AN ABSTRACT OF THE THESIS OF

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(Name of student) (Degree)

in Horticulture presented on May 6, 1971
(Major) (Date)

Title: INTERACTION OF CROP PLANT POPULATION WITH WEED COMPETITION IN CORN (*Zea mays* L.), BUSH SNAP BEANS (*Phaseolus vulgaris* L.), AND ONION (*Allium cepa* L.) AT DIFFERING STAGES OF DEVELOPMENT

Abstract approved:
Dr. Garvin Crabtree

Yield reductions due to competition of weeds with crop plants can be extremely important. Early weed competition can be as important in reducing crop yield as weed competition for the entire season.

The objectives of this study were (1) to determine the weed control achieved by narrow row-cropping patterns, (2) to measure the competitive effect achieved with narrow row-cropping patterns, with low photosynthetic capacity crop plants or with high photosynthetic capacity plants, in competition with high photosynthetic capacity weeds, (3) to determine at what time weed control becomes important and (4) to determine if the time at which competition begins

could be determined by change in weight, sugar content, and/or nitrogen content of the commercial crop. Also, two greenhouse studies were made to evaluate the differential uptake of nitrogen by two competiting species, corn (*Zea mays* L.) and pigweed (*Amaranthus rectroflexus* L.), and to evaluate the effect of competition for soil and light between two broadleaf species, snap beans and pigweed.

Yields of bush snap beans (*Phaseolus vulgaris* L.), corn (*Zea mays* L.), and onion (*Allium cepa* L.) were all decreased significantly by the presence of weed competition throughout the entire growing season. Reduction in total area occupied by an individual crop plant resulted in decreased effects on vegetative and reproductive parts due to weed competition and increased the effect of crop plant-to-plant competition. Early weed control was important in all crops. In 1969, yield reductions in corn and beans allowed to compete with weeds for a period of five to six weeks after crop emergence were equal to those from plots with weed competition for the entire season. In 1970, corn required two weeks of cultivation after emergence and snap beans required three weeks of cultivation after emergence to decrease losses due to weed competition. Weed weight yields were significantly reduced in snap beans at the 5 x 5 inch spacing when compared to the 15 x 5 and 35 x 5 inch spacings.

As measured by leaf fresh weight, competition was determined to begin between snap beans and redroot pigweed at 36 to 44 days after crop emergence at crop plant spacings of 35 x 5 and 15 x 5 inches. Significant weed competition did not develop after 51 days at crop plant spacings of 5 x 5 inches. Competition between corn and redroot developed 41 days after emergence for all plant spacings.

This study indicated the time at which competition between crop and weeds could be determined by leaf fresh weight measurements or by measuring the leaf area of the crop plants.

At a fertilizer rate of 77-101-64 pounds of N-P-K per acre, corn made greater gains in total green weight than did pigweed in the greenhouse. However, with the further addition of 300 pounds of ammonium nitrate per acre, pigweed continued to make gains while corn growth was unaffected. At all fertility rates, pigweed had higher levels of total leaf nitrogen than corn.

When snap beans had emerged and become established before the emergence of pigweed, the total green and dry weight of pigweed was significantly reduced if growing in full competition or in competition for soil factors only.

Interaction of Crop Plant Population with Weed Competition in Corn (*Zea mays* L.), Bush Snap Beans (*Phaseolus vulgaris* L.), and Onion (*Allium cepa* L.) at Differing Stages of Development

by

Clarence Frank Williams

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

June 1971

APPROVED

Associate Professor of Horticulture
in charge of major

Head of Department of Horticulture

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Date thesis is presented May 6, 1971

Typed by Maryolive Maddox Clarence Frank Williams

ACKNOWLEDGEMENTS

Sincere appreciation is expressed to Dr. Garvin Crabtree, my major professor, for his many hours spent in direction, suggestions and personal consideration which made the completion of this study possible.

To Dr. Harry H. Mack of the Horticulture Department for his direction in this study and guidance as a committee member.

To Dr. William Chilcote of the Botany Department, Dr. Roger Petersen of the Statistics Department, and Dr. R. Quatrano of the Botany Department for their suggestions and guidance as committee members.

Alvin Mosely for his encouragement, suggestions and help in the study.

To Karilyn, my wife, for her unending support for which words cannot be found to fully express.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

INTERACTION OF CROP PLANT POPULATION WITH WEED COMPETITION IN CORN (*Zea mays* L.), BUSH SNAP BEANS (*Phaseolus vulgaris* L.), AND ONION (*Allium cepa* L.) AT DIFFERING STAGES OF DEVELOPMENT

INTRODUCTION

There is a strong movement in agriculture today to re-evaluate the standard "row crop" pattern. The old system of the wide row is now giving way to the narrow-row, high-density plant population pattern of planting. Many workers (Mack and Hatch, 1968; Lehman and Lambert, 1960; Nunez and Kamprath, 1969) have indicated that narrow rows with direct seeded crops planted on the square have increased yields.

Bleasdale (1963) suggests, that the advancements of new chemicals that can provide a weed-free environment for the growing of vegetable crops has freed us from the economics of producing these commodities in a wide-row cropping pattern. Frans (1970) states that it was commonly accepted that soybeans were grown first in this country by planting them with a conventional grain drill. However, inability to control weeds effectively under this system was probably responsible for the shift to wider rows, which made cultivation more efficient.

Effective control of infesting weeds becomes one of the largest cost items in crop production. Furtick (1967) presented data showing that the annual loss due to weeds and the purchase of herbicides for their control amounted to 5.06 billion dollars in the United States in 1965. Weed control becomes important due to many factors. Among these are: Production of an alternate host for disease and insects which affect the commercial crop, loss in yield due to direct competition with the commercial crop, and a reduction in product quality.

To enable one to understand more about weed control, two factors may be considered; the first, at what period competition becomes most important in creating production losses, and the second, what factors make it possible for the weed to compete with the commercial crop.

The duration of competition seems to be very important, as does the time of weed seed emergence in comparison to that of crop seed emergence. Knake and Slife (1969) indicated that early competition of giant foxtail (Setaria faberii Herrm.) or until the weed become 9-12 inches high has little effect on corn (Zea mays L.) or soybeans (Glycine max L.). Buchanan and Burns (1970) suggested that when initial weed control measures were delayed six to seven weeks in one test and four to five weeks in another, cotton was not injured. Both workers, however, pointed out that entire season competition resulted in yield reduction.

On the other hand, many suggest that early weed removal becomes very important. Burnside and Wicks (1969) indicated that delaying weed removal three weeks caused a significant sorghum (*Sorghum vulgare* Pers.) yield reduction, but that after four weeks of weed-free environment there was no reduction in yield. Dawson (1964) observed that a weed-free environment in field beans (*Phaseolus vulgaris* L.) must be maintained for five to seven weeks. Müzik (1970), in listing general rules about competition between crop and weeds, stated that competition becomes most severe when the crops are young, i.e., within the first six to eight weeks.

The time of weed seed germination in relation to that of the crop becomes an important factor. Burnside and Wicks (1969) observed that weeds emerging four weeks after planting did not reduce sorghum yields. Nelson and Nyland (1962) indicated that mustard (*Brasssica hirta* Moench.) emergeing three days before peas reduced the fresh weight of the vines by 54 percent, those emerging a short period after emergence of the crop reduced the fresh weight of vines by only 17 percent. Knake and Slife (1965) showed that small amounts of giant foxtail seeded three weeks after planting were not competitive with corn despite the fact that giant foxtail produced 500 pounds of dry matter per acre. In sorghum, when weed emergence took place near the time of crop emergence, weeds produced greater competition than those that germinated one to two months later (Wiese et al., 1964).

Also important are the weed species and crop combination.

Various experiments have shown that for some weed species a sparse stand may have as great an effect on crop yield reductions as a dense one. Swan and Furtick (1962) found that one plant of coast fiddleneck (Amsinckia intermedia F. and W.) per square foot reduced yield by ten bushels per acre in wheat. Gruenhagen and Nalewaja (1969) indicated that five to ten wild buckwheat (Polygonum convolvulus L.) plants per square foot decreased yields in flax (Linum usitatissiumum L.) as much as did heavier densities. Wild buckwheat utilized both soil moisture and nitrogen for growth more efficiently than the flax. On the other hand, Dawson (1964) observed that relatively light stands of barnyard grass (Echinochlora crusgalli (L.) Beauv.) were tolerated up to eight weeks in beans before yield reduction occurred.

Before discussing how a weed species may compete with a commercial crop, it may be worthwhile to state what is meant by the competitive ability of a plant. The meaning to be applied here will be the ability of the undesirable plant to successfully infest the cultivated crops with a resulting reduction of growth in the cultivated crop.

Plant competition may be divided into two major types or classifications: "biochemical" and "physical".

The biochemical basis was proposed by Black, Chen and Brown (1969). They divided plants as to their competitive ability on the method of CO_2 incorporation. Plants that have the C_4 cycle proposed by Hatch and Slack (1968) are considered efficient, or those having a capacity to photosynthesize at a high rate, and are classified as highly competitive. These species have a high light intensity saturation point, show less high temperature response, seem little affected by high oxygen concentration, have a low detectable photorespiration and have a low photosynthetic CO_2 compensation concentration. Many of the common weeds which present the greatest problem to agriculture fall into this category. Those with the Krebs cycle of CO_2 incorporation are considered nonefficient or have a capacity to photosynthesize at a low rate. These species have a low light intensity saturation point, show reduced photosynthesis at high temperature and high oxygen concentrations, and have a high photorespiration. Classified in this group are most of our commercial vegetable varieties which show little ability to compete.

The second classification, the physical basis, is the competing of the weed species and the commercial crop for light, nutrients, space, and moisture. Knake and Slife (1969) suggested that foxtail had little effect on soybeans until the weed species overtopped or grew taller than the soybeans and competition for light occurred. Bandeen and Buchholtz (1967) indicated that addition of N and K_2O slightly reduced the competitive effect of quackgrass (Agropyron repens Beauv.) upon corn. Staniforth (1957) suggested that corn yield reduction due to annual greass weeds was decreased with the addition of nitrogen. Many times, however, higher soil nutrient content favors the weed rather than the crop (Muzik, 1970; Vengris, Colby and Drake, 1955; and Peters and Yokum, 1961).

Soil moisture is an important factor in competition. Feltner, Hurst and Anderson (1969) indicated that the more moisture present, the greater the effect of yellow foxtail (*Setaria lutescens* Hubb.) on the reduction of sorghum growth. Nitrogen fertilizer application greatly reduced the competition of foxtail with corn, particularly when soil moisture was limited for extended periods during mid-summer (National Research Council, 1968 p. 6-36). Others (Gruenhagen and Nalewaja, 1969) observed that high moisture produced more competition between wild buckwheat and flax.

Undesirable plants or weeds become established many times where soil is left exposed, as in the standard row-cropping system. This inefficient use of land is what is being re-evaluated in the move to narrow rows and higher plant densities made possible by new developments in weed control. The use of narrower row spacing and higher plant densities may change the ability of many commercial vegetable crops such that they may aid in the control of infesting weeds.

Many research workers have indicated that chemical weed control was enhanced when used in combination with narrower rows and a high plant population as compared to the standard-width row (Burnside and Wicks, 1969; Marx and Hagedorn, 1961; Wiese, Collier, Clark and Havelka, 1964; Wax and Pendleton, 1968). Frans (1970) showed that when soybeans were planted in seven-inch rows, there was little difference in yield between cultivated (39 bu/A) and non-cultivated (37 bu/A) plots. On the other hand, soybeans, when planted with 35 inches between rows, produced 50 bu/A in cultivated plots and 42 bu/A in non-cultivated plots. Peters et al., (1965) indicated that soybeans in 20- and 24-inch rows usually required only one cultivation when herbicides were used, while those in 32- and 40-inch rows usually needed at least one or two for good weed control and high yields. Other workers (Kurst and Smith, 1969; Wax and Pendleton, 1968; Hammerton, 1970) suggested that herbicides were more effective when used in combination with narrow spacing.

To better evaluate the effect of narrow row-cropping patterns on weed control, the following objectives were undertaken: (1) to determine the weed control achieved by narrow row-cropping patterns, (2) to determine what effect narrow row-cropping patterns of low photosynthetic capacity (bean) and high photosynthetic capacity (corn) vegetable crops would have on their competitive ability with a high photosynthetic capacity plant such as redroot pigweed (Amaranthus retroflexus L.), (3) to determine at what period weed control would become important and (4) to determine if the period at which competition begins could be ascertained by change in weight, sugar content and/or nitrogen content of the commercial crop in competition with pigweed. Also, two studies in the greenhouse were undertaken to evaluate the differential uptake on nitrogen by two competing species, corn and pigweed, and the effect of competition for soil constituents and light between two broadleaf species, snap beans and pigweed.

INTERACTION OF SPACING WITH WEED COMPETITION IN CORN, SNAP BEANS, AND ONION

Abstract

Yields of bush snap beans (*Phaseolus vulgaris* L.), corn (*Zea mays* L.), and onion (*Allium cepa* L.) were all decreased significantly by the presence of weed competition throughout the entire growing season. Reduction in plant spacing resulted in decreased effects on vegetative and reproductive crop plant parts due to weed competition in comparison to the wider row spacings. Early weed competition was important in all crops. Corn required two weeks of cultivation after emergence and bush snap beans required three weeks of cultivation after emergence to decrease losses due to weed competition. Weed weight yields were significantly reduced in bush snap beans at the 5 x 5-inch spacing when compared to the 15 x 5- and 35 x 5 inch spacings.

Introduction

New and more effective weed control methods have made it possible to re-evaluate planting of vegetable crops in the row spacings used in the past to control weeds. Bleasdale (1963) has suggested that the development of an almost weed-free environment for growing of vegetable crops has freed us from the economics of producing these commodities in wide-row patterns.

Variations in weather, soil condition, or inadequacy of available chemicals, may make complete weed control unattainable. Many workers (Burnside and Wicks, 1969; Marx and Hagendorn, 1961; Wax and Pendleton, 1968) have indicated that weed control practices may be more effective when crops are planted at narrower row spacings than when planted at the standard row spacings. It has also been suggested by others (Kurst and Smith, 1969; Wax and Pendleton, 1968; Hammerton, 1970) that when herbicides which have not accomplished complete weed control were used in combination with narrow row planting patterns, the weed control was enchanced over that of the standard width spacing.

Frans (1970) indicated that soybean yields in uncultivated plots were reduced by only two bu/A when compared to cultivated plots if both were planted with only seven inches between rows; however, the yields for soybeans were decreased by eight bu/A on non-cultivated plots when compared to cultivated plots when both were planted at the standard 35 inches between rows. Peters et. al., (1965) observed that soybeans in 20 and 24 inch rows usually required only one cultivation when herbicides were used, while those in 32 and 40 inch rows usually needed at least one or two cultivations for good soybean yields.

The objectives of this two-year study were to evaluate the interaction of weed competition and the effect of weed removal at differing stages of growth on corn (Zea mays L.), snap beans (Phaseolus vulgarus L.), and onions (Allium cepa L.), at different row spacings.

Materials and Methods

The field trials were located at the Oregon State University Vegetable Research Farm at Corvallis on a Chehalis silty clay loam soil, a recent alluvial type. All crops were planted with a Stanhay precision seeder.

1969 Field Plots

Fertilizer, at a rate of 51 lbs N, 67 lbs P, and 42 lbs K per acre, was disked in prior to planting. An additional 26 lbs N, 34 lbs P, and 21 lbs K were banded at the time of planting. Irrigation was by overhead sprinklers at seven to ten day intervals to provide about 10-12 inches of water for the season.

Three crops were evaluated at three spacings (Table I) under eight different weed control treatments (Table II). The trials were set up as a split plot design with the spacings as the main plots and the weed control methods randomized as sub-plots. All plots were replicated four times. Each plot was 16 feet long and the width varied by crop and spacing.

TABLE I. Spacings evaluated in weed competition and control studies.

Crop	Plant arrangements (inches)	No. of rows planted	Planting date	Harvest date	Plants per acre
<u>1969</u>					
Corn (Jubilee)	10 x 12	8	May 22	Sept 12	52, 300
	20 x 12	6			26, 100
	35 x 12	4			14, 900
Bush Snap Beans (Gallatin 50)	5 x 5	8	June 8	Aug 14	250, 900
	15 x 5	6			83, 600
	35 x 5	4			35, 800
Onions (Danvers yellow globe)	5 x 3	8	May 2	Sept 29	290, 000
	10 x 3	4			210, 000
	15 x 3	4			136, 000
<u>1970</u>					
Corn (Jubilee)	10 x 12	8	June 15	Sept 28	52, 300
	20 x 12	6			26, 100
	35 x 12	4			14. 900
Bush Snap Beans (Gallatin 50)	5 x 5	8	June 17	Aug 19	250, 900
	15 x 5	6			83, 600
	35 x 5	4			35, 800

TABLE II. Weed control methods for 1969.

Method	Description
1. Control	Hand weeded continuously throughout the season.
2. Chemical	Corn - 3 lbs ai/A 2-chloro-N-isopropyl acetanilide (Propachlor) post plant. 1 lb ai/A 2-chloro-4-ethylamine-6-isopropylamino-s-triazine (atrazine) post plant.
	Beans -3/4 lb ai/A α, α, α trifluoro-2, 6 dinitro-N, N-dipropyl-p-toluidine (trifluralin) pre-plant. 1 lb ai/A 2-sec-butyl-4, 6-dinitrophenol (dinoseb) at emergence.
	Onion -3 lbs ai/A 2 chloro-N, N-diallylac etamide (CDAA) post plant. 3 lbs ai/A isopropyl m-chloro-carbanilate (chlorpropham) post plant.
3. Clean Early (BL+G)*	Dicotyledonous weeds plus grass removed up to 5 weeks after emergence at which time weeding was discontinued and seeded with annual rye grass (Lolium multiflorum L.) and a broad-leaf weed, redroot pigweed (Amaranthus retroflexus L.)
4. Clean Early (BL)**	All weeds removed up to 5 weeks after emergence then seeded with redroot pigweed only.
5. Clean Late (BL+G)	Grass seed and redroot pigweed seed broadcast at time of planting and allowed to remain 5 weeks at which time weeding was begun.
6. Clean Late (BL)	Only the redroot pigweed seed spread at planting time and removed after 5 weeks.
7. No weeding (BL+G)	Grass and dicotyledonous weeds remain in crop entire season.
8. No weeding (BL)	Dicotyledonous weeds remain in crop entire season.

* (BL+G) Dicotyledonous weed plus grass.
**(BL) Dicotyledonous weed only.

Weed plant weights from bean plots were determined from a 36 x 36 inch area at the time of late weeding, weed plant weights as well as bean plant weights from the same size area were taken again at harvest. Both the green weights and dry weights were determined for the weeds. During the late weeding of the corn, measurements of the stem length, the number of nodes per plant, and the stem diameter from ten redroot pigweed (Amaranthus retroflexus L.) plants was determined.

Plots were hand harvested once to simulate machine harvest in all crops. And eight-foot length of the center rows were harvested to eliminate border effects. All treatments in replications one and two of the corn and beans were harvested on one day and replications three and four the next day. Onions were all harvested on the same date.

After bean plot yields were recorded, the pods from all replications were bulked and sieve size determined with a mechanical bean grader. The pods/plant and leaves/plant were determined from three plants of each plot. Kernel moisture was determined after corn plot yields were recorded. Tip fill of ears was also determined from five ears along with the number of green and dry leaves per plant. All plants for the above observations were selected at random from each plot.

At harvest, onions were graded into three size groups;

2-3 inches, 3-4 inches, and over 4 inches in diameter to obtain graded weights. Bulbs below two inches in diameter were discarded.

1970 Field Plots:

Fertilizer rates were the same as in 1969, except for corn where the addition of 100 lbs N per acre in the form of ammonium nitrate was disked in before planting. The irrigation pattern was similar to that of 1969.

Corn and snap beans were at the same spacings and plot design used in 1969 (Table I). There were some changes in weed control methods. Cultivation treatments were changed, to be discontinued 2, 3, 4 and 5 weeks after emergence, replacing the early and late weeding methods used in 1969.

Prior to the last cultivation on a given plot, redroot pigweed seed was hand broadcast to insure that a fair weed population was present at the time cultivation was discontinued.

During the growing period of corn and snap beans, visual observations were made in an attempt to determine when the soil surface between rows became completely shaded over by vegetative crop growth.

Plots were hand harvested once to simulate machine harvest in all crops. Corn yields were taken from 15 plants in the center of the plot and bean yields were taken from 25 plants in the center of the plot. All replications were harvested on the same day. Plants were obtained at random from each plot.

After weights of beans were recorded, sieve sizes were determined along with pods/plant ratio and leaf weight/plant. Kernel moisture was not taken on corn, but tip fill and ear length were determined. Total leaf weight from plants, excluding suckers, was also determined at harvest time as well as counts of the number of green and dried leaves per plant.

Results

Beans

Weed competition affected weights of leaves, stems and pods of bush snap bean plants.

The number of leaves per plant and the leaf weight per plant were lowered significantly by weed competition in the wider spacing. Losses of 6.0, 25.5 and 51.5 percent in leaf weight were found for the 5 x 5 inch, 15 x 5 inch and 35 x 5 inch spacings respectively, when weed competition was allowed to exist throughout the entire growing season when compared to the weed-free plots. Spacing and weed competition significantly influenced both leaf weight and leaf number on a per plant basis. The leaf weight was reduced by both weed competition and reduction in row spacing. The number of leaves per plant were reduced by 35 percent due to weed competition at the 35 x 5 inch spacing in comparison to a reduction of only 10 percent due to weed competition at the 5 x 5 inch spacing.

Stem weight of beans was significantly affected by the weed competition, spacing, and the weed competition x spacing interaction.

The reduction in stem weight was 16, 31 and 47 percent for the 5 x 5 inch, 15 x 5 inch and 35 x 5 inch spacing respectively.

Figure 1 shows the effect of weed competition on pod number as the plant arrangement was increased for 25 sq inches (5 x 5 inches) per plant to 180 sq inches (35 x 5 inches) per plant. Pod numbers per plant at the 25 sq inch arrangement were not significantly affected by weed competition, but were significantly reduced at the one percent level for the 20 x 5 and 35 x 5 inch spacing.

Pod size was unaffected by weed competition or spacing in 1969. However, when graded in 1970 the bean pods of sieve size four and smaller were significantly higher at the five percent level for the full weed competition period and the two-week period of cultivation than for those taken from weed-free plots.

Total pod weight was also affected by spacing, weed competition and spacing x weed competition interaction in the same manner as pod number.

Yields as affected by weed competition for 1969 and 1970 are presented in Tables III and IV. Mean yields in 1969 for the various periods of weed removal were significantly higher when weed competition was ended during the earlier growing season than those in which competition ended four to five weeks after emergence. Removal of weed competition after four to five weeks resulted in no significant increase in bean pod yields over those with weed competition for the entire season. Mean yields for 1970 were significantly higher at the one percent level if weed control was continued up to three weeks

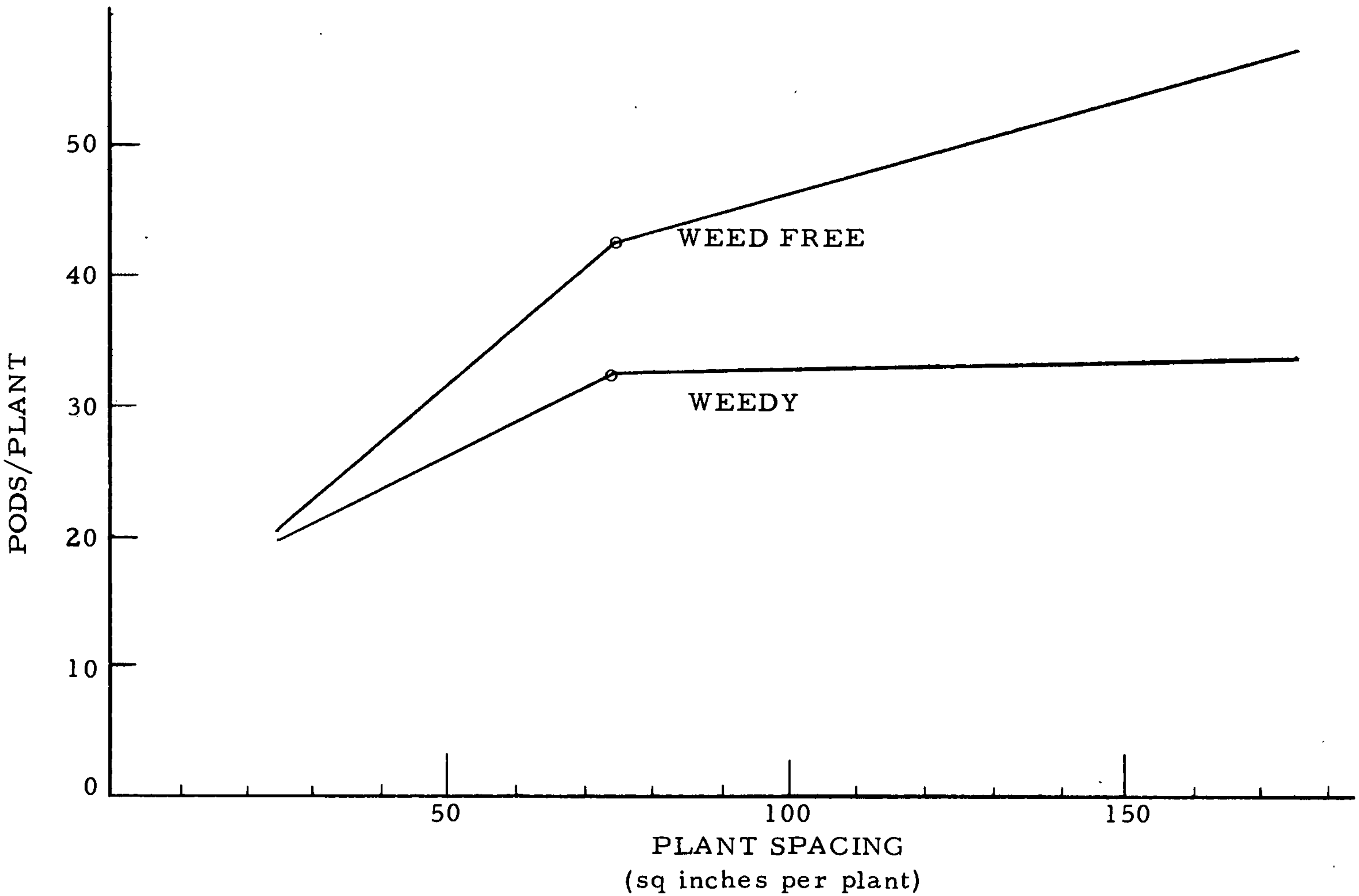

Figure 1. Snap bean pod number as influenced by weed competition with three crop planting arrangements for 1970.

TABLE III. Effect of different times of weed removal on yields of snap beans at three crop spacings (1969).

Method of weed control	Spacing (inches) 5 x 5	15 x 5	35 x 5	Weed control means
Control	12.3*	9.3	8.3	10.0
Chemical	12.7	9.5	8.4	10.2
Early Cultivation	12.8	11.1	8.7	10.8
Late Cultivation (Broadleaf & grass)	10.6	7.4	6.4	8.1
Late Cultivation (Broadleaf)	11.6	7.2	6.4	8.4
No Cultivation (Broadleaf & grass)	13.3	8.7	5.8	9.2
No Cultivation (Broadleaf)	10.8	9.1	7.0	9.0
Spacing means	12.0	8.9	7.4	

* Tons per acre

LSD spacing yield means	5%	0.1
	1%	0.2
LSD weed control yield means	5%	0.2
	1%	0.3
LSD spacing x weed control yield means	5%	NSD
	1%	NSD

TABLE IV. Effect of discontinuing weed removal at various stages of growth on yield of snap beans at three spacings (1970).

Period of weed removal	Spacing (inches) 5 x 5	15 x 5	35 x 5	Weed removal means T/A
Control	10.9*	4.8	3.2	6.3
Non-weeded	8.9	3.4	1.9	4.7
2nd week **	10.4	3.8	2.5	5.5
3rd week	10.4	6.1	3.2	6.5
4th week	11.0	5.3	2.7	6.3
5th week	10.9	5.0	3.3	6.4
Spacing means	10.4	4.7	2.8	

*Tons per acre

** Weed control discontinued after this cultivation

LSD spacing yield means 5% 0.1
1% 0.2

LSD weed removal yield means 5% 0.2
1% 0.3

LSD spacing x weed removal yield means 5% NSD
1% NSD

after emergence over that of non-weeded plots. Weed removal up to two weeks after emergence indicated mean yields significantly greater at the one percent level over non-weeded plots, but were significantly lower at the one percent level when compared to mean yields from plots weeded for three weeks or more. The spacing x weed competition interaction was not significant.

Fresh weight of weeds removed from a nine square foot area in 1969 at the late weeding period, or four to five weeks after bean emergence, averaged 0.4, 0.8 and 0.8 lbs for crop plant arrangements of 5 x 5 inches, 15 x 5 inches and 35 x 5 inches respectively. In 1970 the fresh weights of weeds taken from a nine square foot area at harvest time were 1.75, 6.07 and 5.57 lbs for spacings of 5 x 5 inches, 15 x 5 inches and 35 x 5 inches respectively.

Corn

Weed competition had a marked effect on the reduction of leaf weight, yield per plant and yield per acre.

Weed competition resulted in a leaf weight reduction, on a per acre basis of 39, 35 and 49 percent for the spacings of 10 x 12 inches, 20 x 12 inches and 35 x 12 inches respectively. Leaf weight was not significantly affected if weeds were removed up to two weeks after corn plant emergence. Both the number of green leaves and dry leaves in 1969 were affected by spacing. The presence of weeds did not decrease the number of green or increase the number of dried leaves for the various spacings. In 1970 the effect on leaves due to spacing was not significant.

Ear weights, pounds per plant, for 1969 and 1970 are shown in Figure 2. Highest yield loss per plant (41%) due to weed competition, was at the spacing allowing the greatest soil surface area per plant, while the spacing allowing the smallest area per plant was the least affected (30%). The interaction of weed competition x spacing was significant at the one percent level. The measurement on the lack of ear tip fill in 1969 and 1970 was significantly affected only by spacing. The percent moisture contained in the kernels was reduced by the presence of weeds.

Total yields for 1969 and 1970 are shown in Tables V and VI. Yields for both years were significantly affected at the one percent level by spacing and by weed competition treatment at the five percent level. The spacing x weeding method interaction was not significant. In 1970 mean yields were unaffected by weed competition if it was removed for the two-week period following plant emergence. Weeding four to six weeks after emergence in 1969 was ineffective in controlling losses of yield when compared to the control and early weeding.

Measurements of weed height at the time of late weeding in 1969 indicated that weed height was significantly affected by spacing.

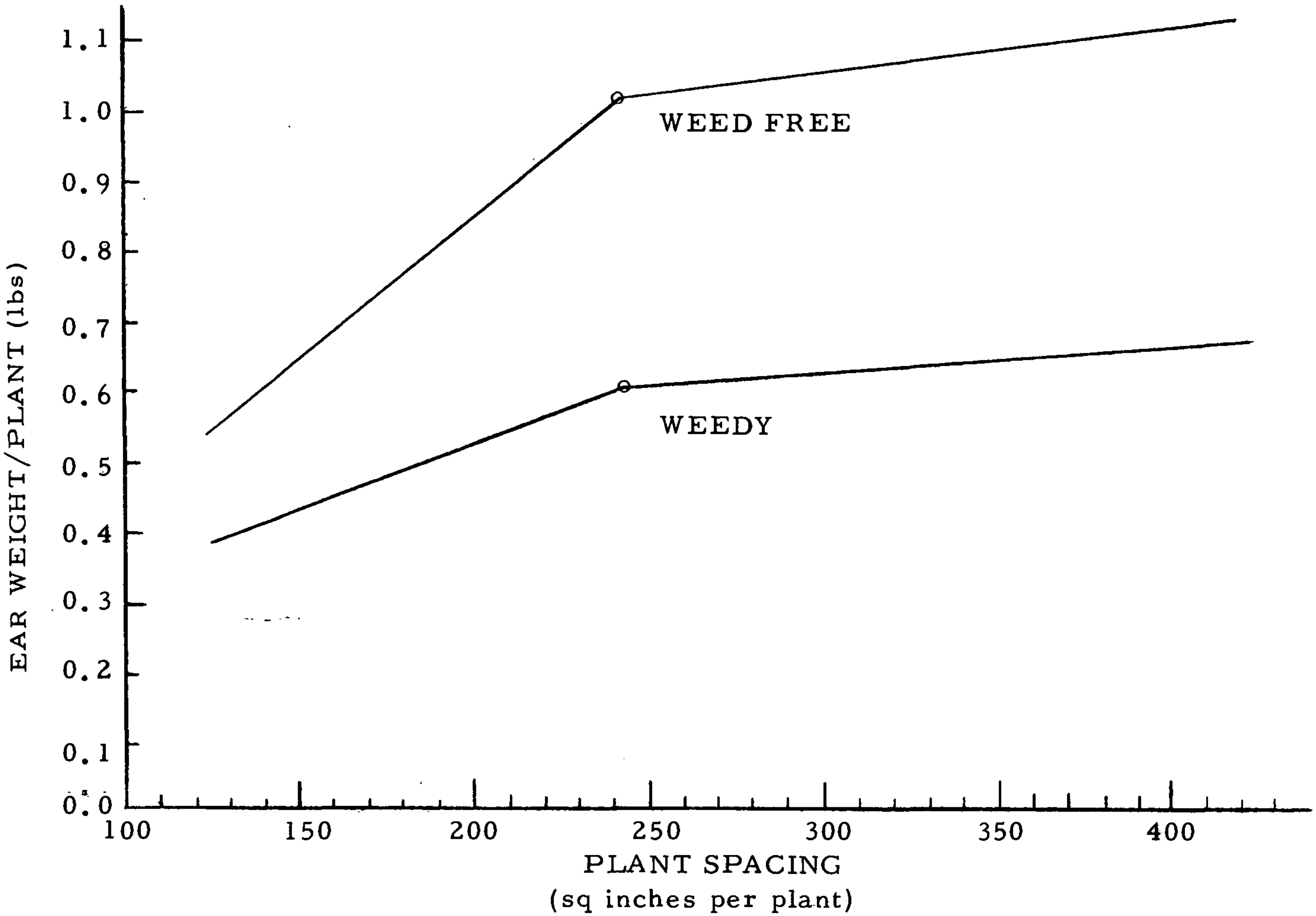

Figure 2. Corn ear weight per plant as influenced by weed competition at three various spacing arrangements averaged for years 1969 and 1970.

TABLE V. Effects of differing periods of weed removal on total corn yields planted at three spacings in 1969.

Method of weed control	Spacing (inches) 10 x 12	20 x 12	35 x 12	Weed control means
Control	15.0*	12.3	9.1	12.3
Late Cultivation (Broadleaf and grass weeds removed)	10.7	7.6	5.9	9.1
Late Cultivation (Broadleaf weeds removed)	11.4	9.7	5.5	8.8
No Cultivation (Broadleaf and grass weeds removed)	10.0	7.6	3.3	7.9
No Cultivation (Broadleaf weeds removed)	8.9	6.4	4.9	6.7
Spacing means	12.2	8.7	5.7	

* Tons per acre

LSD spacing yield means	5%	3.3
	1%	5.1
LSD weed removal yield means	5%	2.4
	1%	NSD
LSD spacing x weed removal yield	5%	NSD
	1%	NSD

TABLE VI. Effect of discontinued weed removal total on corn yields planted at three spacings in 1970.

Weed removal	Spacing (inches) 10 x 12	20 x 12	35 x 12	Weed removal
Control	12.8*	11.0	7.5	10.4
Non-weeded	10.4	7.9	4.9	7.7
2nd week**	13.4	10.4	8.2	10.7
3rd week	10.4	10.2	7.3	9.3
4th week	11.7	9.8	8.1	9.9
5th week	12.5	10.3	8.0	10.3
Chemical	12.9	9.8	6.3	9.7
Spacing means	12.0	9.9	7.2	

* Tons per acre
** Weed control discontinued after this cultivation

LSD spacing yield means	5%	0.6
	1%	1.0
LSD weed removal yield means	5%	1.5
	1%	NSD
LSD spacing x weed removal yield means	5%	NSD
	1%	NSD

As area per corn plant decreased, weed height was found to increase in a somewhat linear relationship.

Estimate of total canopy. Estimates were made to determine when the soil surface area became covered for both snap beans and corn. It was estimated that snap beans formed a complete canopy at approximately 21, 28 and 35 days for spacings 5 x 5 inches, 15 x 5 inches and 35 x 5 inches respectively and for corn at approximately 35, 42 and 49 days for spacings 10 x 12 inches, 20 x 12 inches and 35 x 12 inches respectively.

Onions

The results obtained from the 1969 onion plots in Table VII shows that spacing influenced the yield and bulb size. The 5 x 3 inch spacing and the 10 x 3 inch spacing produced yields nearly equal, but the 10 x 3 produced 66 percent jumbos (onions over three inches in diameter) as compared to 53 percent jumbos produced by the 5 x 3.

The control treatment mean was 42 tons per acre (Table VII) and significantly higher than all other treatments which had yields of 14 to 28 tons per acre. The chemical treatment and the plots which had early competition from broadleaf weeds and grass produced the lowest yields per acre. The interaction of spacing x weeding period was not significant.

TABLE VII. Effect of spacing and weed control methods on yields and size of onions.

Weed Control Treatment	Spacing 5 x 3 inches T/A*	Size Medium 2-3"	Size Jumbo Over 3"	Spacing 10 x 3 inches T/A	Size Medium 2-3"	Size Jumbo Over 3"	Spacing 15 x 3 inches T/A	Size Medium 2-3"	Size Jumbo Over 3"	Weed control Means
Control	54	47%	53%	53	34%	66%	19	21%	79%	42
Chemical	20	62%	38%	13	24%	76%	8	27%	73%	14
Clean Early**	27	84%	16%	28	53%	47%	9	40%	60%	22
Clean Early	31	68%	32%	37	51%	49%	6	55%	45%	25
Clean Late (BL&G)	15	78%	22%	18	46%	54%	9	36%	64%	14
Clean Late (BL)	37	73%	27%	36	36%	64%	13	24%	76%	28
Spacing means	30.7			30.9			11.9			

* Tons per acre **Description of given treatment given in Table I.

LSD spacing yield means 5% 6.2
1% 9.4

LSD weed control yield means 5% 6.1
1% 8.1

LSD spacing x weed control yield means 5% 10.5
1% 14.0

Plots under full season weed competition could not be harvested due to complete failure to make any growth.

Discussion

Yields for bush snap beans, corn and onions, were reduced at all spacings when weed competition existed for the entire season. Results from 1969 and 1970 for snap beans and corn indicated no significant effect on yield reduction due to weed competition with changes in spacing, although in both crops, yield reductions were least for the spacing with the smallest area per plant. In both years, corn yields seemed to be more affected by weed competition with respect to spacing than did snap beans. This response may be in part due to the rapid shading effect that developed at an earlier stage of growth by all snap bean spacings and by corn at the smallest spacing.

Delaying weeding by four to five weeks caused a significant reduction in yields of both snap beans and corn in 1969. These results are in agreement with Dawson (1964) who indicated that a weed free environment must be maintained for a period of five to seven weeks and Burnside and Wicks (1969) who indicated that delaying weed removal after three weeks caused a significant yield reduction in sorghum.

Onion data in 1969 indicated that weed control must be complete for the entire season to insure minimum yield losses.

Yields in 1970 indicated that early cultivations of two weeks for corn and three weeks for snap beans were required to eliminate the losses due to the competition from weeds. Knake and Slife (1965) also observed that weeds seeded three weeks or later in corn or soybeans did not cause yield reductions.

Relationship of competition between a crop plant and adjacent crop plants along with the adjacent weeds were apparent when evaluating vegetative and reproductive changes on a per plant basis. Pod weight, pod number, leaf number, leaf weight and stem weight in snap beans were significantly changed due to weed competition at the larger planting arrangement. Results give some indication that at the larger spacing, with its greater portion of unused surface area, interplant competition between crop and weed becomes the important factor. At the smaller spacing, competition between crop plant and adjacent crop plants was indicated to be the factor most important in crop plant response.

Corn leaf weight due to spacing was not significant; however, the leaf weights were taken from the main stalk only, excluding all suckers. Suckers were produced only at the largest spacing with the exception of non-weeded plots which produced no suckers. If the leaves from suckers had been included, leaf weight at the larger planting arrangement may have been higher.

Results suggest that weed control becomes an important factor at any spacing if highest yields are to be achieved, especially for wider spacing during the early periods of development. The development of a complete canopy or shading of the ground surface plays an important function in snap beans and to a lesser extent in corn in their ability to compete with infesting weeds. Shading seems to be less important in corn as suggested by the observation that the development of a complete canopy did not occur until some time after the second week of cultivation, after which time infesting weeds had no effect.

DETECTION OF COMPETITION BETWEEN REDROOT PIGWEED IN CORN OR SNAP BEANS AT THREE ROW WIDTHS

Abstract

The beginning of competition between bush snap beans (*Phaseolus vulgaris* L.) and redroot pigweed (*Amaranthus retroflexus* L.) was determined by change in total green leaf weight at 36 to 44 days after emergence for spacings of 35 x 5 and 15 x 5 inches. Significant weed competition to affect the total green leaf weight had not developed after 51 days for the spacing of 5 x 5 inches. Competition between corn (*Zea mays* L.) and redroot developed 41 days after emergence for all spacings.

Results indicate that the time at which competition begins between crop and weeds can be determined by the green leaf weight measurements of the crop as effectively as by using leaf area.

Introduction

Competition studies (Burnside and Wicks, 1969; Knake and Slife, 1969; Dawson, 1964; Nelson and Nyland, 1962; Buchanan and Burns, 1970) have indicated that yield reductions results when weeds emerge and grow in direct competition with the commercial crop. However, many (Knake and Slife, 1969; Buchanan and Burns, 1970; Burnside and Wicks, 1967) have suggested that short periods of competition have produced little yield reduction during the early period of growth. Others (Bunting and Ludwig, 1964) have conducted research on the removal of weeds at two, three, four and six weeks after emergence in corn (Zea mays L.). Indications were that relatively short periods, two to four weeks, of competition during the early stages of growth were sufficient to cause a reduction in yield.

Dawson (1964) indicated that competition during the early period of growth must be a low as possible or that the crop be maintained essentially weed-free during this period if reductions in yield are to be avoided at harvest. Muzik (1970) states the general rule that competition is most serious when the crops are in the early stages of growth, i.e., the first six to eight weeks after germination.

The objectives of this study were to determine at what period competition between crop and weed species can first be detected by measuring leaf fresh weight, leaf dry weight, total nitrogen and sugars. Different spacings were used in an attempt to determine the possible interaction of competition and time under different plant densities during the early stages of growth.

Materials and Methods

The plots were located at the Oregon State University Vegetable Research Farm at Corvallis on a Chehalis silty clay loam soil, a recent alluvial type. All crops were planted with a Stanhay precision seeder.

Fertilizer, at a rate of 51 lbs N, 67 lbs P, and 42 lbs K per acre was disked in before planting. An additional 26 lbs N, 34 lbs P, and 21 lbs K were banded at time of planting. The corn had an additional 100 lbs N as ammonium nitrate disked in prior to planting. Irrigation was by overhead sprinklers at seven to ten day intervals to provide about 10-12 inches of water for the season.

A split plot design was used in setting up field plots. The row spacings were used as the main plots and the weed removal treatments as the sub-plots. All plots were replicated four times, with each plot being eight feet long and the width varying for crop and spacing.

Corn was planted at 35 x 12 inch, 20 x 12 inch, and 10 x 12 inch spacings and represented approximately 14,900, 26,100 and 52,000 plants per acre respectively. Beans were planted with spacings of 35 x 5 inches, 20 x 5 inches, and 5 x 5 inches and represented approximately 35,000, 83,000, and 250,000 plants per acre, respectively.

Weed control treatments consisted of plots that were maintained weed-free by hand weeding and those unweeded. Samples, which consisted of ten plants, were taken at random from the center of each plot. Leaves were removed and weights taken for both fresh and dry samples. Leaf area of bean plants were determined by an airflow planimeter described by H. V. Jenkins (1959) and modified to a single grid of 144 square inches.

Samples were taken one week after emergence and thereafter at approximately weekly intervals for a period of six weeks and eight weeks for corn and beans respectively. Data were subjected to analysis of variance.

Total nitrogen, total sugars, and reducing sugars were determined by the use of the Technicon Auto Analyzer as outlined by Ferrari (1960) and Sadler and Chesson (1959).

Results and Discussion

Green leaf weight

Figure 1 shows the leaf fresh weights from bush snap beans at different spacings over a 51 day growing period. The controls, or weed-free plots, at the 15 x 5 inch spacing, when compared to the weedy plots, were found to be significantly higher at the five percent and one percent level 36 and 44 days after emergence respectively. At the 35 x 5 inch spacing reduction in leaf fresh weight for weedy plots as compared to the control plots were significant at the one percent level 36 days after emergence. No significant difference between the control plots and weedy plots were found after 51 days for the

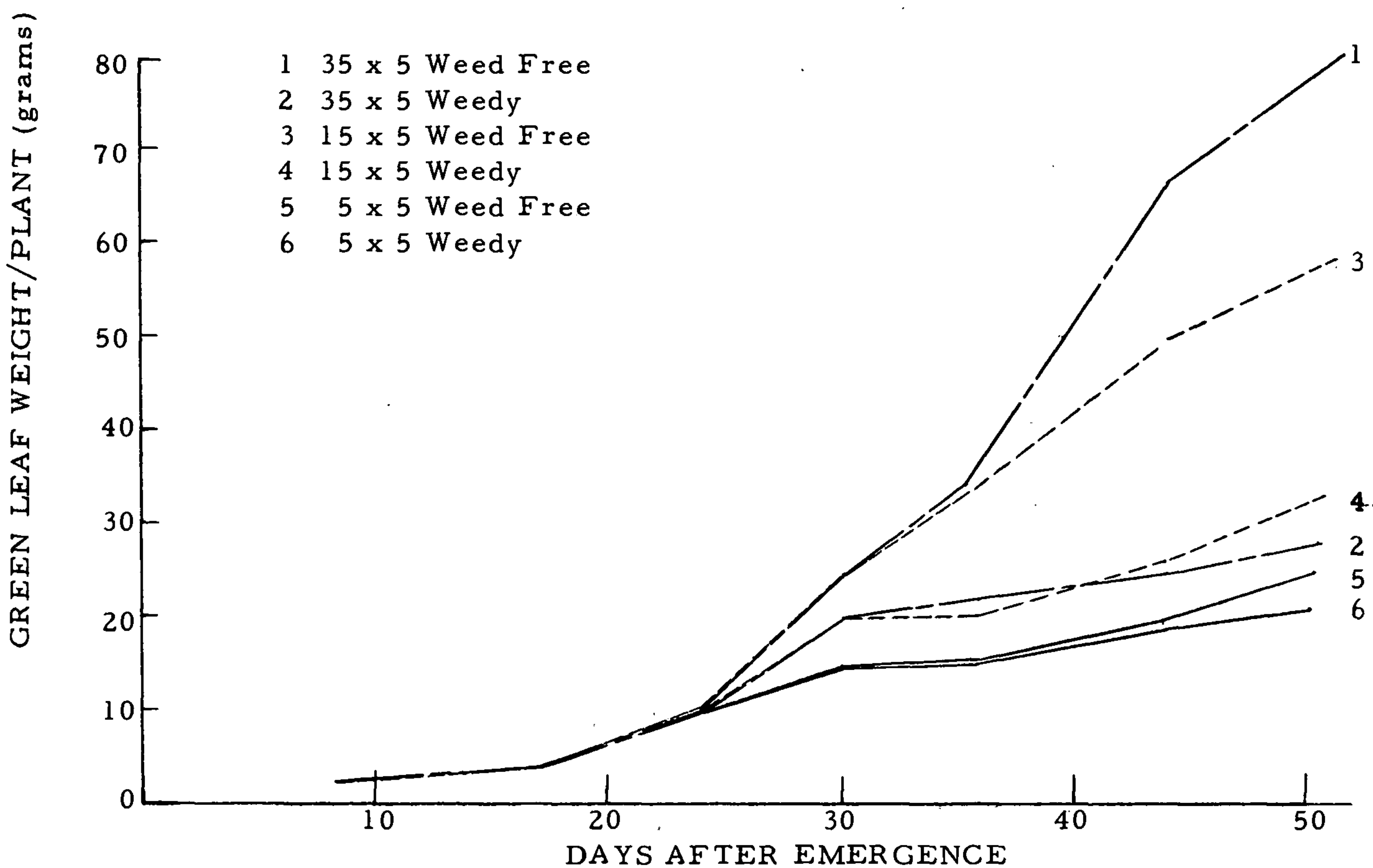

Figure 1. Snap bean fresh leaf weight per plant as influenced by weed competition with three crop spacings over a 51 day period during 1970.

5 x 5 inch spacing.

Figure 2 shows the leaf fresh weight per plant for corn over a 48 day growing period. Leaf fresh weights for the control and weedy plots were significantly different at the one percent level for the three spacings 41 days after emerging. The average reduction in green leaf weight in weedy plots at this date were 49, 63 and 73 percent for the 10 x 12 inch, 20 x 12 inch and 35 x 12 inch spacings respectively. Bush snap beans and corn apparently begin significant competition with infesting weeds at about 36 to 44 days after emergence to result in loss of leaf fresh weight.

In both drops, it appears that in the closer spacings, competition between crop plant and weeds becomes important later in the growing season, when compared to the wider spacing. This was indicated by the bush snap beans in that no significant reduction in green leaf weight developed due to weed competition at the 5 x 5 inch spacing. This response again may be due to the crop plant-to-plant competition for such factors as soil moisture, nutrients, and light being more important than the competition between crop plant and weeds. Figure 1 indicates this relationship at about 30 days after emergence by the difference in leaf fresh weight between the controls for the three different spacings with little difference between the control and weedy plots when compared at the same spacing.

In corn it was estimated by observation that the soil surface

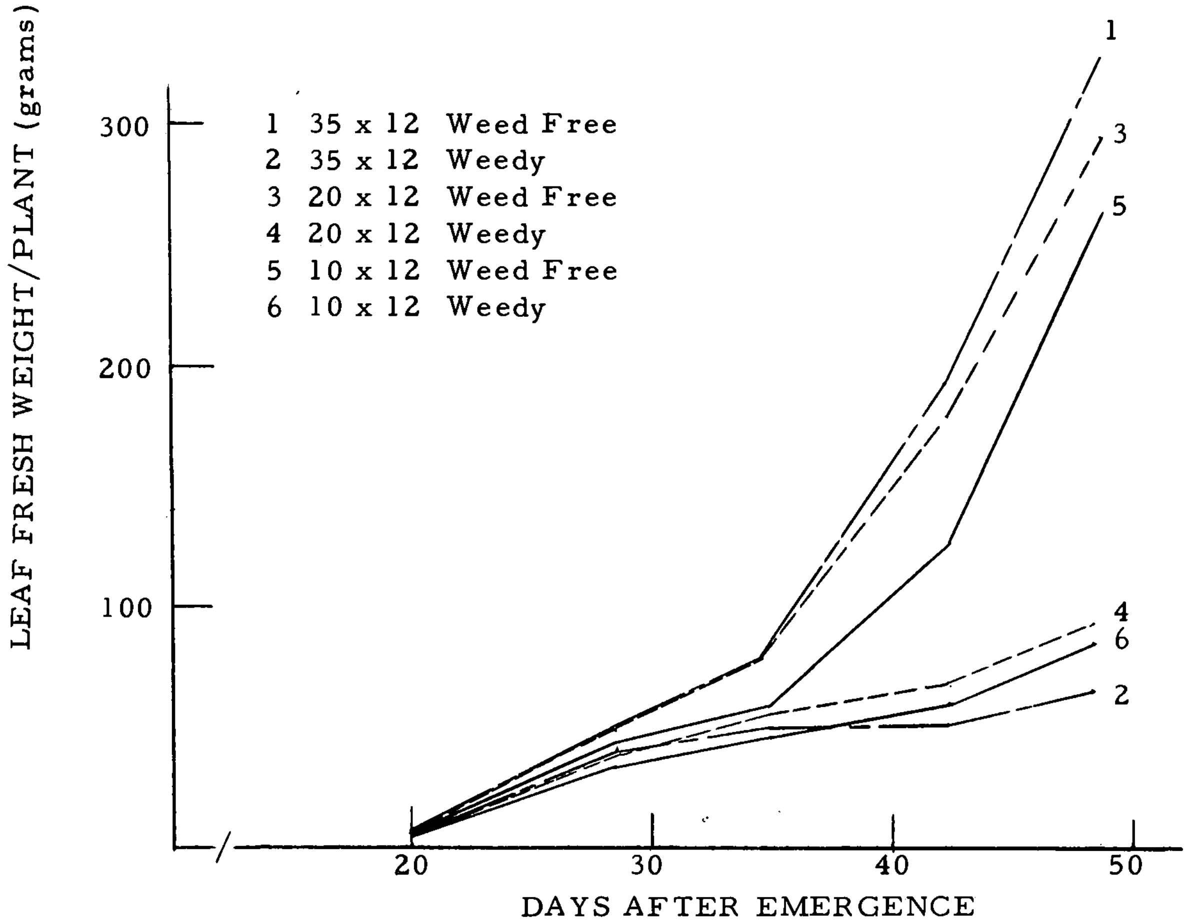

Figure 2. Corn fresh leaf weight per plant as influenced by weed competition with three crop spacings over a period of 48 days during 1970.

was completely shaded by plant foliage at approximately 35, 42 and 49 days after emergence, at spacingx of 10 x 12 inches, 20 x 12 inches and 35 x 12 inches respectively with comparatively lower leaf fresh weights in the weed-infested plots beginning at 32 to 41 days after emergence. Snap beans had shaded the soil surface with plant foliage at approximately 21, 28 and 35 days after emergence for spacings of 5 x 5, 15 x 5 and 35 x 5 inches respectively with reduction in leaf fresh weight gains beginning at 36 to 44 days after emergence in weedy plots.

Reduced leaf fresh weight gains occurred somewhat later in snap beans than in corn. It appears that competition was developing in corn before competition for light became the dominant factor. This may be especially true in the wider spacing. This would be in agreement with Bandeen and Buchholtz (1967) when they indicated that the growth habit of corn in the early season would not make competition for light a major factor, but that early slowing of growth was an effect which must involve the soil and root system.

Dry weight

Results from leaf dry weight measurements were similar to those of leaf fresh weight with reduction in weights beginning 12 to 41 days after emergence. Bean leaf dry weight was significantly reduced by weed competition at the five percent level when compared to the control. Results indicate that weed competition seems to have less effect on the production of leaf dry matter than it does on the leaf fresh weight in bush snap beans.

Stem weight, stem length, and pod number

Figure 3 shows results from data taken on stem weight for bush snap beans. Indications are that loss in weight due to weed competition had become significant at the five percent level by 36 days and the one percent level by 44 days after emergence for the 35 x 5 inch planting arrangement. Significant differences in stem weight occurred at the one percent level by 44 days after emergence for the planting arrangement 15 x 5 inches. Again, as in leaf fresh weight, no significant stem weight difference developed between the weed-free plots and weedy plots at the smallest spacing.

Pod numbers per plant were significantly reduced by weed competition 57 days after emergence at the five percent level for the spacing of 35 x 5 inches. At 44 days after emergence there was an average difference of 12 less pods per plant from weedy plots as compared to weed-free plots at the largest spacing. There was no significant difference between the weed-free plots and weedy plots for the intermediate and the smallest spacings. The means for the different spacing at this date were 40.4, 28.3 and 20.9 for the arrangements 35 x 5 inches, 15 x 5 inches and 5 x 5 inches respectively.when

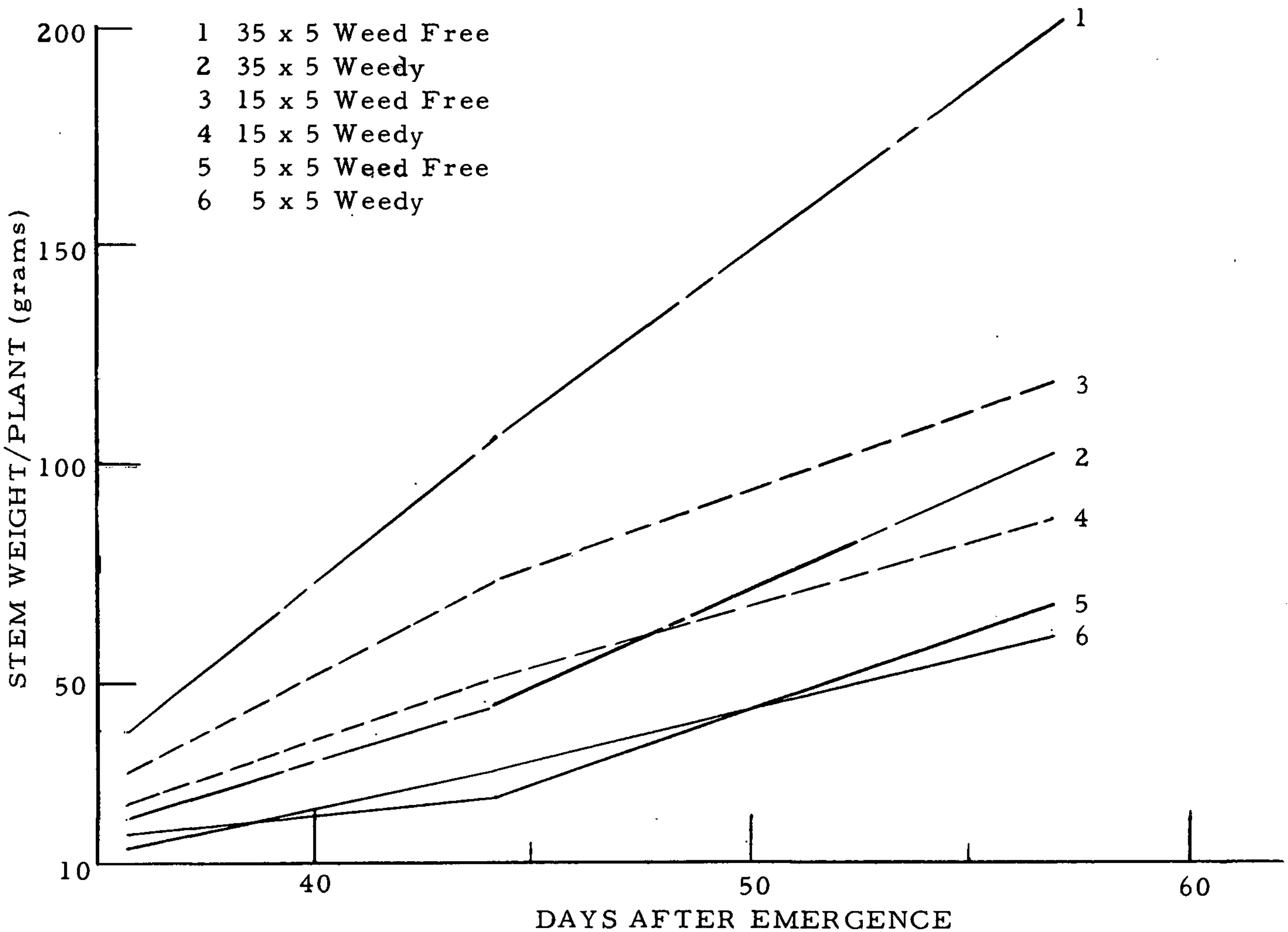

Figure 3. Snap bean stem weight per plant as influenced by weed competition with three crop spacings over a 21 day period during 1970

considering only non-weedy plots. The decrease in pods per plant for beans in competition with weeds and those in weed-free plots after 57 days of development were 23, 11 and 0 pods per plant for spacings 35 x 5 inches, 15 x 5 inches and 5 x 5 inches respectively. Means for the number of pods on the weed-free plots were 55.5, 42.1 and 21.3 pods per plant for the respective spacings.

When considering pod number per plant, it seemed apparent that pod numbers are more influenced at an earlier stage of development by spacing than by the competition of weeds. This may again indicate that the factor of crop plant to crop plant competition was more effective on pod numbers earlier in growth than was competition between crop plant and weed.

Stem length of bean plants was not significantly affected by weed competition or spacing.

Leaf area

Measurements of leaf area were significant at the one percent level at approximately 36 days after emergence for the difference between control plots and those in competition with weeds. This was at approximately the same time there was an indication of reduction in leaf fresh weight at the largest spacing of 35 x 5 inches. Interactions of spacing x weed competition and spacing x weed competition x sampling date were not significant. It is apparent from this study that measurements of leaf fresh weight was as useful a measurement for determination of competition as was leaf area. Robison and Massengale (1967) also indicated this relationship in studies conducted with alfalfa.

Nitrogen and Sugars

Percent total nitrogen was significantly decreased by weed competition at the five percent level for bush snap beans and by sampling date at the one percent level for bush snap beans and corn. Weed competition up to harvest time did not significantly reduce the percent total nitrogen in corn leaves.

Total sugars and reducing sugars were not significantly affected by weed competition. These results seem to agree with Weatherspoon and Schweizer (1969) who indicated that there would not be more than one percent decrease in sucrose unless competition existed for ten weeks or more. Total carbohydrates were not determined and may be the item of most importance when considering production of storage products and the determination of the time at which competition can be detected.

The change in leaf fresh weight of bush beans due to weed competition begins at approximately 36 to 44 days after emergence but only at the two wider spacings. When considering competition between corn and weeds, it begins at approximately 32 to 41 days after emergence and was unaffected by spacing.

Also indicated was the fact that crop plant to crop plant competition, especially at the narrowest spacing, was most important in bush snap beans while the crop plant to weed competition seemed to be of greater importance in corn.

More detailed field work is required before competent estimates can be made of the environmental factors that may be in competition, between crop plant and weeds. In addition, continued work is needed to determine the environmental factors that are most important to one crop in comparison to that of another when competing with weeds.

Indications from results obtained make it apparent that to give a reliable estimation of the factors that become important in competition will require more detailed field work. The results also indicate that for each crop the factors of competition change; that no one factor may be the most important; and in combination and in the field may be impossible to separate.

THE EFFECT OF VARYING FERTILITY LEVELS AND SHADING ON REDROOT PIGWEED GROWN IN COMPETITION WITH CORN AND BUSH SNAP BEANS

Abstract

At a fertilizer rate of 77-91-64 pounds of N-P-K per acre, corn made greater gains in total green weight than did pigweed. However, with the further addition of 300 pounds of ammonium nitrate per acre, pigweed continued to make gains while corn growth was unaffected. At all levels of fertility, pigweed had higher levels of total leaf nitrogen in comparison to corn. Corn height at the higher fertility level was unaffected by competition of pigweed over a four to five week period.

Pigweed's total green and dry weight was significantly reduced when growing with bush snap beans in full competition or in soil competition only.

Introduction

Weeds growing in competition with crop plants compete for the major environmental factors of soil moisture, nutrients and available light. The total effect on crop plant growth and yield due to competition from weeds may result from long or short periods of competition for one or more of the factors of soil moisture, nutrients, and available light during the critical stage of development. Increasing one or more of these factors may or may not give a competitive advantage to the crop plant.

Swanson (1957) indicated that if enough nutrients were supplied, competing weeds would have no effect on corn. Staniforth (1957) found that corn yields were increased two to three times more than grass with the addition of nitrogen and that yield reductions averaged 14, 10 and 5 bushels per acre due to weed compeition when 0, 70 and 140 pounds of nitrogen were applied respectively. Canada thistle numbers were shown to have decreased markedly in grasses when nitrogen was added and it was suggested that the more sustained competition of the grasses throughout the season due to the increased fertilization may have been partially responsible (Thrasher, *et al.*, 1963).

Vengris, Colby and Drake (1955) stated, however, that the addition of 200 pounds of P_2O_5 to corn infested with weeds still produced less than corn with no added P_2O_5 and infesting weeds and, therefore, questioned the thought that if enough nutrients were added corn yields would not be affected by weed competition.

Work by Welbank (1963) indicated that weed competition effects on kale, sugar beets or wheat generally were not significantly decreased by high nitrogen. Research (Peters and Yokum, 1961) has also suggested that increasing the fertility level did not favor the competitive ability of alfalfa due to the corresponding increase in competitive response by foxtail.

Bandeen and Buchholtz (1967) stated that corn height within one month after emergence was reduced due to competition and that the addition of 500 lbs/A of nitrogen and potash only slightly reduced this competitive effect, but the corn height never did equal the height in weed-free plots.

It was suggested (Bandeen and Buchholtz, 1967) that corn and quackgrass are not likely to compete for light during the early period of the growing season and that the competitive effect involved was in the soil and the root system. Knake and Slife (1969) also suggested that foxtail was more competitive in the early growing season with corn, while in soybeans the effect was later in the season at the time when weeds had topped or begun to shade the crop plant. Dawson (1964) has also indicated that weeds did not depress bean growth appreciably until the weeds exceeded the crop plants in height.

These results would seem to indicate that in corn, soil-root competition becomes important, while Knake and Slife (1969) indicate that for soybeans, weed height and the resulting shading become important.

The object of this study was to determine the effect of varying levels of soil fertility on redroot pigweed (Amaranthus retroflexus L.) and corn when growing in competition with each other and to make observations on the effect of bush snap beans on pigweed at varying degrees of light competition.

Materials and Methods

The study was carried out in a greenhouse located at Oregon State University during the fall of 1970. Due to the short day length, supplemental artificial light was used to give a 13-hour-day period. The temperature was maintained at 70°F for night temperature and 80°F for day temperature.

The interaction of fertilizer rates was studied by growing two corn plants and five pigweed plants in a four gallon container. Due to the rapid growth of the corn, in comparison to the slower emergence of the pigweed, the corn seed was planted approximately seven days after the pigweed. This allowed for a period of good weed growth before it became necessary to harvest the corn, due to greenhouse environmental factors limiting optimum corn growth after five to six weeks.

Two studies on the interaction of corn and pigweed at varying fertility rates were run. In the first study, greenhouse sandy loam soil with very low natural fertility, plus peatmoss was used, with no additional fertilizer; greenhouse soil plus 77 lbs N, 91 lbs P and 64 lbs K per acre respectively (commercial fertilizer 8-24-8 at the rate of approximately 965 lbs/A); and greenhouse soil plus commercial fertilizer with an additional 300 lbs ammonium nitrate per acre. In the second study, the treatment with only commercial fertilizer was replaced with one similar to the third treatment, with the exception that corn was grown without pigweed competition. All treatments were replicated three times.

At different times between emergence and five weeks after planting, corn heights were measured. At the end of five weeks the corn was harvested, height measured, green and dry weight determined sugars determined by auto-analyzer (Sadler and Chesson, 1955), and total nitrogen determined by standard Kjeldahl methods.

To study the effect of shading on weed growth, bush snap beans and pigweed were grown in plastic containers of 10.5 x 13.5 inch surface area. The first part of this experiment consisted of four treatments of eight, four, two and zero bush snap bean plants per container and were represented by plant spacings of a 5 x 3 inch, a 5 x 5 inch and a single row. The second part of the study consisted of four treatments at the 5 x 3 inch spacing with treatments consisting of beans grown alone, of beans with pigweed but held away from the center of the container in an attempt to stop shading and of weeds grown alone.

The pigweed seed (0.15 grams per container) was distributed as evenly as possible in the center of the container between the bean rows. All treatments were replicated four times. After a period

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pigweed made greater gains with the addition of ammonium nitrate to the commercial fertilizer than did corn. Pigweed made gains in both total green weight and dry weight with the addition of commercial fertilizer. The addition of ammonium nitrate to commercial fertilizer resulted in an additional response in the growth of pigweed green weight and dry. The initial application of fertilizer to corn produced a marked response in growth, but the addition of ammonium nitrate to the commercial fertilizer produced no additional gain in green weight or dry weight.

It becomes apparent from these data that corn responds to a given amount of nitrogen and that the addition of ammonium nitrate was of little increased value. On the other hand, pigweed seems able to continue use of additional nitrogen in the production of total plant green weight and total plant dry weight.

When determining the percent moisture, corn increased very little (88 to 90 percent) with the addition of fertilizer. Pigweed percent moisture, like green weight and dry weight, continued to increase with the addition of fertilizer (82, 87 and 89 percent moisture for no additional fertilizer, commercial fertilizer, and commercial fertilizer plus ammonium nitrate respectively).

Green weight and percent dry matter of corn when grown alone at the high rate of fertility were not significantly different from corn grown in competition with pigweed over a four to five week period. This is not to say that for a longer period of time competition would not begin to develop. In comparing the green weight and dry weight means of corn growing with weeds and corn growing without weeds, the former were less, and with continued growth may have become significantly reduced.

It is apparent from these results that added nitrogen has both a beneficial effect on total plant green weight and total plant dry weight of corn, but also has the corresponding effect on pigweed to such an extent that increased fertilizer may be more beneficial to the pigweed. This seems to be in agreement with Peters and Yokum (1961) when they indicated that increasing fertility did not favor alfalfa over foxtail.

Results from measurements of total leaf nitrogen in corn and pigweed are shown in Table I. Pigweed was significantly higher in total nitrogen, with the exception of the highest fertility treatment when commercial fertilizer plus ammonium nitrate were used in combination, than was corn for the same fertility levels. Pigweed increased in total nitrogen by 38.7 and 40.4 percent while corn made increases of 50.5 and 54.0 percent when the fertility level was increased by additions of commercial fertilizer and commercial fertilizer plus ammonium nitrate respectively.

Total nitrogen for corn grown without pigweed and for corn grown in competition with pigweed when fertilized with commercial

TABLE I. Total percent leaf nitrogen for corn grown at varying levels of fertility. (On a dry weight basis.)

Plant	Leaf Nitrogen (%) No added fertilizer	8-24-8	8-24-8 100 lbs N	Plant means
Corn	1.38	3.00	3.39	2.60
Pigweed	2.16	3.47	3.62	3.09
Treatment Means	1.75	3.24	3.51	

LSD between nitrogen treatment means	5%	0.41
	1%	0.96
LSD among plant means	5%	0.07
	1%	0.13
LSD among plants at same nitrogen levels	5%	0.13
	1%	0.23

fertilizer plus ammonium nitrate were 3.8 and 3.5 percent respectively. The difference between these values was not significant.

Growth of corn as influenced by combination treatments of fertilizer levels and weed competition is shown in Table II. Corn height of plants grown without pigweed competition and corn height of plants grown with pigweed competition indicated no significance between the treatments. Corn in combination with fertilizer and fertilizer plus weeds were both significantly greater at the one percent level than corn plus weeds without the addition of fertilizer five weeks after emergence.

Corn hëight was unaffected when growing in competition with pigweed for a period of up to five weeks. Melsted, Motto and Pick (1968) indicated tha no measurable growth response can be measured until the total nitrogen falls below three percent. This may account for lack of growth reduction after one month as indicated by Bandeen and Buchholtz (1967). It is apparent from data taken during this short period that competition between pigweed and corn was primarily a result of soil factors, as indicated by Bandeedn and Buchholtz (1967). It also indicates that although corn continued to take up additional nitrogen when added to the soil, it does not produce the continued gain in green weight and dry weight that was produced in the pigweed.

TABLE II. Height of corn plants in competition with pigweed with varying degrees of fertility.

Date	Corn Height			Date Means
	Fert	Fert + Weeds	Weed	
Dec. 15	60.5*	58.5	49.0	56.0
Dec. 21	80.9	78.9	60.4	73.4
Dec. 28	112.0	112.2	72.4	95.5
Height means	84.5	81.0	60.6	

* Centimeters

LSD height means	5%	11.0
	1% NSD	19.7
LSD date means	5%	12.5
	1%	20.1
LSD height x date means	5%	14.3
	1%	24.0

TABLE II. Height of corn plants in competition with pigweed with varying degrees of fertility.

Date	Corn Height			
	Fert	Fert + Weeds	Weed	Date Means
Dec. 15	60.5*	58.5	49.0	56.0
Dec. 21	80.9	78.9	60.4	73.4
Dec. 28	112.0	112.2	72.4	95.5
Height means	84.5	81.0	60.6	

* Centimeters

LSD height means	5%	11.0
	1% NSD	19.7
LSD date means	5%	12.5
	1%	20.1
LSD height x date means	5%	14.3
	1%	24.0

Shading trial

Pigweed growing in competition with bush snap beans produced significantly less green weight and dry weight than pigweed growing alone. Green weight and dry weight was not significantly different as the result of the number of bean plants present.

When screens were used to maintain a shade-free center, weed weights again were not significantly different from those that were shaded. Light energy measurements were 89.60 cal/sq cm/day at the center of the containers with only weeds, and the green weight of weeds produced was 3.78 grams, while the light energy measurements were 86.31 cal/sq cm/day and the green weight of weeds produced was 0.15 grams for containers with beans plus screens. Light energy at the center of the container with beans and weeds was 29.5 cal/sq cm/day and produced a weed green weight of 0.08 grams.

These results may point to the soil as a major area of weed competition with observation that weed weights in soil competition with bush snap beans were lower than weeds growing without bush snap beans, yet the light energy received was near that of the weeds growing alone. It is felt that the pronounced effect that snap beans had on the growth of pigweed in the green house was due to the difficulty faced in getting rapid germination and emergence of pigweed in the greenhouse during this study. In the field, pigweed germination and emergence presents little problem and would present more competition to bush snap beans than was produced in the greenhouse.

SUMMARY AND CONCLUSION

Yields for bush snap beans, corn and onions were greatest when these crops were grown for the entire growing season under weed-free conditions for all spacings. Results also indicate that a continuous weed-free environment for the two to three week period after emergence was very important at all spacings, however, it is felt that at the smallest spacing weed control, as a result of shading the exposed soil surface before weeds could become established, was greater than at the largest spacing.

It was also noticeable in bush snap beans, when looking at 1970 data, that yields in weedy plots at the smallest spacing (8.9 tons/acre) were appreciably greater than the yields in weed-free areas at the larger spacings (4.8 and 3.2 tons/acre for 15 x 15 and 35 x 5 inches respectively). In corn this was only true at the largest spacing, 10.4 tons per acre for 10 x 12 inch weed plots as compared to 11.0 and 7.5 tons per acre for weed-free spacings 20 x 12 and 35 x 12 inches respectively. These results indicate that the smallest spacing may permit a crop plant considered of low photosynthetic capacity to compete more successfully with a plant of high photosynthetic capacity.

Results indicate that the early period of weed control becomes the most important. Yields of both corn and beans were significantly reduced when weeds were allowed to remain in competition for a period of four to five weeks after emergence. However, if weeding was discontinued after two weeks for corn and three weeks for beans no significant yield reductions occurred when compared with plots with continuous weeding. It becomes apparent that early establishment of the crop becomes extremely important and that this period of establishment was very rapid once emergence had taken place. This was especially true with the smallest spacing in which the crop plants quickly occupied the available soil surface.

The time at which competition between weeds and corn or beans begins, as determined by total leaf fresh weight reduction, was found to be 32 to 41 days after emergence for corn and 36 to 44 days after emergence for beans. The fresh weight of all leaves on the crop plant was determined to be the best measure of determining the time when competition first could be detected between crop plants and weeds. It is felt that competition between crop plants and weeds could possibly be detected with other plant chemical or physiological characteristics at an earlier time than with the methods used in this study.

This study also indicated that competition was detected at an earlier stage in the wider spacings. However, in the control plots leaf weight was less in the narrowest spacing in comparison to the two wider spacings. It is felt that this was due to the importance of competition from crop plant to crop plant at the smallest spacing.

Results also indicated that with the addition of nitrogen, both corn and pigweed increased in total nitrogen. Pigweed continued to increase in plant growth with increased nitrogen levels in soil. Corn growth improved only with the first increment of added nitrogen. It is indicated that the addition of all of the fertilizer to corn at one time may be of little value and, in fact, may be more beneficial to the weeds. This implication requires further study as to the value of applying fertilizer in split applications to corn.

Spacings can play an important role in the controlling of weeds; the weeds in turn play an important role in competing with crop plants for moisture, nutrients, etc. The period during the early stages of crop plant growth must be maintained weed free if highest yields are to be realized.

BIBLIOGRAPHY

1. Bandeen, J. D. and K. P. Buchholtz. 1967. Competitive effects of quackgrass upon corn as modified by fertilization. Weeds 15:220-224.

2. Black, C. C., T. M. Chen and R. H. Brown. 1969. Biochemical basis for plant competition. Weed Sci. 17: 338-344.

3. Bleasdale, J. K. A. 1963. Crop spacing and management under weed free conditions. Crop Production in a Weed Free Environment. Blackwell Sci. Publ., London.

4. Buchanan, Gale A. and Earl R. Burns. 1970. Influence of weed competition on cotton. Weed Sci. 18:149-154.

5. Bunting, E. S. and J. W. Ludwig. 1964. Plant competition and weed control in maize. Seventh British Weed Cont. Conf. Proc. 1:385-388.

6. Burnside, O. C. and G. A. Wicks. 1967. The effect of weed removal treatments on sorghum growth. Weeds 15: 204-207.

7. Burnside, O. C. and G. A. Wicks. 1969. Influence of weed competition of sorghum growth. Weed Sci. 17:332-334.

8. Dawson, J. H. 1964. Competition between irrigated field beans and annual weeds. Weeds 12:206-208.

9. Feltner, K. C., H. R. Hurst and L. E. Anderson. 1969. Yellow foxtail competition in grain sorghum. Weed Sci. 17:211-213.

10. Ferrari, Andres. 1960. Nitrogen determination by a continuous digestion and analysis system. Annals of the New York Academy of Science. 87:792-800.

11. Frans, R. E. 1970. What width row? Weeds Today 1:16-18.

BIBLIOGRAPHY (Continued)

12. Furtick, W. R. 1967. National and international weeds for weed science. A challenge to WSA. Weeds. 15:291-295.

13. Gruengagen, R. D. and John D. Nalewaja. 1969. Competition between flax and wild buckwheat. Weed Sci. 17: 380-384.

14. Hammerton, John L. 1970. Crop seed rate and MCPA effectiveness. Weeds Res. 10:178-180.

15. Hatch, M. D. and C. R. Slack. 1966. Photosynthesis by sugarcane leaves. A new carboxylation reaction and the pathway of sugar formation. Biochem. J. 101: 103-111.

16. Jenkins, H. U. 1959. An airflow planimeter for measuring the area of detached leaves. Plant Physiology. 34:532-536.

17. Knake, E. L. and F. W. Slife. 1965. Giant foxtail seeded at various times in corn and soybeans. Weeds. 13: 331-334.

18. Knake, E. L. and F. W. Slife. 1969. Effect of time of giant foxtail removal from corn and soybeans. Weed Sci. 17:281-283.

19. Kurst, Cyril A. and R. R. Smith. 1969. Interaction of linuron and row spacing for control of yellow foxtail and barnyard grass in soybeans. Weed Sci. 17:489-491.

20. Lehman, W. F. and J. W. Lambert. 1960. Effect of spacing of soybean plants between and within rows on yield and its components. Agron. J. 52:84-86.

21. Mack, H. J. and D. L. Hatch. 1968. Effect of plant arrangement and population density on yield of bush snap beans. Proc. Amer. Soc. Hort. Sci. 92:418-425.

BIBLIOGRAPHY (Continued)

22. Marx, G. A. and D. J. Hagedorn. 1961. Plant population and weed growth relations in canning peas. Weeds 9:494-496.

23. Melsted, S. W., H. L. Motto and T. R. Peck. 1968. Critical plant nutrient composition values useful in interpreting plant analysis data. Agron. J. 61:17-20.

24. Muzik, Thomas J. 1970. Weed Biology and Control. McGraw Hill Book Company. New York. p. 273.

25. National Research Council. Agricultural Board. Committee on Plant and Animal Pests. Subcommittee on Weeds. 1968. Weed control. Vol. 2. Principles of plant and animal pest control. Washington, D. C. 471 p. (National Academy of Sciences. Publication 1597)

26. Nelson D. C. and R. E. Nyland. 1962. Competition between peas grown in processing and weeds. Weeds. 10:224-229.

27. Nunez, Robertao and Eugene Kamprath. 1969. Relationship between N response, plant population, and row width on growth and yield of corn. Agron. J. 61:279-282.

28. Peters, Elroy J., Maurice R. Gebhardt, and J. F. Strutzke. 1965. Interrelations of row spacing, cultivation, and herbicides for weed control in soybeans. Weeds 13: 285-289.

29. Peters, R. A. and H. C. Yokum. 1961. Effect of associated growth on yields and nutrient uptake of alfalfa and yellow foxtail. WSA Abstr. p. 35.

30. Robison, Cayland D. and M. A. Massengale. 1967. Use of area weight relationship to estimate leaf area in alfalfa (Medicago sutiva L. Cultivar 'Moapa') Crop Sci. 7:394-396.

BIBLIOGRAPHY (Continued)

31. Sadler, W. W. and R. R. Chesson. 1959. Automated reducing sugar analysis. Abstr. 13th Tobacco Chemist Conf., Lexington, Kentucky.

32. Staniforth, David W. 1957. Effect of annual grass weeds on the yield of corn. Agron. J. 49:551-555.

33. Swan, D. G. and W. R. Furtick. 1962. Competition of fiddleneck with wheat. Weeds. 10:121-123.

34. Swanson, C. L. W. and G. M. Jacobson. 1957. Effect of adequate nutrient supply and varying conditions of cultivation, weed control and moisture supply on soil structure and corn yields. Agron. J. 49:571-577.

35. Thrasher, Frank P., Clee S. Cooper, Jesse M Hodgson. 1963. Competition of foliage species with Canada thistle as affected by irrigation and nitrogen levels. Weeds 11:136-138.

36. Vengris, Jonas, William G. Colby and Mack Drake. 1955. Plant nutrient competition between weeds and corn. Agron. J. 47:213-216.

37. Wax, L. M. and J. W. Pendleton. 1968. Effect of row spacing on weed control in soybeans. Weed Sci. 16: 462-464.

38. Weatherspoon, D. M. and E. E. Schweizer. 1969. Competition between kochia and sugarbeets. Weed Sci. 17: 464-467.

39. Welbank, P. J. 1963. A comparison of competitive effects of some common weed species. Annals of Applied Biology 51:107-125.

40. Wiese, A. F., J. W. Collier, L. E. Clark and U. D. Havelka, 1964. Effect of weeds and cultural practices on sorghum yields. Weeds. 12:209-211.