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A Novel Irrigation System (Water Pillow) with Mulching Effect for the Control of Weeds in Soybean Plants of Arid and Semi-arid Regions

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Abstract: The mulch effect of a new irrigation system, Water Pillow (WP), on the growth of weeds was investigated. The objective of this study was to determine the effects of this novel system on growth of weeds in soybean. The system evaluated for the weed controlling ability. Also the effectiveness of WP was investigated for the preservation of irrigation water. WP covers most of the furrow surface and prevents soil from entering sunlight. In this study, WP was laid over the soil surface between rows throughout the furrow length and prevented weed germination and the growth. WP in various diameters (28, 34.6 and 40 cm), with various covering area, was placed between the rows in which the effect of mulch was tested. The results showed that the fresh and dry weight of weeds decreased as the diameter of WP increased. The lowest fresh (3.0 g) and dry (1.1 g) weight of weeds were obtained from the treatment of 40 cm diameter of WP. All treatments of WP were found statistically different from the control treatment in respect to biomass accumulation. Also, the 40 cm diameter of WP contributed 11.1% crop yield increment compared to the control treatment. Crop yield obtained from the 34.6 cm diameter of WP was also higher than the control treatment. However, the 28 cm diameter of WP was not much effective when compared to the control treatment in respect to crop yield. The main benefit of this system not only provides weed control but also reduces irrigation and evaporation. With the introduction of this method, the use of herbicides and labor were significantly reduced. Therefore, it would be a useful tool for the Integrated Weed Management.

Key words: Weeds, Water Pillow (WP), soybean, mulch

INTRODUCTION

Weeds reduce crop productivity by competing with soybean for nutrients, water and light and thus, they reduce both the yield and the quality[1]. Crop yield reductions due to weed competition can be vary with both environmental and cultural conditions[2]. There are several methods such as chemical, mechanical, physical, biological and cultural for the control of weeds. The current trend in agricultural production is to reduce the use of pesticides due to the side effects of herbicides on environment and non-target organisms[3]. Therefore, an alternative method should be explored. One of the possible alternative methods for the control of weeds is the use of mulch. For centuries, mulching has been recognized a beneficial practice in agronomic systems where, it often enhances growth and yield of crops[4-8]. Park *et al.*[5] recorded seed yield increase in soybean by 18% with transparent film and by 15%with black film.

Plastic mulch generates these benefits though increased soil temperature and suppression of weeds growth. In addition to favorable temperature, plastic mulch also provides some positive impact in the area of non-chemical pest control. Hu *et al.*[4] reported that the high temperatures created at the soil surface reduced soil-borne diseases. A mulch may take many forms: a living plant ground cover, loose particles of organic or in organic matter spread over the soil or sheets of artificial or natural material laid on the soil surface[9]. The use of black polypropylene woven mulch is usually restricted to perennial crops and other situations where long-term weed suppression is required[9]. Various colors of woven and solid film plastics have been tested for weed control in the field[5,10]. White and green coverings had little effect on weeds, whereas brown, black, blue and white on black (double color) films prevented weeds emerging[11]. Therefore, black polyethylene mulches are commonly used for weed control in a range of crops. So far, there

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seems to be no record for the use of mulch in the soybean for the control of weed.

For the efficient use of water in field crops, weed control occupies an important place. Because, many weed species compete for the sunlight and nutrients and absorb more water from dry soils than soybean[5]. In arid regions, preservation of water as well as weed control can be quite vital for the soybean production. Because, water is the main factor in soybean production and also it is a component of the plant biochemical system. Water stress during reproductive development resulted in important decreases of plant physiological activity,vegetative growth and productivity and had a visible impact on plant canopy architecture at both stresslevels[11].

In arid and semi arid regions, irrigation frequency enhanced leaf area development, crop growth and seed yields of soybean[12].

So far, several studies have been reported on the effect of mulch and irrigation systems separately for the crop production. A novel system (WP) which includes both irrigation and the effect of mulch for the control of weeds and the enhancement of irrigation efficiency[13,14]. An experiment has been designed to study the effect of this system on the soybean yield in relation to weed control and water management.

MATERIALS AND METHODS

Experimental design and site conditions: The experiments were conducted on silty clay soil with pH 7.7 during the 2002-2003 growth seasons at the University of Harran, Agricultural Research Station, Sanliurfa, Turkey. Average temperatures of experimental area were 28.6°C in June, 32.6°C in July, 32.7°C in August and 26.4°C in September. There were 5.2 and 0.1 mm rainfall in June and September, respectively. However, no rainfall was recorded in July and August during growing period. Relative humidity was 35, 29, 32 and 42% in June, July, August and September, respectively.

The experiment was conducted in a Randomized Complete Block Design with three replications. Each plot was 2.8 by 10 m long with four rows (apart 70 cm) and 1 m space was left between plots. Seeds of soybean (A3925 cultivar) were sown into 3 cm depth by hand and the crops were thinned in every 5 cm inter-rows following emergence to maintain uniform density. Plots were fertilized with 60 kg ha^{-1} of N, P_2O_5 during sowing and 40 kg ha^{-1} of N during flowering stage in urea form. The plots were then sprayed with water to enable emergence of the plants.

Weed and crop measurement: Naturally occurring weed populations were used in all trials. Weed infestations and biomass were evaluated in the middle of each plot by classifying and counting weeds in a 1 m^2 quadrate per plot. For assessment of the biomass, plants of each weed species were cut off the ground level two days before the harvest and the fresh weight was recorded then dried at 70°C for 48 h, finally dry biomass was determined.

Data were recorded from the middle rows of which 1 m from both front and rear end of the plots were excluded to avoid the border effect for the precise soybean yield assessment. At the harvest stage, the crops were cut off the ground level then seeds were gradually separated from the pods by drying them under the sunlight.

Design of the system: WP system (300 μm in thickness) in various diameters, (A) 28, (B) 34.6, © 40 cm, with various cowering area (41, 49 and 56 cm between rows, respectively) and various volumes, at full capacity, (0.615, 0.940, 1.256 m^3, respectively) placed into the rows in which the effect of mulch was tested. Micro holes (2 mm in diameter) were placed beneath the

Fig. 1: A view of mulch effect irrigation system, WP in soybean

WP (10 m long) with 50 cm intervals to maintain water leakage. The system provided 356.0 mm water for A, 536.8 mm water for B and 712.0 mm water for C. An open furrow irrigation which provided 712.0 mm water was served as a control treatment. WP was filled up with water every 10 days from 11th of July till 10th of September 2003 to sustain plant development. WP was placed in every other row (Fig.1). In addition, there were untreated plots served as control.

Statistical analysis: Statistical analysis of the data was performed by using the SPSS for Windows statistical data analysis package program[15].

RESULTS

Weed assessment: Density of weeds (number of weed m^{-2}) and their biomass were used to assess the preventive effect of WP for the control of weeds. WP system reduced the weed density (Table 1). The most common weeds were *Amaranthus albus* L., *Convolvulus arvensis* L., *Cynodon dactylon* (L.) Pers., *Glycrrhiza glabra* L., *Prosopis farcta* (Banks and Sol.) Mac., *Sorghum halepense* (L.) Pers. and *Xanthium strumarium* L. in the experimental area. All WP treatments resulted in a significant ($p<0.001$) reduction in both density and fresh and dry matter contents of weeds when compared to the control group (Table 1). Fresh and dry matter contents of weed decreased as the diameter of WP increased (Table 1). The lowest fresh (3.0 g) and dry (1.1 g) matter contents of weeds were obtained from the C-treatment of WP. There were no significant differences between A and B treatment in respect to fresh and dry weight matter contents. All treatments were found to be statistically different from the control treatment in respect to biomass accumulation.

Table 1: Densities of weed species m^{-2} in the plots treated with A, B, C and control and their total fresh and dry matter accumulation per m^{-2}

Treatment	Weed species	Density	Fresh weight (g)	Dry weight (g)
A	*Cynodon dactylon* (L.) Pers.	5		
	Sorghum halepense (L.) Pers.	10	107.8±7.54b	40.8±5.36b
	Xanthium strumarium L.	4		
B	*Amaranthus albus* L.	1		
	Sorghum halepense (L.) Pers.	3	100.1±3.75b	27.6±2.11b
	Xanthium strumarium L.	2		
C	*Cynodon dactylon* (L.) Pers.	3		
	Sorghum halepense (L.) Pers.	1	3.0±0.52a	1.1±0.11a
Control	*Convolvulus arvensis* L.	1		
	Cynodon dactylon (L.) Pers.	10		
	Glycrrhiza glabra L.	2	283.6±38.58c	101.6±12.05c
	Prosopis farcta (Banks and Sol.) Mac.	4		
	Sorghum halepense (L.) Pers.	5		
	Xanthium strumarium L.	10		

±SE, Different letter in the columns indicate differences between treatments

Table 2: The effect of different treatment of WP on crop yield

Treatments	Yield (kg da^{-1})
A	134.6±3.3c
B	205.3±3.6a
C	225.9±2.0b
Control	203.3±2.5a

±SE Different letters in the columns indicate the differences between treatments

Crop yield assessment: The crop production in treatment A was not higher than the control group (Table 2). The crop production, in fact, was significantly lower than the control group. However, treatment C, gave higher production than the control treatment. Statistically A and C treatments were found significantly different from B and Control treatments and no differences were found between Control and B treatment (Table 2).

DISCUSSION

The WP system reduced both weed biomass and weed density. Weeds significantly reduced the yield of soybean. However, the WP system effectively prevented weed growth due to long-term weed suppression. Black polyethylene mulches are used for weed control in a range of crops[11,16,17]. Hanada[16] reported that black polyethylene film gave effective weed control by cutting down solar radiation by more than 90% resulting from etiolated growth. The death of weeds eventually occurred under the film. Results of present study confirm this finding. In this experiment, weeds were not able to grow between rows. Results showed that WP system could be used for the control of weed in soybean cultivated field effectively, which is an alternative way to chemical and other control methods. So far, there has been no report available for the use of mulch in soybean. Therefore, this study has demonstrated an irrigation system with mulching effect in soybean cultivation. In this system, water goes to a target plant, in which a drop of water is used as effective as in a drip irrigation system. However, it is different from a drip irrigation system in that it has offers a covering area like mulch effect. Either drip irrigation or mulch effect has lack of this feature. So, the system covers the surface of the soil and prevents weed germination. The preventive effect resulted in higher yield and lower weed density and weed biomass. Plastic tube also prevented soil entering from the sunlight; therefore, spread and development of weeds were minimized. As a result, no herbicides were applied to the soil.

Results also showed that the system provided higher yield than that of the control treatment. It is known that irrigation in warm climate is crucially essential for the crop development. In addition to that, high temperature also results in evaporation. Therefore, the system reduced evaporation and increased the use of water efficiency.

Weeds are the source of main exploitation factors for water and nutrition in crop production. Conley[18] reported that soybean yield loss increased linearly as giant foxtail (*Seteria faberi*) shoot biomass increased. Allowing common waterhemp (*Amaranthus rudis*) interference to persist 10 week period reduced soybean seed yield by an average of 43%[19]. There is also evidence that cocklebur (*Xanthium* sp.) is competitive for water under conditions of limiting soil moisture. Those above weeds exploit a greater volume of soil for water than soybeans. Some of these weeds such as *Amaranthus albus*, Cynodon dactylon, *Convolvulus arvensis*, *Glycrrhiza glabra*, *Prosopis farcta* and *Xanthium strumarium* densities were also reduced with the help of WP (Table 1). Results of experiment also showed that the treatment B contributed crop production as great as control treatment although much less amount of water was applied. However, in treatment C, as the amount of water reached the level of control treatment (712.0 mm water) the increase in crop production was significant (Table 2). This clearly demonstrated that WP is more efficient than open irrigation system both in controlling weeds and increasing in crop production.

The control of weeds with this system will be helpful to conserve water and plant nutrition, especially, where water shortage occurs. From the results, it can be concluded that the system is efficient for the weed control and it provides an effective use of water by reducing densities of weeds. It is also practical to use in other row crops.

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