purslane competition experiment was initiated in October of 1975. 0.1 m² flats were filled with Houghton muck soil and seeded with both onion, cv. 'Spartan Banner' and common purslane. Two rows of onions (12 plants per row) spaced 15 cm apart, were seeded into the flats on October 14. On this same date, purslane seed was added to obtain final purslane densities of 9, 18, 36, 72, and 144 plants per 0.1 m² (per flat). Purslane seed used in the experiment was obtained from H. J. Hopen at the University of Illinois. Adequate moisture levels were maintained throughout the experimental period by hand watering. The greenhouse minimum night temperature was 12.8°C. Supplemental lighting consisted of 850 f.c. of illuminance supplied on a 14 hour photoperiod for 2 weeks followed by a 16 hour photoperiod for the remainder of the experiment.

The treatments included 5 purslane removal dates; 2, 3, 4, 5, and 6 weeks with purslane, and a weed free control. This completely randomized block design experiment contained three replicates. Onions were harvested on December 2, and the plant numbers, and fresh and dry weights recorded. Analysis of variance and Duncans multiple range tests were performed on the data.

Field Competition Experiment. There were two onion-purslane experiments conducted simultaneously at Michigan State University Muck Farm. The onions, cv. 'Spartan Banner' were machine planted on May 27, 1976

in 53 cm rows with a "Planet Junior" seeder. There was sufficient indigenous purslane seed in the soil to insure adequate stands. Fertilizers were broadcast prior to planting and the insecticide Diazinon (0,0-diethyl 0-(2-isopropyl-6-methyl)-4-pyrimidinyl)phosphorothioate) was applied at planting and throughout the season on a regular spray program to control onion maggot. Herbicides nitrofen (2,4-dichlorophenyl p-nitrophenyl ether) and dichlofop-methyl (methyl-2-(2,4-dichlorophenoxy)phenoxy propanoate) were utilized when needed to control purslane and annual grasses respectively. A completely randomized block design with 5 replicates was used in both experiments. Each 2.3 m^2 plot contained three onion rows with a 27.9 cm alley separating adjacent plots and a .75 m alley separating adjoining plots. Overhead sprinkler irrigation was supplied when necessary to maintain adequate moisture levels. Purslane emergence was first observed on June 3.

The first experiment was designed to achieve three purslane densities; 10, 100, and a natural population/ m^2 , 5 durations of competition, and 5 replicates. The weed removal dates included 0, 10, 20, 30, and 40 days with purslane following which time the purslane was removed and the plots kept weed-free. The various purslane densities were maintained at their designated numbers and other weed species were removed by hand weeding and hoeing.

At each date for weed removal, four 0.1 m^2 areas were staked per plot, numbers of purslane counted and removed, and the appropriate data recorded. Following the 40th day, the experimental plots were sprayed with nitrofen at 2.18 kg/ha when needed to control emerging

purslane and other broadleaved weeds.

The second experiment also imposed 3 purslane densities and 5 replicates, but the durations were altered as follows: weedy throughout season, 10, 20, 30, and 40 days weed-free followed by purslane establishment. Due to their maturity, purslane plants from the weedy plots were harvested on August 30th. The remainder of the plots were harvested on September 13-15. Four random 0.1 m^2 sections were once again selected from each plot to determine the actual purslane populations. All the common purslane shoots were removed from each plot, and fresh and oven-dry weights recorded. The onions from both experiments were harvested on September 30th. Total onion bulb weight and weight per 100 bulbs were determined.

During the course of the growing season, quantitative differences in light quality within the canopy were measured. The Plant Growth Photometer light meter measured the Blue, Red, and Far-Red spectrum in microwatts/cm². The data were collected for plots with various weed densities. Other observations included determinations of purslane height, onion height, and number of onion leaves per plant. Two plots containing undisturbed, natural weedy vegetation were harvested and the species identified, numbers noted and weights recorded. This provided an estimate of the distribution and density of weeds within this plot area.

Onion-Purslane Seedling Interactions. To provide an indication of growth stimulation or depression of purslane and onion seedlings grown in concert, the two species were germinated together in the

presence or absence of activated charcoal as an adsorbant.

Flasks were filled with 200 ml of distilled water and attached individually to a continuous aeration system. To half the flasks, .04 g of activated charcoal was added. The six treatments included; onions alone, purslane alone, onion + purslane, purslane + charcoal, onion + charcoal, and onion + purslane + charcoal. In each case, 10 seeds of onion (cv. Spartan Banner) and/or 10 seeds of common purslane were added to each flask. This completely randomized block design included 4 replicates. Growth measurements were taken 7 days after planting.

RESULTS AND DISCUSSION

Greenhouse Competition Experiment. Dry weight data of onions associated with five purslane densities and three durations were extremely variable (Table 1). Although many of the treatments were not significantly different from the weed-free control, 2 and 4 weeks with a purslane density of 170 plants/m² or 6 weeks with a density of 90 plants/m² seemed to enhance onion growth. Densities of up to 650 plants/m² were tolerated

Table 1.--Dry Weight of Onion Plants Grown with Five Densities and Three Durations of Common Purslane.

Purslane Density (plants/m ²)	Onion Dry Weight (g/m ²)		
	2 wks	4 wks	6 wks
0 Weed-free	3.5 abc	3.5 abc	3.5 abc
90	4.0 bc	3.5 abc	4.3 c
170	4.4 c	4.7 c	3.7 abc
360	3.9 abc	4.0 abc	3.8 abc
650	3.5 abc	4.0 abc	3.7 abc
1250	2.9 ab	2.7 a	2.7 a

throughout the six week experimental period without decreasing growth. These were unexpected findings since several previous competition studies with onion indicated a corresponding growth or yield decrease when other weeds were present (3,4,7,11). These results may differ from those in the field experiments because of unfavorable growth conditions in the

greenhouse during fall and winter. Cool night temperatures slow the growth of purslane according to both Hopen and Zimmerman (6,12). Light intensities and light quality were also considerably inferior to that of summer field conditions on muck soils. Moisture may also have been less limiting than in the field. Also to be considered is the restriction imposed upon the root systems of both crop and weed species by the potting containers. This would limit root extension, nutrient availability, and water movement. The factors mentioned above are always of concern when experiments are conducted in winter greenhouse settings, and are particularly important in plant competition work. Other than to show general trends, competition data collected under these conditions are probably not definitive.

Due to the findings of apparent increased onion growth with purslane, two large field experiments were initiated the following; the results of which are presented in the following section.

Field Competition Experiment. Purslane produces prolific growth on muck soils, as indicated by the mass computed on a per hectare basis (Table 2). These results were compiled from plots containing purslane and onions throughout the season. Higher yields could be realized if two generations were produced per year in a crop or weed-free environment and if harvests were performed before physiological maturity and senescence occurred.

The desired purslane densities were 10, 100, and a natural population per m^2 . The actual levels obtained were 58, 153, and 463 plants/ m^2 for the early competition experiment, and 44, 95, and 115 common purslane plants/ m^2 for the late competition experiment.

Table 2.--Quantity of Common Purslane Produced per Hectare as Influenced by Density.

Plant Density (plants/m ²)	Fresh Weight (MT/ha)
44	17.52
95	24.43
115	23.87

This discrepancy is due to the large quantity of germinating seedlings associated with each rainfall. Although volunteer plants were removed at weekly intervals, small seedlings emerged and were included with the large purslane plants at the time for weed removal. They contributed little to the fresh weight harvested per plot, but their numbers were included in the above plant density averages.

There was a general pattern of decreasing weight per plant with increasing plant density. This has been found true in a number of other cases where space was limiting to weeds or crops. When factors necessary for optimum growth become limiting, there is a resulting decrease in plant size.

Onion Results. To determine the competitive effect of common purslane on onion yields and size, weights were recorded for both total onion bulbs produced and for 100 bulbs. The first experiment imposed early purslane competition from 10 to 40 days after planting. Twenty days

with the lowest purslane density of 58 plants/m² provided an apparant increase in onion yields while a 40 day duration provided yields comparable to the weed-free control (Table 3). The onion plants were capable of withstanding competition of 20 and 10 days with purslane densities of 153 and 463 plants/m² respectively, without decreasing yields. With longer durations of competition, yields were significantly decreased. The same trends occurred for bulb size (Table 4).

Table 3.--Onion Bulb Yield (MT/ha) as Influenced by Early Competition with Several Densities and Durations of Common Purslane.

Days with Purslane after Onion Planting	Purslane Density (plants/m ²)		
	58	153	463
0	24.3 b	24.3 b	24.3 b
10	26.6 b	22.9 b	27.0 b
20	29.4 b	24.2 b	10.7 a
30	25.1 b	10.3 a	7.0 a
40	22.1 b	7.7 a	4.0 a

Low purslane densities did not significantly alter bulb weight over the 40 day experimental period when compared to the weed-free control. There were, however, noticeable declines in bulb weight after a 10 day period with weed pressure from purslane densities of 463 or 20 days with 153 plants/m². These yield data suggested a slight stimulatory effect of common purslane on onion growth early in the growing season.

Table 4.--Onion Weight per Bulb (g) as Influenced by Early Competition with Several Densities and Durations of Common Purslane.

Days with Purslane after Onion Planting	Purslane Density (plants/m ²)		
	58	153	463
0	81.7 d	81.7 d	81.7 d
10	72.6 d	81.7 d	86.3 d
20	82.3 d	63.6 cd	45.4 bc
30	68.1 d	40.9 ab	36.3 ab
40	77.2 d	31.8 ab	22.7 a

This agrees with the results obtained with low densities in the greenhouse.

The second experiment involved maintaining the plots weed-free for various lengths of time at the beginning of the season. The only treatment which significantly decreased onion yields was purslane competition throughout the season (Table 5). A 40 day weed-free period in early season followed by the lowest purslane density of 44 plants/m² produced the highest yields. The comparable initial weed-free periods to obtain optimum onion yields for purslane densities 95 and 115 plants/m² were 30 and 20 days respectively. These data suggested once again a stimulatory effect of low purslane densities on onion growth. The presence of 44 plants/m² after 10 days enhanced onion yields over that obtained with 115 plants after 10 days and appeared to exceed that of the weeded control.

Table 5.--Onion Bulb Yield (MT/ha) as Influenced by Later Season Competition With Several Densities and Durations of Common Purslane.

Days Weed-Free Prior to Purslane Establishment	Purslane Density (plants/m ²)		
	44	95	115
0	11.5 b	4.6 ab	1.6 a
10	28.5 cd	25.3 cd	23.4 c
20	30.9 cd	31.4 cd	30.0 cd
30	31.2 cd	31.8 cd	25.2 cd
40	33.7 d	28.8 cd	22.1 cd
Weed Free		24.3 cd	

Similar results were obtained for onion weight per bulb (Table 6). Purslane competition during the entire season decreased onion bulb weight 3 to 5 times depending upon densities; however, a period of 10 days with weed-free growth allowed for optimum yields. With purslane, there was no single "critical period" as Hewson and Roberts suggested for maximum onion yields (5). The period varied in these experiments in relation to the various purslane densities. At the lower densities, yields were often higher than the weed-free control and no yield decreases were noted when competition was imposed throughout the 40 day experimental period. As the early common purslane densities increased, the weed-free time period needed to maximize yields increased.

Table 6.--Onion Weight per Bulb (g) as Influenced by Later Season Competition with Several Densities and Durations of Common Purslane.

Days Weed-Free Prior to Purslane Establishment	Purslane Density (plants/m ²)		
	44	95	115
0	59.0 b	27.2 a	13.6 a
10	99.9 c	86.3 c	86.3 c
20	90.8 c	95.3 c	99.9 c
30	127.1 d	104.4 cd	90.8 c
40	104.4 cd	99.9 c	99.9 c

There may be several reasons for the apparant higher yields associated with small densities of purslane. Weekly weed removal of volunteer purslane in and around the weeded plots may have hindered the production of or damaged the lateral roots and subsequent yield. This may also have accounted for the inability of the onion plants to recover following removal of high purslane densities after a number of weeks. Small quantities of purslane which lay prostrate may provide a moisture seal for retention of ground water during hot summer days. They may also provide a cooler microclimate on extremely hot days by preventing absorption of heat by exposed soil. This could be of great benefit to onion plants in close proximity with purslane as compared to onions grown in weed-free plots. It is also possible

that common purslane exudes or removes some factor which subsequently increases growth. Rhodes and Gerdemann (8) demonstrated an increase in P uptake with mycorrhizal vs non-mycorrhizal onions. Perhaps purslane is responsible for a stimulation of mycorrhizal activity in the soils with a resulting increase in onion growth due to a greater capacity for nutrient uptake.

Other Field Observations. When considering the competition exerted by common purslane on onion plants, direct effects on onion growth at earlier stages were also measured. Data obtained 2.5 months after emergence show a general trend of increasing plant height with increasing periods of initial weed-free growth (Table 7). This same trend occurred with the numbers of onion leaves produced per plant. The longer the plots remained weed-free early in the season, the greater the number of onion leaves present. Purslane height was also found to be affected by its density. In one experiment, a range in purslane height was noted from a low of 17.8 cm for densities of 44 plants/m² to 25.4 cm for densities of 95 plants/m² and finally a high of 30.5 cm for the highest purslane density of 115 plants/m². Common purslane has a prostrate growth habit only at low plant densities. For this reason, it should be considered to exert some shading effect on crop plants when present at high densities. Vengris et al. (10) found common purslane height was also influenced by photoperiod, with a 16 hour light period creating an upright 19 cm plant vs a 6.1 cm prostrate plant grown in a 12 hour photoperiod. Since these plants were grown under one photoperiod, the height difference was probably due to the

to the limited growth space available and competition for light.

Table 7.--Growth of Onion as Influenced by Duration of Common Purslane Competition.

Days Weed-Free Prior to Purslane Establishment	Average Onion Height (cm)	Average Number Onion Leaves
0	28	3.5
10	53	5.5
20	56	8.0
30	71	8.5
40	58	10.0

To measure shading effects, light meter readings were obtained on August 18 comparing differences in Red, Far-Red, and Blue wavelengths intercepting the soil surface (Table 8). The taller purslane plants, allowed less light to penetrate to the soil surface. There was an average three fold decrease in light penetration between purslane plants 6.4 cm tall and plants 30.5 cm tall. This shading could greatly hinder the photosynthetic ability of the crop species particularly in their early stages of establishment. Further research should be initiated to determine the degree of shading common purslane may exert upon onion plants. Where perhaps it was once considered to be of little concern, these results suggest it could contribute to the competitive

influence of the weed particularly at higher densities early in the season.

Table 8.--Light Meter Reading (uw/cm^2) Beneath Various Purslane Canopies.

Wavelengths	Full Sunlight	Purslane Height (cm)				
		6	9	15	20	31
Blue	150	20	5.4	3.7	1.7	1.4
Far-Red	120	8.2	27	7.6	5.5	6.2
Red	175	4.5	3.7	2.9	1.9	1.6

In natural non-cultivated competitive situations on muck soils, common purslane would not become a dominant species. Appendix 1 provides a listing of the weed species/ 0.1 m^2 found in undisturbed plots expressed in both density and weight. Ladysthumb Smartweed (Polygonum persicaria L.) and Redroot Pigweed (Amaranthus retroflexus L.) exerted severe competition on both onion and purslane due to their abundance and height. This resulted in small, etiolated crop and purslane plants. Zimmerman's experiments on purslane shading showed it to be a very shade-susceptible plant; maturity was delayed, yields decreased, and seedling germination diminished (13). This suggested that while common purslane is an active competitor in cultivated unshaded areas, undisturbed plots provide an ideal situation for taller weed species to predominate.

Onion-Purslane Seedling Interaction. Both common purslane and activated charcoal appeared to stimulate onion growth (Table 9). When the three (onion, purslane, and charcoal) were combined, no growth increase was realized. Activated charcoal may inactivate inhibitors present in the onion or growth promoting substances released by purslane.

Purslane growth, however, was enhanced with all three treatments (Table 10). Activated charcoal substantially increased purslane seedling length perhaps by tying up some natural growth inhibitor. The addition of onion seed also enhanced purslane growth.

An increase in onion growth with low densities of common purslane was demonstrated in both the greenhouse and field experiments as well as in these short term tests. Some mutually beneficial stimulus must be present to cause growth stimulation in both species. This area should receive an intensive research effort.

Table 9.--Onion Seedling Growth as Influenced by Common Purslane Seedlings and Activated Charcoal in Aerated Water.

Treatment	Seedling length (cm)			
Onion	2.9			
Onion + Purslane	3.5			
Onion + Charcoal	3.5			
Onion + Purslane + Charcoal	2.9	L.S.D. 5% N.S.		

Table 10.--Common Purslane Seedling Growth as Influenced by Onion Seedlings and Activated Charcoal in Aerated Water.

Treatment	Seedling length (cm)
Purslane	.6
Purslane + Onion	1.1
Purslane + Charcoal	1.4
Purslane + Onion + Charcoal	1.8
	L.S.D. 5% .27
	L.S.D. 1% .39

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APPENDIX

APPENDIX

Table 1.--Weed Species Located in Undisturbed 0.1 m² Plots.

SUNLIGHT CONDITIONS			
Weed Species	Fresh wt (kg)	Number of plants	Height (m)
Ladysthumb Smartweed (<u>Polygonum persicaria</u> L.)	13.2	176	1.3
Redroot Pigweed (<u>Amaranthus retroflexus</u> L.)	4.1	48	1.2
Common Purslane (<u>Portulaca oleracea</u> L.)	2.0	43	Ground Level (G.L.)
Onion (<u>Allium cepa</u> L.)	.06	31	G.L.
Large Crabgrass (<u>Digitaria sanguinalis</u> L. Scop.)	.03	14	G.L.
Shepherdspurse (<u>Capsella bursa-pastoris</u> (L.) Medic.)	.03	5	G.L.
Mouseear Chickweed (<u>Cerastium vulgatum</u> L.)	.03	2	G.L.
PARTIAL SHADE			
Common Purslane	.3	84	G.L.
Onions	.1	48	G.L.
Ladysthumb Smartweed	5.4	44	1.8
Redroot Pigweed	7.3	30	1.8
Assort. Cruciferae	.6	-	G.L.
Large Crabgrass	.9	7	G.L.

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