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Study Phenological Relationships Between Soybean and Some Weed Species

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Abstract: This study identifies the relationship between growth stages of some annual weeds and soybean. Three different species of broadleaf annual weeds were planted at intervals during two crop seasons 2009 and 2010 in a soybean field in Qaemshahr Islamic Azad University Agriculture College. Redroot pigweed, common lambsquarters and velvetleaf were tested for seedling emergence in various cohorts for stages of sprouting. Records were taken for number leaves of soybean and related weeds during three-day intervals, until soybean reached the third trifoliate stage. Results showed that until appearance of the third leaf of soybean (third trifoliate), those weeds that had emerged simultaneously with soybean had six leaves, while those that were on cohorts V_1 (weeds emerging from the unifoliate to the first trifoliate), V_2 (from the first to the second trifoliate) and V_3 (from second to third) had about leaf numbers of 5, 2 and 1, respectively. The most important factor affecting variations during growth stages of crop and weeds in this experiment was the time of emergence of weed seedlings.

Key words: Common lambsquarters % Phenology % Redroot pigweed % Soybean % Velvetleaf

INTRODUCTION

Bio-phenologic indices are mainly used in agriculture to classify information on environmental and parasitic stresses. Knowledge from pest and weed phenology enables agronomic managers to apply more effective strategies. However, research has shown that the use of phenology for weed control application is not yet widely practiced [1-3]. Efficiency of operations such as tillage, herbicide application and weed perennial cutting, is increased if weed biomass is visible [4]. Appropriate timing of weed control (mechanical or chemical), makes weed management much more viable [5-7].

Phenological research is an alternative approach to predict weed emergence and to enable appropriate herbicide application. But it is specific to a geographical location because climatic factors have an effect on crop growth, influencing simultaneous weed growth. Hence, their growth stages are related to each other. If a special event in a crop (for instance leaf appearance or beginning of blooming) is applicable with maximum sensitivity to herbicide, it can be used as a bio calendar.

The determination of an appropriate time to apply post emergence herbicides is related to the interrelationship of weed and crop growth stages. In this context, a leaf number index can be applied as a decision-making criterion [8]. Herbicide applications outside of the specific period may cause crop damage or result in unsatisfactory weed control. More post emergence herbicides have low residue effects in the soil and growers often delay using them until they are confident of majority weed emergence. The main issue is to determine the length of time taken for weeds to compete with a crop before final yield is affected. In the Qaemshahr region, the critical period for application of weed control measures on a soybean crop has been determined as ranging from V_1 to R_1 [9]. It is recommended that herbicides be applied at the beginning of the growth season [10]. Weed control out of this period may not be beneficial to a crop [11].

Without field inspection, the determination of weed emergence is difficult. However, it is possible to estimate a crop's growth stages on the basis of cumulative degrees in days. This method for controlling a weed community isn't capable of extension because weed growth simulation depends on seed depth, location and seed dormancy [5]. After emergence, the rate of leaf appearance in a crop and associated weeds is mainly related to temperature and in some cases on a photoperiod [12-15].

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Therefore, the relative leaf development of a weed and a crop may be assured by an index for predicting weed emergence. In this case, an evaluation of the relationship between leaf growth of a crop and associated weeds provides useful information. The objective of this study was to determine the relationship between growths stages of three weed species' cohorts, up until

MATERIALS AND METHODS

This experiment was carried out at the Research Field of the Faculty of Agriculture at Islamic Azad University, Qaemshahr Branch, Iran during 2009 and 2010 growing season. The geographical location of the site was latitude 72°36' N, longitude 46°52' E and height above sea level 15 m. Soil characteristics were as follows; soil texture and amounts of nitrogen, phosphorus, potassium, organic carbon and pH were loamy-clay, 0.09%, 7.95 mg/kg, 165.5 mg/kg, 1.19, 1.19% and 7.7, respectively.

The planting bed was prepared with one application of deep tillage by a moldboard plow with two vertical discs during autumn seasons of 2008 and 2009 and during the subsequent spring for each year. Before planting, clods were crushed by a rotary. Nutrients were applied as 150 kg/ha super phosphate triple and 50 kg/ha urea in a shape band placement and at a spacing of 3 cm space from row at planting time. The experiment was laid out in randomized complete block design with three replications. Treatments included three different planting dates for velvetleaf (*Abutilon theophrasti*), common lambsquarters (*Chenopodium album*) and redroot pigweed (*Amaranthus retroflexus*). These plants were used in these tests as they are regarded as the most troublesome weeds to affect soybean cultivation [16-18]. Plant dates (cohorts) for each species were zero, two and four weeks after soybean planting.

Each plot had 12 rows that were each eight meters in length. Among the rows, one middle row was selected so that there were six points allocated for planting seeds of each weed species. Each point from the neighboring row, the next point and the end of the row, at least had distances of 15, 75 and 50 cm, respectively. Hence, the share of each species was two points in each plot.

Seeds of velvetleaf, redroot pigweed and common lambsquarters had been collected from fields during the previous year and kept at a low temperature (5°C), pending the experiment. Seeds were evaluated in a standard germination test before planting.

Planting dates for JK cultivar, during years 2009 and 2010, were 6 May and 22 June, respectively. To reach the optimum density for each species (3-10 p/100 cm^2), additional seedlings were thinned after emergence. Other weeds were left until appearance of the third trifoliate. For calculations, growth degree was taken per day and base temperatures for soybean, velvetleaf and redroot pigweed were considered as 10, 5 and 16°C [19-21], respectively.

Soybean and weed species growth stages were based on the Fehr and Cavines index and evaluations for leaf number were measured [22]. Analysis of variance for leaf number was done by the PROC CATMOD procedure [23].

RESULTS AND DISCUSSION

Soybean seeds emerged on the seventh and fourth day after planting soybean for years 2009 and 2010, respectively (Fig.1). May and June were more rainy and warmer in the year 2010 than in 2009. Total rainfall during those months in the years 2009 and 2010 were 53.1 and 121.4 mm, respectively. Cumulative thermal time in May and June and for years 2009 and 2010 were 560 and 577.3, respectively.

In total, two or three cohorts were observed for each species and for each year (Table 1).

Total numbers of observations during the two years and for all cohorts consisted of 142, 301 and 432 seedlings for common lambsquarters, velvetleaf and redroot pigweed, respectively. Common lambsquarters had fewer cohorts for each year. This was probably related to adverse conditions for germination and less seed bank in the soil. Only a few seedlings emerged after the V_3 stage. High correlation existed between appearance of leaves for soybean and weed species for both years and cohorts ($P<0.001$).

Analysis of variance showed that for all weed species, the most effective factors affecting leaf number were growth stage of soybean and time taken for weed emergence (Table 2). The factor of year and interactions between them were less significant.

On appearance of the first leaf let trifoliate of soybean more weeds were present during V_E cohort that had three to four leaves (Fig. 2). Velvetleaf and redroot pigweed, at least in 56% of cases for both years, had four leaves.

On appearance of the second leaf let trifoliate of soybean, weeds that were located during V_E cohort, had an average of five leaves (Table 3).

Table 1: Weed cohorts [a] emerging in soybean [*Glycine max* (L.) Merr] in 2009 and 2010

Weed[b]	2009	2010
AMARE	VE V1 V2	VE V1 V2
ABUTH	VE V2 V3	VE V2 V3
CHEAL	VE V2	VE V1

[a] VE, weeds emerging before the crop unifoliate stage; V1, weeds emerging from the unifoliate to the first trifoliate; V2, weeds emerging from the first to the second trifoliate; V3, weeds emerging from the second to the third trifoliate.

[b] AMARE, redroot pigweed (*Amaranthus retroflexus* L.); ABUTH, velvetleaf(*Abutilon theophrasti* L.);CHEAL (common lamsquarters (*Chenopodium album* L.)

Table 2: Analysis of variance[a] of weed leaf numbers in relation to soybean [*Glycine max* (L.) Merr] growth stage and time of weed emergence (cohort) with data pooled over years

Statistic	AMARE[b]	ABUTH	CHEAL
Crop stage	393	963	338
Cohort	799	451	59
Year	13	NS	17
Crop stage by cohort	13	34	5
Cohort by year	28	32	6
Crop stage by year	24	107	NS

[a] NS indicates $P > 0.05$

[b]AMARE, redroot pigweed (*Amaranthus retroflexus* L.); ABUTH, velvetleaf (*Abutilon theophrasti* L.); CHEAL (common lamsquarters (*Chenopodium album* L.)

Table 3: Mean SE weed leaf number at the soybean second trifoliate stage in relation to time of weed emergence, with data pooled over 2009 and 2010

	Weed cohort[a]		
Weed species[b]	VE	V1	V2
AMARE	6.5(1.1)	3.1(1.2)	2.4(1)
ABUTH	4.7(1.4)	2.3(1.3)	1.7(1.4)
CHEAL	-	2.6(0.3)	1.4(0.2)

[a] VE, weeds emerging before the crop unifoliate stage; V1, weeds emerging from the unifoliate to the first trifoliate; V2, weeds emerging from the first to the second trifoliate.

[b] AMARE, redroot pigweed (*Amaranthus retroflexus* L.); ABUTH, velvetleaf(*Abutilon theophrasti* L.);CHEAL (common lamsquarters (*Chenopodium album* L.)

Table 4: Mean SE weed leaf number at the soybean third trifoliate stage in relation to time of weed emergence, with data pooled over 2009 and 2010

	Weed cohort[a]			
Weed species[b]	VE	V1	V2	V3
AMARE	7.4(0.1)	5.5(0.2)	2.8(0.1)	1.8(0.3)
ABUTH	6.8(0.1)	5(0.1)	2(0.2)	0.8(0.3)
CHEAL	5(0.3)	3.7(0.3)	2.7(0.2)	1.8(0.2)

[a] VE, weeds emerging before the crop unifoliate stage; V1, weeds emerging from the unifoliate to the first trifoliate; V2, weeds emerging from the first to the second trifoliate; V3, weeds emerging from the second to the third trifoliate.

[b] AMARE, redroot pigweed (*Amaranthus retroflexus* L.); ABUTH, velvetleaf (*Abutilon theophrasti* L.) ;CHEAL (common lamsquarters (*Chenopodium album* L.)

Weeds that emerged later (at V_1 and V_2 cohorts) had less leaves. There was a 78% probability of redroot pigweed having more than five leaves during the first cohort; and this probability was 50% for velvetleaf. Moreover, it was only redroot pigweed that at the V_2 cohort and the second leaflet trifoliate stage of soybean that had more than two leaves.

On appearance of the third leaf let trifoliate stage of soybean the range of leaf number was from five leaves (common lambsquarters) to seven leaves (redroot pigweed) (Table 4). Weeds that emerged during V_1, V_2 and V_3 cohorts had averages for number of leaves of five, three and one respectively. All weeds that emerged before appearance of the first leaflet trifoliate of soybean appearance at the third leaflet trifoliate had at least five leaves and 59% of them had eight leaves or more. On average in the case of redroot pigweed in lieu of each soybean growth stage two leaves were added but only one leaf appeared for velvetleaf.

Broad leaf weeds on soybean are controlled at the three leaves stage, in Mazandaran state [24]. In this research redroot pigweed and velvetleaf that emerged simultaneously with soybean (Fig. 2) or even a little later (Table 3) had three leaves. Therefore in order to apply herbicide with confidence in terms of timing, weed species and densities need to be monitored and must be done with more accuracy. Hence, it is recommended that herbicide application must be carried out at appearance of the first leaflet trifoliate of soybean (Fig.2). Herbicide application on appearance of the second leaflet trifoliate in soybean can be useful for removal of weeds located at the V_1 cohort, but it is too late for weeds belong to the V_E cohort (Table 3).

Regardless of herbicide efficiency, late application of weed control (appearance of second or third leaflet trifoliate in soybean) weeds that emerged early (V_E), in conditions with high soybean row spacing, high weed density and low soil moisture content can result in yield loss [10,11,25,26].

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