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Araştırma Makalesi/*Research Article (Original Paper)*

The Effects of the Pass Number of the Planker on Soil Physical Properties, Plant Growth and Weed Species in Cotton Agriculture

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Abstract: In cotton (*Gossypium hirsutum* L.) agriculture, very loose soil results in reduced seed emergence and stand establishment because the contact between soil and seed is deficient. Therefore, the use of a planker before planting may help firm seedbeds and improve stand establishment. The objective of this study is to determine the effects of different pass numbers of the planker on soil bulk density, moisture content and cotton seed emergence. Also, weed species and plant growth parameters were determined in the study. The five treatments including different soil planking levels (P0, untreated control; P1, one pass of planker; P2, two passes of planker; P3, three passes of planker; P4, four passes of planker) was compared by using completely randomized block design with three replications. The results of the study indicated that while the soil bulk density and moisture content was increased with increasing the pass number of planker, multi-pass of planker significantly reduced seed emergence rate and SPAD value. The highest seed cotton yield per plant was found at P1 (one pass of planker) treatment. Also, soil planking levels affected the weed species and the density of this species. Control plots (P0) had higher weeds species than other treatments. In conclusion, the findings of this research suggest that multi-pass of planker may reduce seed emergence and cotton yield although it increases the moisture content at 0-10 cm soil depth which has positive effect on seed emergence, under the soil and climate conditions like the experimental field.

Keywords: Bulk density, Cotton, Moisture content, Seed emergence, Soil planking

Pamuk Tarımında Tapan Geçiş Sayısının Toprağın Fiziksel Özellikleri, Bitki Gelişimi ve Yabancı Ot Türlerine Etkisi

Öz: Pamuk (Gossypium hirsutum L.) tarımında, toprağın fazla gevşek olması, tohumun toprakla temasını azalttığı için bitkinin çimlenmesi ve çıkışında düşüşlere neden olmaktadır. Bu nedenle, bitki çıkış oranını ve gelişimini artırmak için ekim öncesi tarlaya en az 2-3 kez tapan çekilerek, toprak bastırılmaktadır. Bu çalışmada, tapanın farklı geçiş sayılarının, toprağın hacim ağırlığı, nem içeriği ve tohum çıkış oranına etkisinin belirlenmesi amaçlanmıştır. Ayrıca, çalışmada yabancı ot türleri ve bitki gelişim parametreleri belirlenmiştir. Beş farklı tapan geçiş sayısının (P0, kontrol; P1, tapanın bir defa geçişi; P2, tapanın iki defa geçişi; P3, tapanın üç defa geçişi; P4, tapanın dört defa geçişi) denendiği çalışma, tesadüf blokları deneme desenine göre, üç tekerrürlü olarak yürütülmüştür. Çalışmanın sonuçları, tapan geçiş sayısındaki artışın, toprak hacim ağırlığı ve nem içeriğinde artış meydana getirdiğini, fakat bitki çıkış oranını ve SPAD değerini önemli ölçüde azalttığını göstermiştir. En yüksek bitkideki kütlü pamuk verimi, P1 uygulamasında elde edilmiştir. Ayrıca, tapan geçiş sayısının, deneme alanındaki yabancı ot tür sayısını da önemli düzeyde etkilediği görülmüştür. Kontrol parsellerindeki yabancı ot tür sayısının daha yüksek olduğu gözlenmiştir. Sonuç olarak, bu denemenin sonuçları, ekim derinliğindeki toprağın nem içeriğini olumlu yönde etkilemesine rağmen, aynı iklim ve toprak koşullarında tapanın birden fazla geçiş sayısının bitki çıkış ve veriminde düşüşlere neden olabileceğini göstermektedir.

Anahtar kelimeler: Toprak hacim ağırlığı, Pamuk, Nem içeriği, Tohum çıkış oranı, Tapan çekme

Introduction

Planker have long been used to improve soil–seed contact for more uniform crop emergence and subsequent plant growth in cotton agriculture because soil planking may create better growth conditions for cotton seeds by improving the physical characteristics of the soil (Montemayor 1995). Successfully to initiate germination, emergence and establish in a mature plant, a seed needs specific soil conditions such as moisture, temperature, air. One of the most important factors for seed germination is water absorption of seed from soil. It is reported that high levels of seed-soil contact is required for this absorption process (Smet et al. 1999; Bewley et al. 2013). However, soil planking may result in reduced yield due to excessive soil compaction and decreasing plant root penetration because it reduces pore spaces between soil particles by increasing soil bulk density and penetration resistance. Hanks and Thorp (1956) reported that its germination and emergence can be reduced due to lack of oxygen if the seed stays in the saturated soil for a long time. Gemtos and Lellis (1997) determined that the increased soil compaction decreased root growth and delayed seed emergence in cotton as a result of increased soil compaction. Chen et al. (2014) reported that excessive compression can reduce the absorption of nutrients by plants as well as the infiltration and redistribution of water in the soil. The degree a planker can compact the soil varies with the water content of the soil, soil texture and the force of compaction applied to the soil (Mamman and Ohu 1998; Shahgholi and Jnatkhah 2018). Although it is expected that seed-soil contact can be increased by soil planking, an important question is: which amount of soil compaction is beneficial and at which point of soil compaction the seed germination rate decreases according to soil conditions. The objective of this study is to investigate the effects of different pass numbers of a planker on soil physical properties (bulk density, moisture content), seed emergence, SPAD value, and yield and weed species in cotton agriculture.

Materials and Methods

The experiment was established at a farmer's field in Diyarbakır province in South East Anatolia region of Turkey during cotton growing season of 2018. The characteristics of the experiment site are: 630 m above sea level (latitude: 37°55'36'' N, longitude: 40°13'49'' E). Mean monthly air temperature and rainfall during the growing season of the experiment (April-October) are shown in Fig.1. The rainfall at experimental growing season was significantly higher than long-term average at May after cotton planting. There was no much difference between mean monthly air temperatures of long-term years and 2018. Post-planting rainfall and soil temperature may significantly influence seedling emergence and growth (Berti et al. 2008).

The field had a clay loam soil with pH of 8.03, organic matter content of 1.58%, total salt of 0.08%, $CaCO_3$ of 6.08%, saturation with water of 62.7% at 0-20 cm soil depth. The soil moisture content and bulk density before the application of the treatments are given in Table 1.

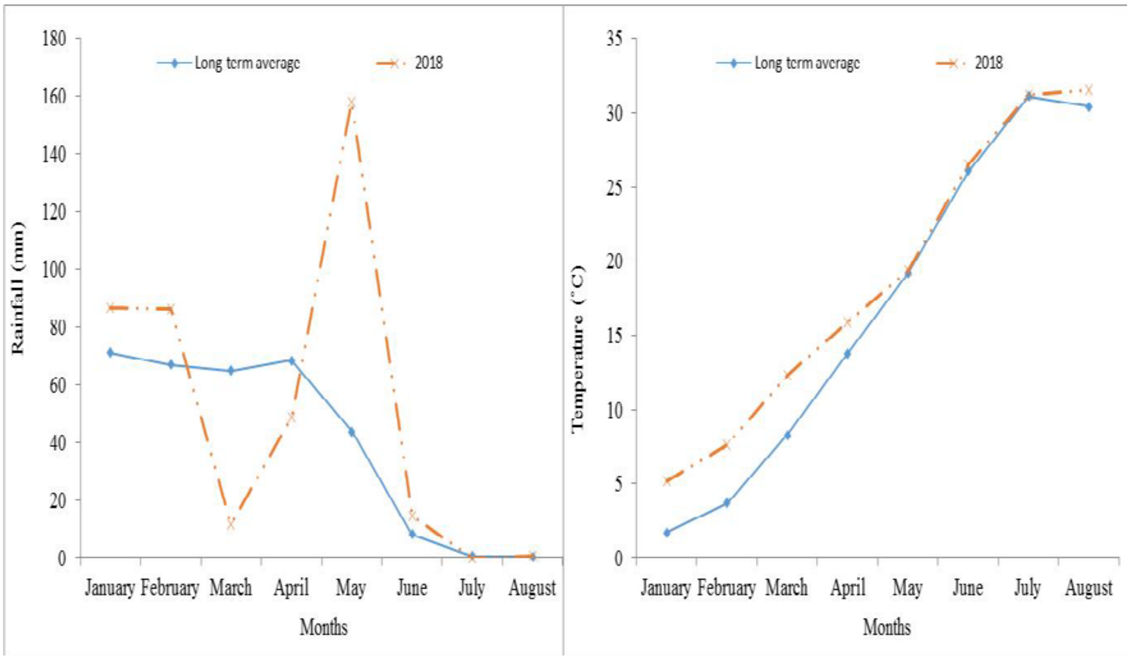

Figure 1. Total monthly rainfall and average monthly temperature during experiment year and long-term average rainfall and temperature at Diyarbakır.

Table 1. The soil moisture content and bulk density at 0-20 cm soil depths before the application of the treatments

Soil parameters	0-10 cm		10-20 cm	
	Mean	SD	Mean	SD
Moisture content (%, d.b.)	12.96	1.07	26.82	2.42
Bulk density (g cm^{-3})	0.92	0.2	1.02	0.45

The previous crop in the experiment field was cotton and the cotton stalk was chopped and evenly spread over plots. Moldboard plowing to 20 cm was applied as primary tillage in November and the experiment field was tilled by cultivator (10 cm) after broadcasting the fertilizer (20-20-0%, N-P_2O_5-K_2O for supplying 60 kg N plus 60 kg P_2O_5 ha^{-1}) in April. A completely randomized block design with three replications was used for the experiment. Treatments included five different soil planking levels: untreated control (P0), one pass of planker (P1), two passes of planker (P2), three passes of planker (P3), and four passes of planker (P4).

The plots were 6 m wide to accommodate the planker width and 30 m long. A rectangular planker was pulled by New Holland T6600 tractor with 4-wheel-drive (119 kW) at 5.4 km h^{-1}. The length, width and weight of planker were 600 cm, 20 cm, 1200 kg, respectively. Its weight per meter was calculated as 200 kg m^{-1}. The first passing of planker was applied on 15 April 2018, and other passing was applied two days after the first passing of planker. A pneumatic precision seed drill was used to plant the cotton seed of 20 kg ha^{-1} at on approximately 5 cm depth two days after application of treatments. Machine hoe was used to loose, aerate the soil and control the weeds three times. Also, the lister was used to apply the top-dress fertilizer (100 kg ha^{-1} ammonium nitrate) and make the furrow before the first irrigation.

The experimental plots were irrigated by furrow irrigation system. The first irrigation was applied 60 days after the seeding and the latter irrigations were applied by 7 times at approximately 11-13 days intervals during growing season. For a given irrigation, all plots received the same amount of water.

Soil moisture content and bulk density were determined by the core sampling method. Soil samples were taken from undisturbed soil at two random locations of each plot before application of treatments and two days after planting. The soil moisture content (dry basis) and dry bulk density was calculated by using the initial weight and the weight after oven-dried at 105 °C for 24 h of soil samples.

Seed emergence rate was determined as the ratio of plants emerged about 15 days after planting to seeds sown on 1 m of two center rows.

SPAD values were measured by “SPAD-502” meter on the upper fourth leaf at early square growth stage according to Li et al. (2014).

To determine seed cotton yield per plant, ten plants randomly selected at each plots was harvested by hand. Each plot sample was weighted and divided by ten to calculate seed cotton yield per plant.

Weed species were recorded through all treatments before the first hoeing and their density was classified using *, **, ***, **** scale, which is modified from Uremis (2005).
*, represents weed density <1 weeds m^{-2}
**, represents $1\leq$weed density<2 weeds m^{-2}
***, represents $2\leq$weed density<3 weeds m^{-2}
****, represents ≥ 3 weeds m^{-2}

The JMP statistical software package was used to perform the analysis of variance (ANOVA). The means between five treatments were compared with LSD’s multiple range tests at the significance level of 0.05.

Results and Discussion

Figure 2 shows the variation of bulk density at different pass numbers of planker. Soil bulk density was significantly increased with increasing the pass number of planker at both 0-10 and 10-20 cm soil depths. While the highest soil bulk density was found at P3 treatment at 0-10 cm depth, it was the highest at P4 at 10-20 cm. It is known that soil bulk density is one of the important factors affecting both shoot and root growth, and nutrient uptake of plants. Several researchers (e.g. Silva et al. 2012, Falkoski Filho et al. 2013, Dias et al. 2015) reported that increasing soil bulk density resulted in reduced root growth. Falkoski Filho et al. (2013) found that increasing soil bulk densities from 1.20 to 1.60 g m^{-3} resulted in a 50% reduction in root growth in cotton cultivars. Also, Parlak and Özaslan Parlak (2011) found that the increase in bulk density caused a significant decrease in dry root and shoot weights of plants such as hairy vetch (*Vicia villosa* Roth.), common vetch (*Vicia sativa* L.), Italian ryegrass (*Lolium italicum* Lam.) and barley (*Hordeum vulgare* L.).

While the pass number of planker significantly affected soil moisture content at 0-10 cm, there was no significant difference among treatments at 10-20 cm soil depth (Fig.2). Two times passes of planker significantly resulted in increasing the soil moisture content at 0-10 cm depth. This leads to the hypothesis that soil planking capillarity brought the water to the surface. Also, it may prevent the soil moisture by evaporation (Tong et al., 2015).

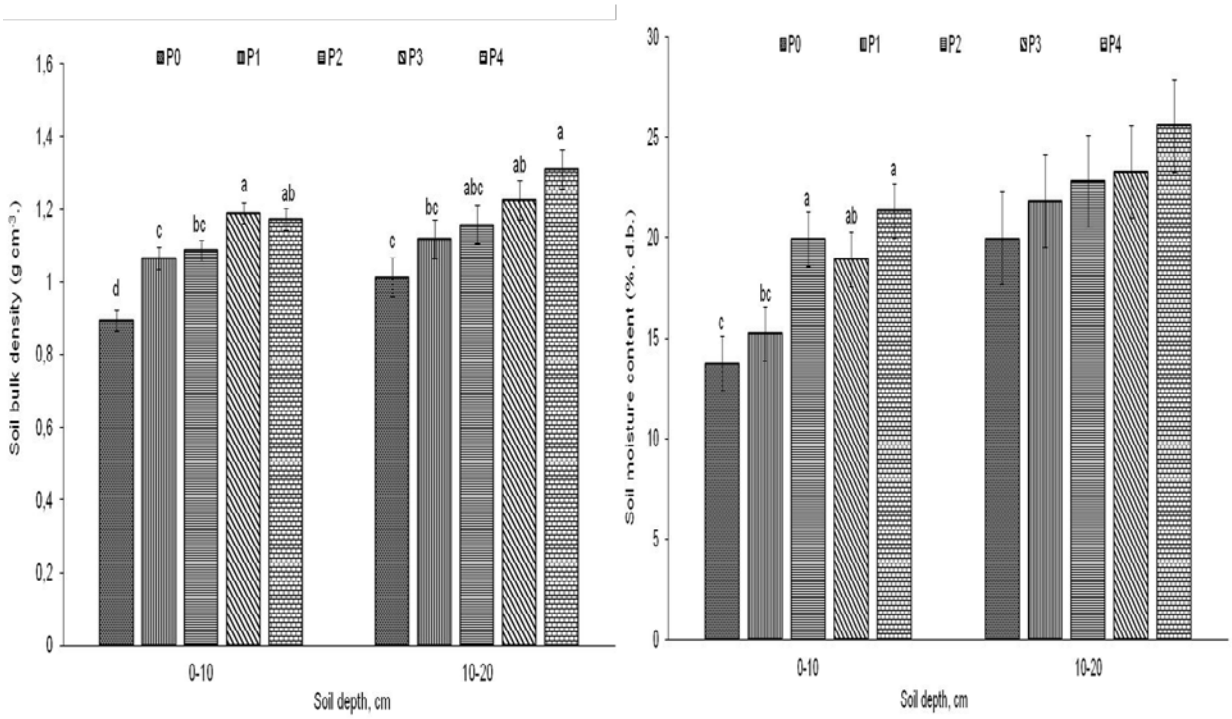

Figure 2. Effects of the pass number of planker on bulk density and moisture content at 0-10 cm and 10-20 soil depths. P0, untreated control; P1, one pass of planker; P2, two passes of planker; P3, three passes of planker; P4, four passes of planker. Means followed by different letters are significantly different according to LSD's multiple range test at the significance level of 0.05.

Seed emergence rate was affected by the pass number of planker. The highest seed emergence rate was found at P0 treatment. The use of planker significantly decreased the plant stand of cotton. There was no significant difference among the pass of planker in two, three, four times (Fig. 3). Effect of planking levels on seed emergence rate may be affected by post planting rainfall because the precipitation after planting cause the natural settlement of the soil near seed zone. As seen in Fig.1, the fact that high rainfall after planting excessively increased soil moisture content may result in low soil oxygen rate and temperature and therefore decreasing seed emergence rate.

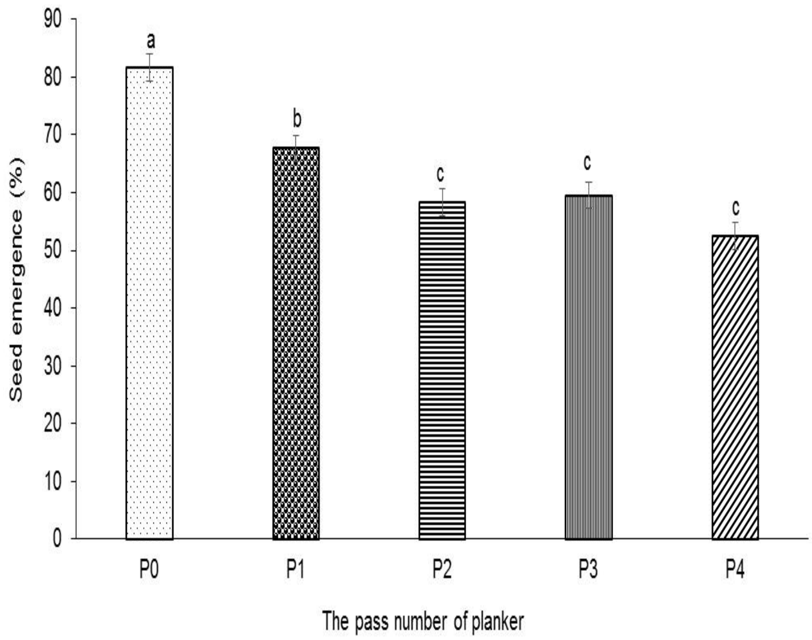

Figure 3. Seed emergence rate affected by the pass number of planker. P0, untreated control; P1, one pass of planker; P2, two passes of planker; P3, three passes of planker; P4, four passes of planker. Means followed by different letters are significantly different according to LSD's multiple range test at the significance level of 0.05.

Chlorophyll content of cotton measured by SPAD meter was significantly affected by planking levels. While the highest SPAD value was found at P0, there was statistically no significant difference between P0 and P1, and among P1, P2, P3 and P4 treatments (Fig.4). SPAD meter can quickly measure the relative value of chlorophyll content in leaf blades and this information can be used to diagnose the nutrition status of plants. A higher SPAD value indicates higher the nutrient uptake of plant from soil (Sadras et al.2005). Therefore, SPAD value decreased by increased planking levels shows that soil compaction will reduce the nutrient uptake of plant from soil. Lipiec and Stcpniewski (1995) reported that the effect of soil compaction on transport of nutrients to the roots depends on the amount of soil compaction and water and nutrient supply.

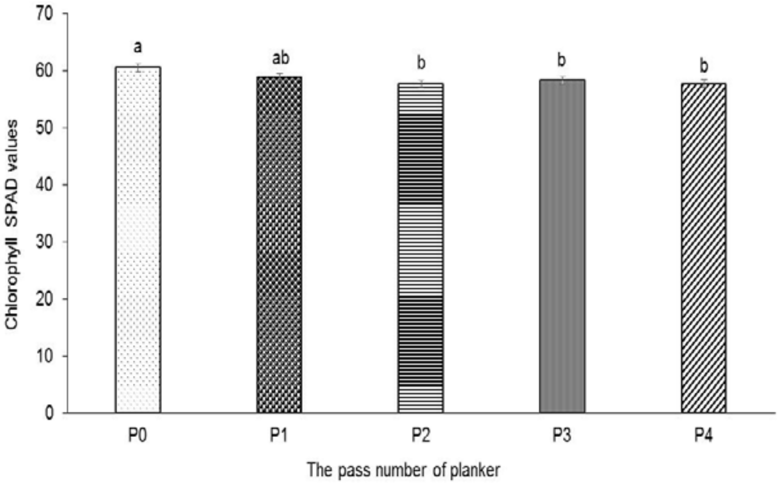

Figure 4. Chlorophyll SPAD values affected by the pass number of planker. P0, untreated control; P1, one pass of planker; P2, two passes of planker; P3, three passes of planker; P4, four passes of planker. Means followed by different letters are significantly different according to LSD's multiple range test at the significance level of 0.05.

The seed cotton yield per plant affected by the pass number of planker is demonstrated in Fig. 5. The highest value of seed cotton yield per plant was obtained as 42.33 g per plant at the one pass of planker (P1) whereas the lowest seed cotton yield was found to be 31.13 g per plant at four passes of planker (P4). The P1 treatment was followed by P2, P0, P3 treatments, respectively. But, there was not statistically difference among those treatments. Crop yield depends on many factors such as soil properties and environmental conditions (Agnew and Carrow, 1985). Soil planking significantly changes soil properties, therefore crop yield. Hultgreen (1990) found that packing pressures of 17 kg (167 N) significantly increased wheat yield. Johnston et al. (2003) found that the effect of soil packing levels on canola yield significantly changed according to climatic conditions in 1997, 1998 and 1999. They determined that increasing packing force improved canola grain yield at dry conditions after planting.

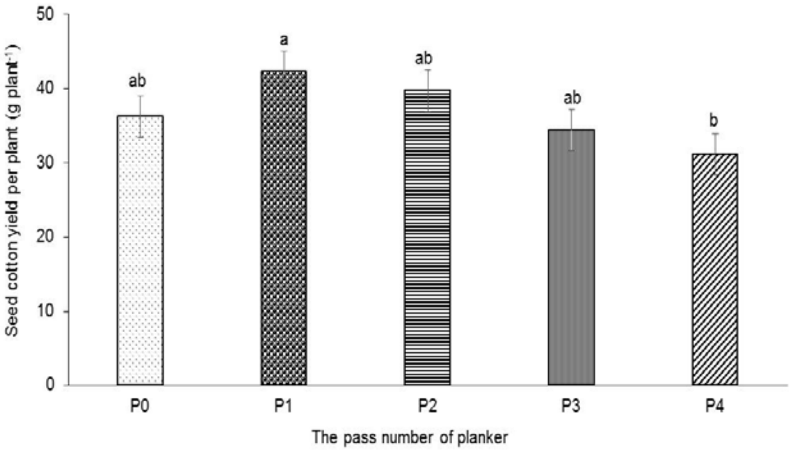

Figure 5. Seed cotton yield per plant affected by the pass number of planker. P0, untreated control; P1, one pass of planker; P2, two passes of planker; P3, three passes of planker; P4, four passes of planker. Means followed by different letters are significantly different according to LSD's multiple range test at the significance level of 0.05.

The weed species affected by the pass number of planker are prensented in Table 2. The number of weed species was the greatest at P0 among treatments. Also, P0 had the highest density of Bermudagrass (*Cynodon dactylon* (L) Pers.) and Field bindweed (*Convolvulus arvensis* L.). However, It was found to be the highest density of Common reed (*Phragmites australis* (Cav.) Trin ex.Steud) at P1, Little hogweed (*Portulaca oleracea* L.) and Giradol (*Chrozophora tinctoria* (L) Rafin.) at P2. Common reed (*Phragmites australis* (Cav.) Trin ex.Steud) was the highest density (≥3 plants m^{-2}) in P4 treatment among all treatments. This shows the effect of soil packing on weed density change according to weed species. Çelik and Altıkat (2006) reported that soil tillage and compaction is one of the most important agricultural practices affecting weed seed distribution in the tilled layer and their emergence capability. They found that weed density increased as row compaction level decreased. Similarly, Yalcin et al. (2003) stated that tillage system applied in cotton farming has a considerable role in the development of weed population. They determined that the amount and density of weed in cotton farming with reduced tillage were higher than the conventional tillage.

Table 2 Weed species affected by different pass numbers of planker

Weed species				
P0	P1	P2	P3	P4
Bermudagrass (Cynodon dactylon, (L) Pers.)***	Common reed(*Phragmites australis* (Cav.) Trin ex.Steud)***	Little hogweed (*Portulaca oleracea* L.)***	Common reed (*Phragmites australis* (Cav.) Trin ex.Steud)*	Flower-of-an-our (*Hibiscus trionum*)*
Giradol (*Chrozophora tinctoria* (L) Rafin.)*	Little hogweed (*Portulaca oleracea* L.)*	Giradol (*Chrozophora tinctoria* (L) Rafin.)***	Purple nutsedge (*Cyperus rotundus* L.)*	Common reed (*Phragmites australis* (Cav.) Trin ex.Steud)****
Cocklebur (*Xanthium strumarium* L.)*	Black nighshade (*Solanum nigrum* L.)*	Purple nutsedge (*Cyperus rotundus* L.)*	Mexican Ground-cherry (*Physalis philadelphica* Lam.)*	Giradol (*Chrozophora tinctoria* (L) Rafin.*
Purple nutsedge (*Cyperus rotundus* L.)*	Field bindweed (*Convolvulus arvensis* L.)*	Common reed(*Phragmites australis* (Cav.) Trin ex.Steud)*	Little hogweed (*Portulaca oleracea* L.)*	Field bindweed (*Convolvulus arvensis* L.)**
Field bindweed (*Convolvulus arvensis* L.)***	Giradol (*Chrozophora tinctoria* (L) Rafin.)*	Black nighshade (*Solanum nigrum* L.)*		Purple nutsedge (*Cyperus rotundus* L.)*
Flower-of-an-our(Hibiscus trionum)	Purple nutsedge (*Cyperus rotundus* L.)*	Chamomile (*Anthemis* sp.)*		
Common reed (*Phragmites australis* (Cav.) Trin ex.Steud)*	Mexican Ground-cherry(*Physalis philadelphica* Lam.)*	Field mallow (*Malvella sherardiana* (L.) Jaub and Spach)*		
Mexican Ground-cherry (*Physalis philadelphica* Lam.)*		Mexican Ground-cherry (*Physalis philadelphica* Lam.)*		
Black nighshade (*Solanum nigrum* L.)**				

P0, untreated control; P1, one pass of planker; P2, two passes of planker; P3, three passes of planker; P4, four passes of planker. *, weed density <1 weeds m^{-2}; **, 1≤weed density<2 weeds m^{-2}; ***,2≤weed density<3 weeds m^{-2}; ****weed density≥3 weeds m^{-2}

As a result, this study indicated that while soil bulk density and moisture content at seeding depth was significantly increased with increasing the pass number of planker, seed emergence rate and SPAD value decreased in planked soil compared to non-planked. However, one pass of planker resulted in the highest seed cotton yield per plant. Also, the pass number of planker affected the weed species. The number of weed species was found to be decreased significantly in compacted soil compared to non-compacted treatments. It is suggested that multi-year and location field trials could be carried out to understand relationships between the change in soil properties by planking and crop growth because there are several natural and man-induced factors affecting the degree of the soil compaction and its effects on crop yield.

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