

RELATIONSHIP BETWEEN WATER STRESS AND SEED YIELD OF TWO DRIP-IRRIGATED ALFALFA VARIETIES

Clinton C. Shock, Erik B.G. Feibert, Fawn L. Pettet, Andrew M. Sadowski,
and Lamont D. Saunders,
Malheur Experiment Station, Oregon State University
Jim Klauzer
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Summary

Two alfalfa varieties ('Tango' and 'Accord') were grown for seed using subsurface drip irrigation with four evapotranspiration (E_t) replacement levels: 20, 40, 60, and 80 percent of the accumulated deficit. After flower bud formation, the alfalfa was irrigated every 3 to 4 days and the corresponding E_t deficit applied. In the 2001 season, 'Tango' seed yield was optimized at 39 percent of E_t replacement or 13.2 inches of applied water and 'Accord' seed yield was optimized at 45 percent of E_t replacement or 13.8 inches of applied water.

Purpose

Work at the Malheur Experiment Station in the 1980's demonstrated that water stress was associated with high alfalfa seed yields (Shock et al. 1989). Achieving uniform water stress across the length of the field with furrow irrigation is problematic because water application is not uniform. In areas of the field where more water soaks into the soil, alfalfa remains vegetative, while alfalfa in dry areas can become excessively dry. Subsurface drip irrigation applies water more uniformly and allows for uniform water stress. Subsurface drip irrigation also has environmental benefits compared to furrow irrigation, due to (1) more efficient water use, (2) elimination of deep percolation of water, and (3) elimination of runoff losses of water and nutrients. The purpose of this experiment was to determine the level of deficit irrigation that optimizes seed yield of two alfalfa varieties.

Methods

Alfalfa was grown for seed on a Nyssa silt loam of modest fertility and productivity. The site was chosen to be representative of fields used for alfalfa seed production. The field was previously planted to wheat. Two varieties of alfalfa were planted on April 6, 2000 at 2 lb/acre in 30-inch rows. 'Tango', with a dormancy rating of six was planted in the upper half of the field and 'Accord', with a dormancy of four was planted in the lower half of the field. The alfalfa was irrigated with drip tape (T-Tape TSX 515-16-340, T-Systems Int., Kennewick, WA) buried at 12-inch depth between two alfalfa rows. The drip tape was buried on alternating inter-row spaces. The flow rate for the drip tape was 0.34

gal/min/100 ft at 8 PSI with emitters spaced 16 inches apart, resulting in a water application rate of 0.066 inches/hour. In 2000 the field was irrigated uniformly the entire season. The seed was harvested with a commercial combine.

Alfalfa Irrigation

In 2001, the alfalfa was not irrigated until bud formation. The alfalfa was flailed on May 3 to delay flowering. Approximately 2 acre-inch were applied on May 23 and another 2 acre-inch on June 1. The small irrigation differences between treatments up to June 1 were unintentional (Fig. 1). After June 1, the alfalfa was irrigated at four levels of alfalfa crop evapotranspiration (ET_c) replacement (20, 40, 60, and 80 percent) with five replicates of each treatment (Table 1, Fig. 2). Each treatment was irrigated every 3-4 days to replace the percentage of the ET_c deficit that had accumulated since the last irrigation. Irrigations were terminated on August 23.

Each plot was eight alfalfa rows wide, 480 ft long, and had two subplots corresponding to the two alfalfa varieties. Each plot was irrigated separately by its own pressure regulator, electronic solenoid valve, and water meter. Water meters were read before and after each irrigation.

Alfalfa evapotranspiration was calculated with a modified Penman equation (Wright 1982) and peak alfalfa crop coefficients using data collected at the Malheur Experiment Station by an AgriMet weather station (U.S. Bureau of Reclamation, Boise, Idaho) adjacent to the field. The ET_c was estimated and recorded from dormancy break on March 1 until the final irrigation on August 21. After the alfalfa was flailed, the ET_c was adjusted using crop coefficients. The crop coefficients were derived from weekly measurements of the percent ground cover until full cover was achieved.

Determination of Soil Water Content

Volumetric soil water content was determined by one Gro-Point soil moisture sensor (Environmental Sensors Inc., Escondido, CA) installed at 12-inch depth and one at 20-inch depth in each plot. The Gro-Point sensors were installed horizontally halfway between the drip tape and the alfalfa row in the plot center. Sensors were located 70 ft from the field middle in the 'Tango' subplots. Sensors were connected by buried cables to electronic communication boards housed in two locations in the field. The electronic communication boards were connected by a cable to a personal computer, allowing the soil water content to be read and logged every hour.

Alfalfa Seed Yields

On August 6, biomass samples were taken in each subplot by cutting the plants at ground level in 3.3 ft of one row. The samples were weighed, oven dried, and weighed again. The dried samples were separated into stems, leaves, and seed pods.

The alfalfa was desiccated with Boa (Paraquat dichloride) at 0.63 lb ai/acre and Reglone (Diquat) at 0.5 lb ai/acre on August 28. On September 5, 66 ft of each subplot was harvested with a small plot combine (52-inch width). The harvested seed was

cleaned to separate the plant debris from the seed. The seed and the debris were weighed.

Lygus Bug Monitoring and Control

Lygus bugs were monitored twice weekly by taking three 180° sweeps with an insect net in each of six locations throughout the field. The total number of early and late instars and adults was counted at each location. When the total number of insects (early and late instars, and adults) reached four per sweep, insecticides were applied (Table 1).

Results and Discussion

Differential Irrigation

The total Et_c from dormancy break to the start of flowering (March 1 to June 2) was 11.7 inches, substantially higher than the approximately 4 acre-inch applied uniformly to all plots (Fig. 1). After the start of flowering, the treatments were clearly differentiated in terms of cumulative amount of water applied over time (Fig. 2). The total amount of water applied was 19.5, 14.8, 9.8, and 5.0 acre-inch per acre for treatments 1 through 4, respectively. The total Et_c from the start of flowering until the last irrigation was 26.2 acre-inch. The total Et_c for the season was 37.9 inch.

Soil moisture was closely related to the irrigation treatments (Fig. 3). Soil moisture content at 12-inch depth for treatments 1, 2, and 3 was similar during irrigations, but became lower between irrigations in accordance with the irrigation treatments. Soil moisture content at 12-inch depth for treatment 4 at 20 percent Et_c remained lower than for the other treatments during and after irrigations. Soil moisture content at 20-inch depth was lower than at 12-inch depth for all treatments (Fig. 4). Soil moisture content at 20-inch depth for treatments 1, 2, and 3 was similar during and between irrigations. Soil moisture content at 20-inch depth for treatment 4 did not responded to irrigations.

Alfalfa Seed Yields

Lygus bug insecticide applications were not effective in maintaining the population below the economic threshold (four lygus bugs per 180° sweep) during the season (Fig. 5). Lygus bug populations were very damaging to the driest treatments, which began blooming first. This was because lygus bug populations happened to be high early.

Alfalfa seed yield increased with increasing Et_c replacement (Fig. 6) and applied water (Fig. 7), reached an optimum, and then decreased. 'Tango' seed yield was optimized at 39 percent of Et_c replacement or 13.2 inches of applied water and 'Accord' seed yield was optimized at 45 percent of Et_c replacement or 13.8 inches of applied water. Whole plant, stem, and leaf dry matter yields increased with increasing water applied (Fig. 8). Seed pod dry matter yield increased with increasing applied water, reached a maximum, and then decreased. 'Tango' seed pod yield was optimized at 38 percent of Et_c replacement or 11.9 inches of applied water and 'Accord' seed yield was optimized at 45 percent of Et_c replacement or 15.6 inches of applied water (Fig. 8 and 9).

References

Shock, C.C., W.P. Stephen, V. Cairo, T.D. Stieber, and M. Saunders. 1989. Irrigation, insect population, and disease management for alfalfa seed production. Oregon State University Agricultural Experiment Station, Special Report 844:16-21.

Wright, J.L. 1982. New evapotranspiration crop coefficients. J. Irrig. Drain. Div., ASCE 108: 57-74.

Table 1. Insecticide applications for lygus bug control. Malheur Experiment Station, Oregon State University, Ontario, OR.

Date	Application mode	Product	Rate lb ai/acre
June 6	Ground	Capture	0.099
		Cygon	0.25
July 2	Aerial	Metasystox-R	0.5
July 12	Aerial	Metasystox-R	0.5
July 22	Aerial	Capture	0.032
August 1	Aerial	Metasystox-R	0.5
August 11	Aerial	Capture	0.032

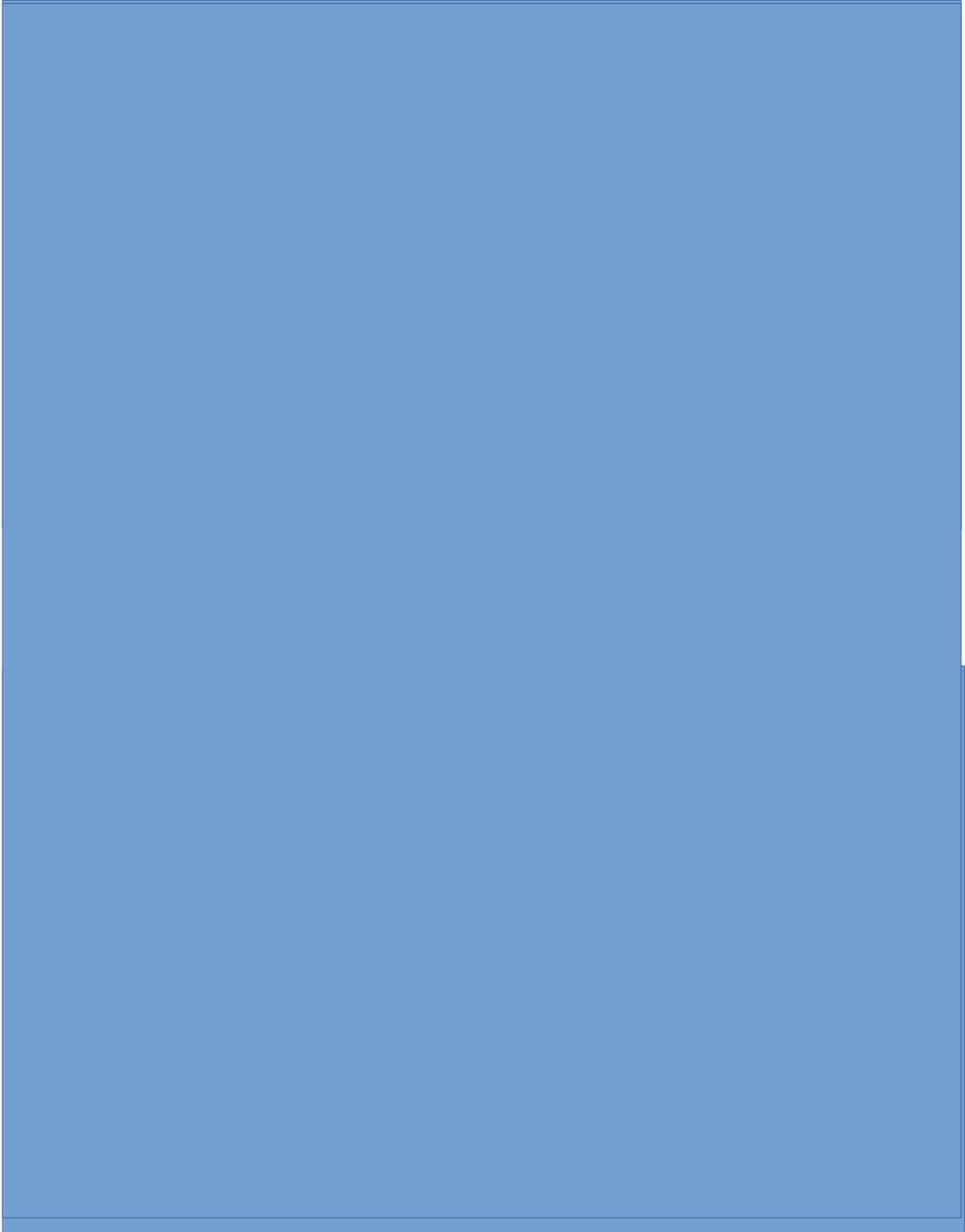


Figure 1. Cumulative water applied from dormancy break to flowering compared to Et for alfalfa seed. The small irrigation differences between treatments up to June 1 were unintentional. Malheur Experiment Station, Oregon State University, Ontario, OR.



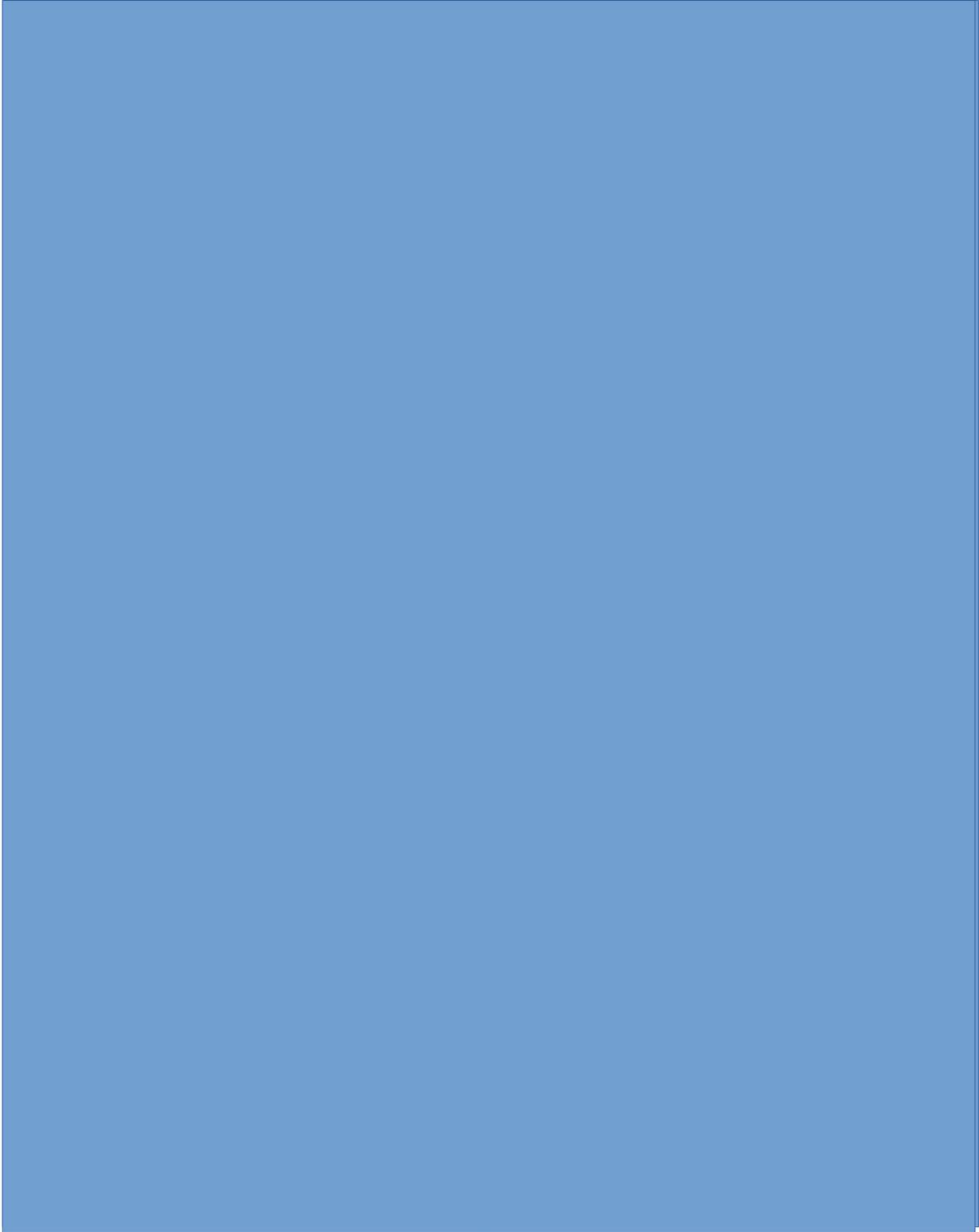
Figure 2. Cumulative water applied after flowering compared to Et for alfalfa seed submitted to four drip-irrigation treatments. Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 3. Soil moisture at 12-inch depth in response to irrigation treatments in a drip-



irrigated alfalfa seed field. Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 4. Soil moisture at 20-inch depth in response to irrigation treatment in a drip-



irrigated alfalfa seed field. Malheur Experiment Station, Oregon State University, Ontario, OR.

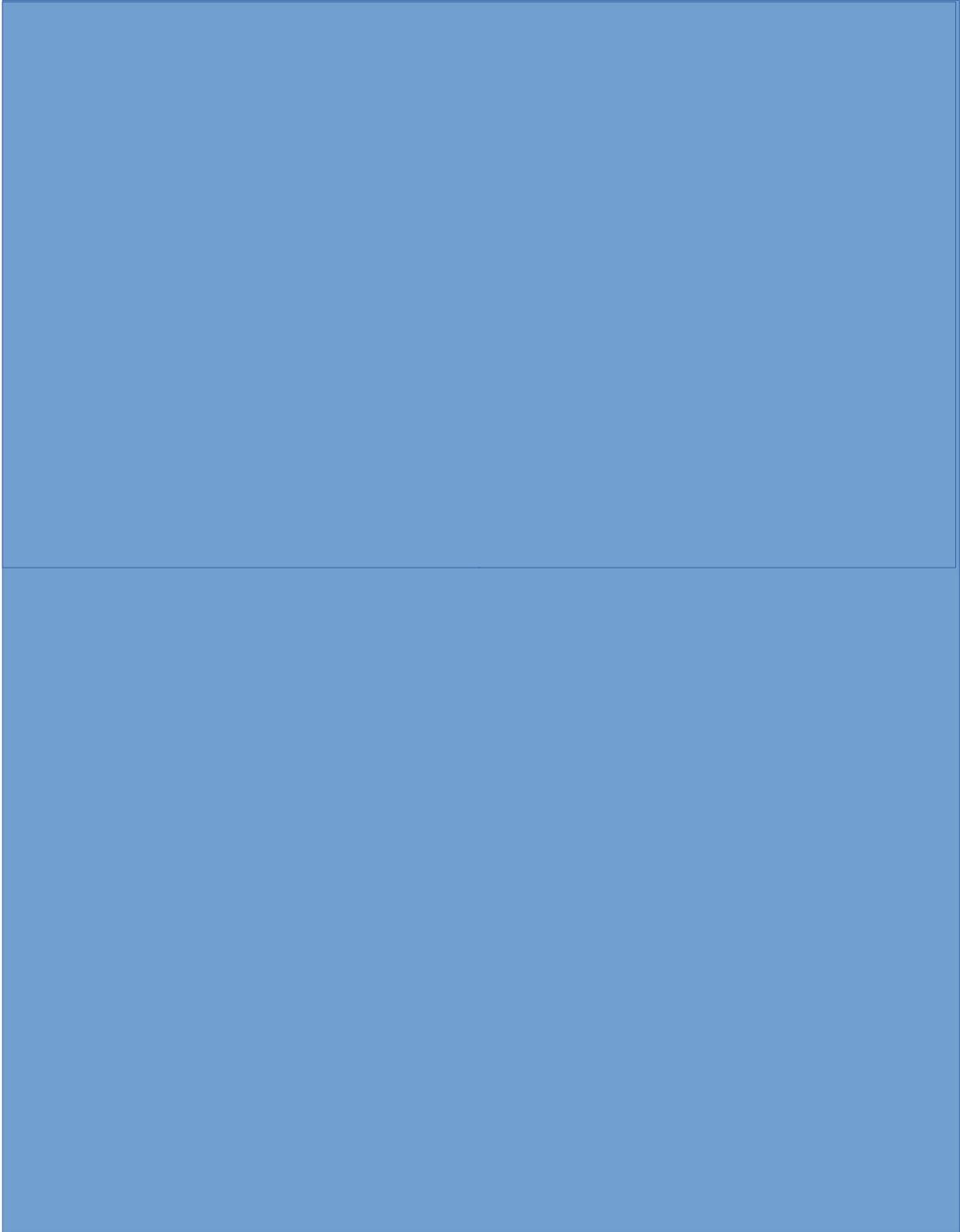
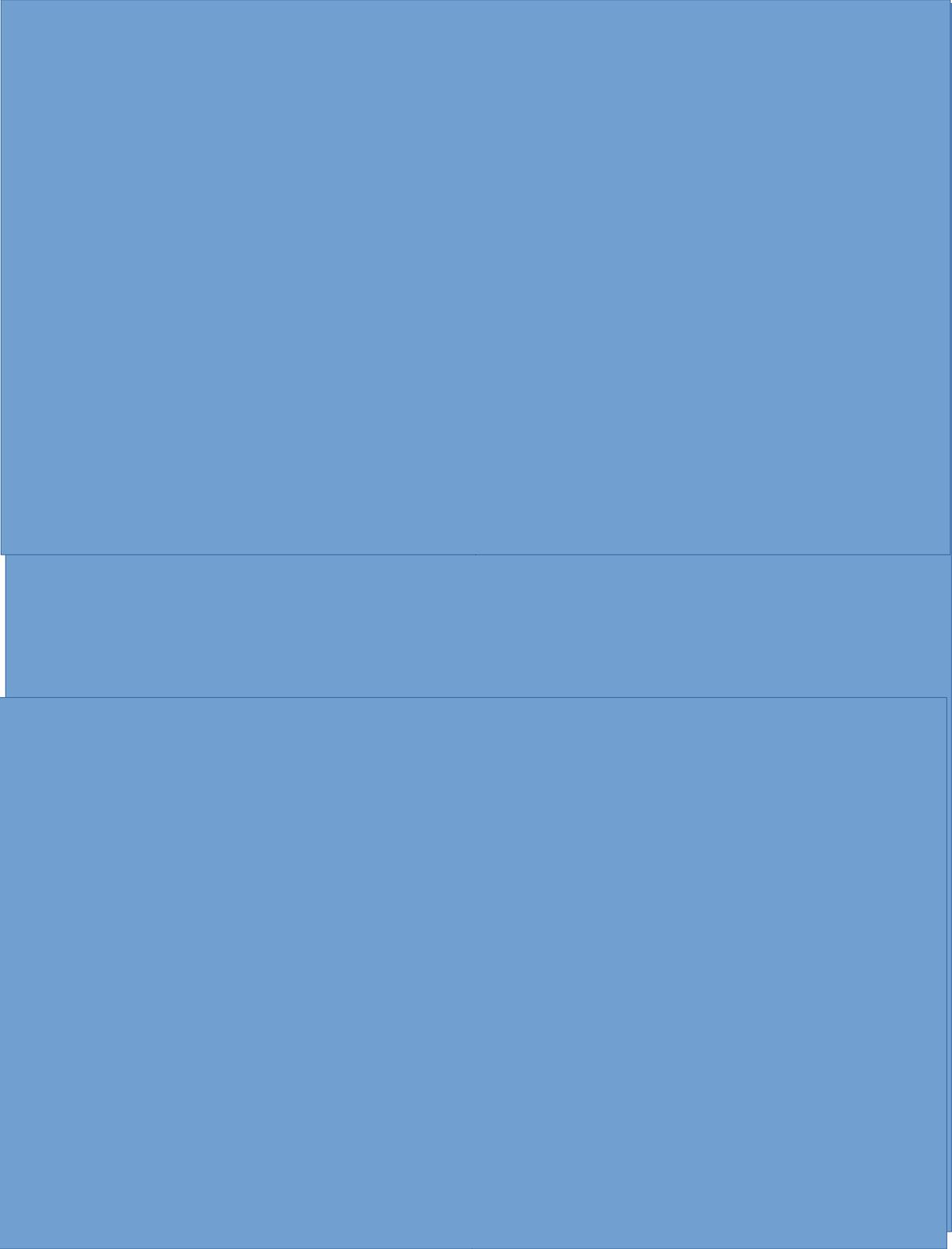
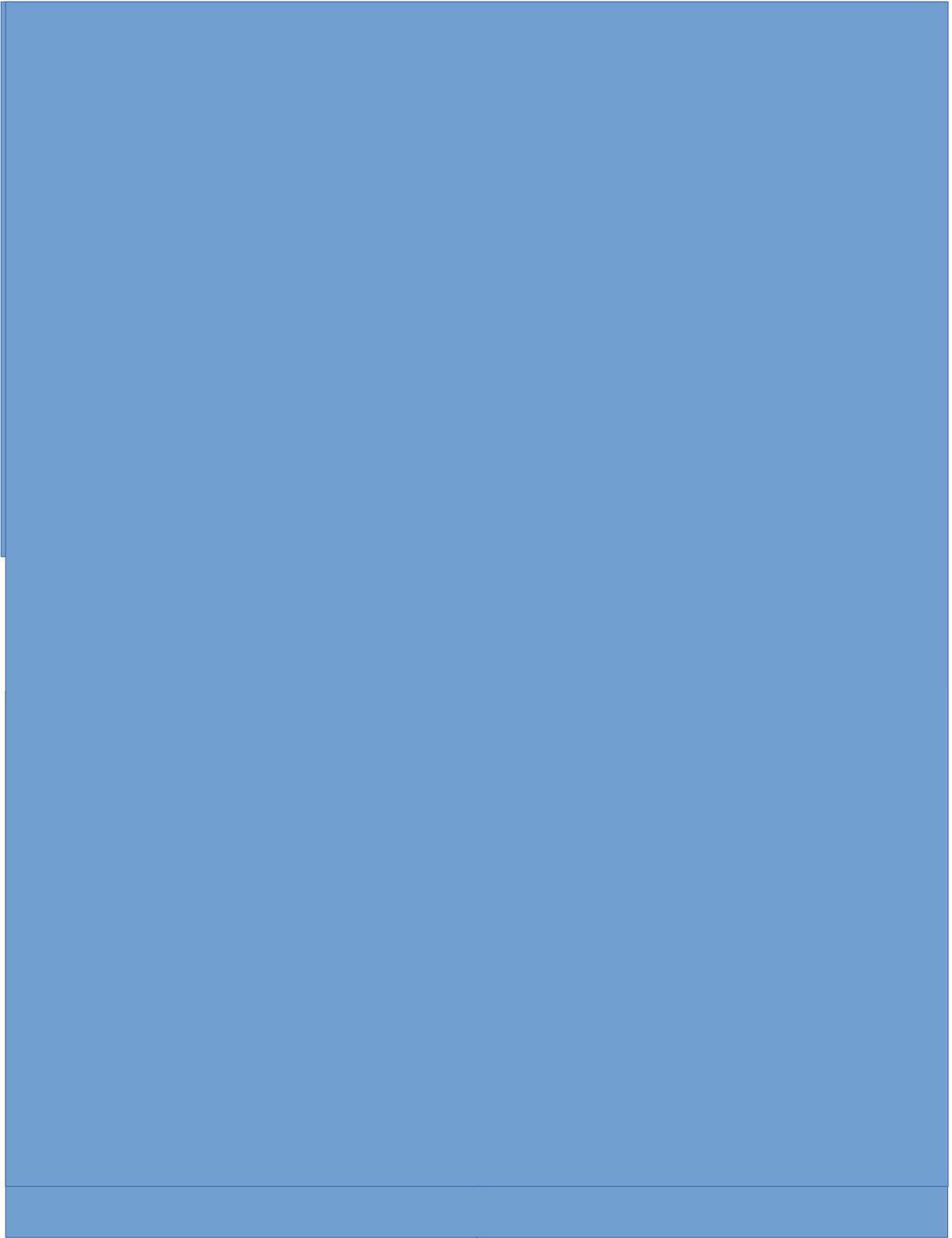
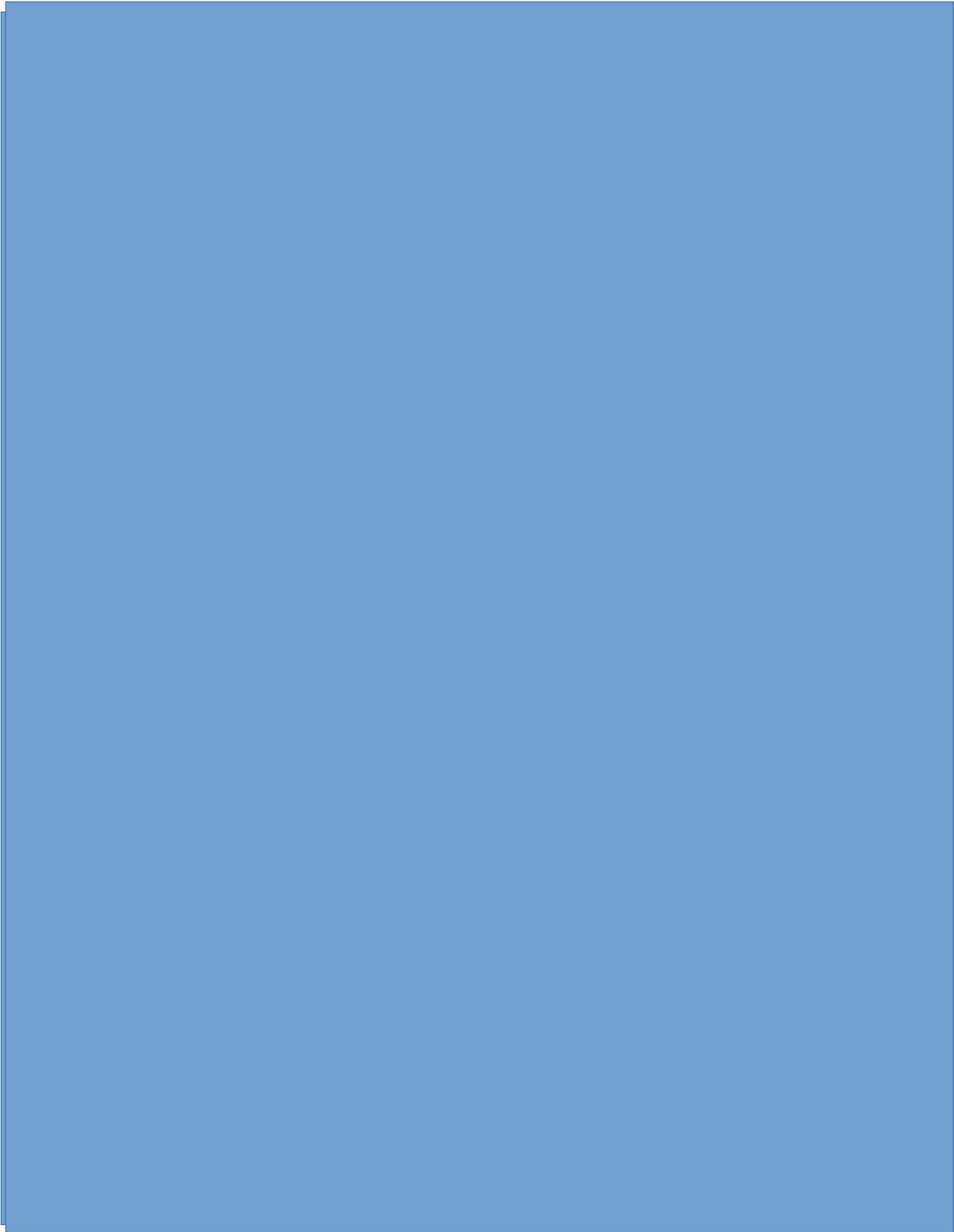


Figure 5. Alfalfa seed lygus bug population level. Arrows denote insecticide applications. A pre-bloom application was made on June 6. Malheur Experiment Station, Oregon State University, Ontario, OR.







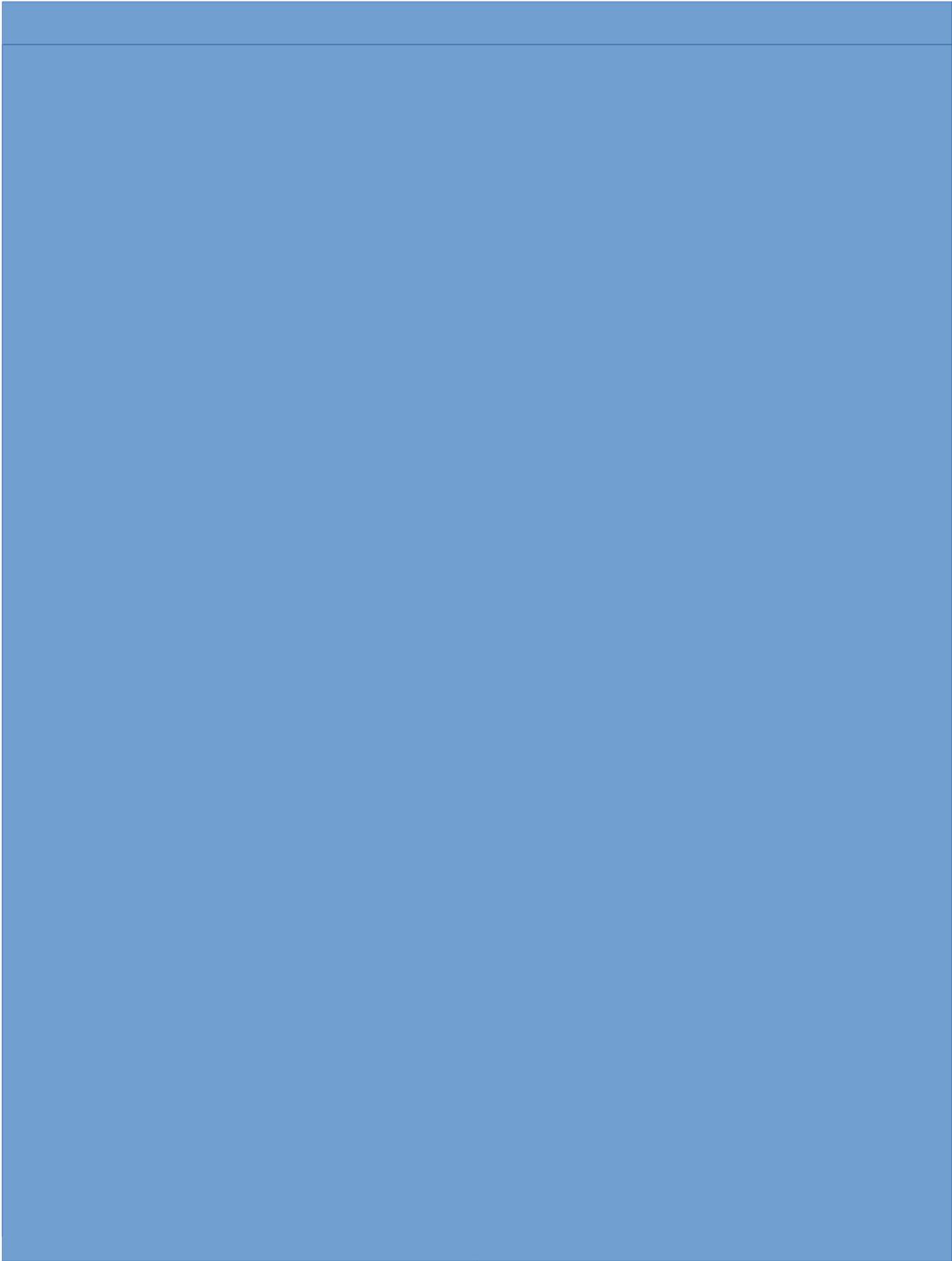




Figure 6. Alfalfa seed yield response to E_t replacement. Both excessive water stress and abundant irrigation decreased seed yields. Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 7. Alfalfa seed yield response to total water applied. Both excessive water stress and abundant irrigation decreased seed yields. Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 8. Response of alfalfa dry matter yield fraction to total water applied. Malheur Experiment Station, Oregon State University, Ontario, OR.