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Influence of Tillage System and Soil Mulching on Sesame Weed Control

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ABSTRACT

This study aimed to apply the sesame integrated weed management using tillage accompanied with soil mulching to avoid the plant injuries due to the mechanical weeding and the herbicides environmental side effects. The experiment was established and designed statistically as a split plots with three replications. The main plots involved tillage treatment levels of rotary plough as a minimum tillage, moldboard plough followed by disc harrow and chisel plough (two perpendicular passes) followed by disc harrow as a conventional tillage. The sub plots included soil mulching treatment levels of black, white and transparent polyethylene sheets (30 micron thick), comparing with bare soil. The results indicated that the rotary plough accomplished the higher actual field capacity of 0.92 fed/h and the lower specific energy requirements of 25.43 MJ/fed. While, the moldboard plough followed by disc harrow achieved the moderate soil mean weight diameter of 84 mm. The moldboard plough followed by disc harrow system accompanied with the transparent polyethylene sheet achieved the higher values of both the soil moisture content and the weed control efficiency at the periods of 7, 30 and 60 days after planting. Also, it recorded the higher sesame seed yield of 1.26 ton/fed. So, it is recommended to apply the moldboard plough followed by disc harrow and accompanied with the transparent polyethylene sheet as a proper sesame weed control method.

INTRODUCTION

Sesame is a variable annual herb. It is grown mainly for its seeds which contain 50–52% oil, 17–19% protein and 16–18% carbohydrates. There are three varieties of sesame seeds; black, white and red. The black variety yields the higher oil quality. It is used for medicinal purposes. The white seeds are extremely rich in calcium and are useful in all cases of calcium deficiency. The red variety is exceptionally rich in iron. It is emollient that softens the skin. Sesame seeds are used in cooking purposes, baking, candy and other food industries. The extracted oil from sesame seeds contains about 47% oleic and 39% linoleic acid. It is very high medicinal quality. Also, it is used in the manufacture of soaps, paints, perfumes, pharmaceutical purposes and insecticides. After the oil is extracted, the seeds contain high-protein amount of 34-50% that is useful for poultry and livestock feeding (Ministry of Agriculture and Land Reclamation, 2016).

Major factor influencing sesame yield in a competitive situation is the ratio between the relative leaf area of the weed and the crop at the time of crop canopy closure. Sesame seed is similar to the size of many weed seeds. So, seed cleaning may be difficult and some of the weed seeds may be toxic; sesame seeds require 99.99% purity. Also, sesame cotyledons are also small when they emerge compared to other crops and do not grow as fast. Consequently, the presence of weeds can reduce the sesame yield with up to 65%. Hence, sesame needs a critical weed-free period of up to 50 days after planting (Aref *et al*., 2013).

Depending on row spacing and phenotype, sesame mechanical cultivation requires careful weed management for the first 30 to 60 days after planting (Rahman *et al*., 2017). Besides the side environmental effects of the herbicides, weed control using the herbicides may lead to yellowing of the growing tip, poor growth, and lack of formation of capsules for a period of time, resulting in a critical for economic production (Vafaei *et al*., 2013).

Integrated weed management can be defined as a holistic approach to weed management that integrates different methods of weed control to provide the crop with an advantage over weeds. It is practiced globally at varying levels of adoption from farm to farm. IWM has the potential to restrict weed populations to manageable levels, reduce the environmental impact of individual weed management practices, increase cropping system sustainability, and reduce selection pressure for weed resistance to herbicides (Bhadauria *et al*., 2012 and Harker and O'donovan, 2013).

Tillage is the mechanical manipulation of the soil and plant residues to prepare an appropriate seedbed for crop planting, which have several advantages such as loosening soil, regulating the circulation of water and air within the soil, increasing the release of nutrient elements from the soil for crop growth, and controlling weeds by burying weed seeds and emerged seedlings (Rusu *et al*., 2011; Vakali *et al*., 2011; López-Garrido *et al*., 2014; Hosseini *et al*., 2016 and Najafabadi, 2017).

Mulches are defined as materials that are applied to, or grow upon, the soil surface, as opposed to material laid or grown over the soil surface. Mulch is a protective layer of either organic or inorganic material that is spread on the soil surface to reduce the moisture loss from the soil by preventing evaporation from sunshine and desiccating winds, improve soil conditions, prevent weed growth, provide home for earthworms and natural enemies found in the soil and reduce soil compaction from the impact of heavy rains (Aref *et al*., 2013; Ibrahim, 2013; Khater and Hassan, 2017 and Khedr, 2018).

The present study aimed to identify the effect of some tillage systems accompanied with soil mulching on sesame weed control.

MATERIALS AND METHODS

Experimental Site and Soil Texture

During 2017 summer season, a field experiment of one feddan (70 × 60 m) was carried out at Gallia 2nd Village, El-Dakhlia Governorate. According to the standard procedures as cited by El-Serafy and El-Ghamry (2006), the experimental site soil was mechanically analyzed at 19.28% (db) soil moisture content as shown in table (1).

Table 1. Experimental site soil mechanical analysis

Sand, %			Silt, %	Clay, %	Soil texture class
Corse, %	Fine, %	Total, %			
10.08	11.30	21.38	41.52	37.10	Silty clay loam

Agricultural practices

Tillage

The tillage was conducted as follows

1. Moldboard ploughing was conducted at 0.25 m depth using a three bottoms moldboard plough of 0.82 m ploughing width.
2. Chisel ploughing was employed in 2 perpendicular directions at 0.15m depth using a seven shanks in two rows.

3. Rotary ploughing was conducted at 0.10 m depth using 24 L-shape blades which are arranged on the total machine width (1.55 m). It was operated at rotary speed of 145 rpm (2.41 m/s peripheral speed) which was obtained by operating the tractor PTO at a speed of 540 rpm, and adjusting the gearbox position.
4. Disc harrowing was achieved at 0.10 m depth using a tandem of 3.30 m total width. It consists of four disc groups, two groups of notched discs of 0.57 m diameter in the front and two groups of completed disc edge of 0.59 m diameter in the rear. The disc spacing in each group is 0.23 m

Precision land leveling

The precision land leveling was carried out at 0.01% slope using a mounted hydraulic land leveler of 1.26 m^3 capacity (0.60 × 3.00 × 0.70 m) which was accompanied with a laser control equipment that consists of transmitter (Spectra-physics 1145 laser plane), control box (CB2MTD), receiver mast, receiver unit and telescoping grade rod (1084 English).

Soil mulching

After tillage, the soil was irrigated one day before mulching. Then, the soil was covered manually using polyethylene sheets (30 micron thick) for 30 days.

Planting

After one day from removing the mulching sheets, the selected sesame seeds of Shandweel 3 variety were planted using a pneumatic planter with a rate of 2 kg/fed at 0.02 m depth, 0.60 m row spacing and 0.20 m hill spacing apart along the same row.

A 2 WD tractor of 45 kW power was used at 3.85 km/h forward speed for moldboard, rotary and chisel ploughs and at 4.50 km/h forward speed for disc harrow and planter. The precision land leveling unit was operated using a 4 WD tractor of 90 kW power at 4.25 km/h forward speed.

All other practices were applied as recommended by Ministry of Agriculture and Land Reclamation, 2016.

Treatments and statistical design

During the experiment the following treatments were tested

1. Tillage treatment: It included levels of rotary plough as a minimum tillage, moldboard plough followed by disc harrow and chisel plough (two perpendicular passes) followed by disc harrow as a conventional system.
2. Soil mulching treatment: It included levels of black, white and transparent polyethylene sheets (30 micron thick), comparing with bare soil.

The experiment was established and designed statistically as a split plots with three replications. The main plots involved the tillage treatment levels and the sub plots included the soil mulching treatment levels.

Measurements

Implement performance

1. Actual field capacity (AFC)

It is determined as cited by Srivastava *et al*. (2006) as follows:

$$AFC = \frac{1}{ATT} \text{, fed/h} \qquad (1)$$

Where: **ATT is the actual total time required for acting one fed, hrs.**

2. Soil mean weight diameter (MWD)

According to Dimoyiannis (2009), soil samples were taken after removing the polyethylene sheets using a sampler box of 0.50 × 0.20 × 0.20 m. The soil crumbles were sieved using a set of sieves of 2, 5, 10, 20, 50 and 100 mm mesh whole diameters. The MWD is determined as follows:

$$\text{MWD} = \frac{1}{w} \text{ x } (2A + 5B + 10C + 20D + 50E + 100F)\text{, mm} \qquad (2)$$

Where: **A + V +... + G is mass of separated soil by the set, kg.**

$$W = A + B + C + D + E + F\text{, kg.}$$

3. Specific energy requirements

As cited by ASAE (2003), the auxiliary tractor of 82.8 kW power pulled the tractor-drawn tillage implement combination. The draught force is measured as the horizontal component of the force between the driving tractor and the tractor -implement combination using a spring dynamometer. The average dynamometer readings are determined when the auxiliary tractor and the tractor-implement combination are moving in sequence on the experimental soil surface. The traction force required for the tillage implement is estimated as the difference between the dynamometer reading and the pulling resistance of the 45 kW tractor which is estimated by pulling the tractor alone on the experimental soil surface. Then, the power required (P) for operating the tillage implement is calculated as follows:

$$P = 3.61 \text{ x TF x S x } 0.85\text{, MJ} \qquad (3)$$

Where: **3.61 is coefficient of changing from kWh to MJ.**
TF is traction force, kN.

$$TF = Sw \text{ x } \vartheta\text{, kN.}$$

$$P = \frac{TFxS}{c}$$

Where: **Sw is specific work, kN.m/m^3.**
ϑ is volume of tilled soil, m^3.
S is actual tractor forward speed, m/s.

$$Specific\ energy\ requirements = \frac{P}{AFC} \times 100\text{, MJh/fed} \qquad (4)$$

According to Ismail (2007), the equivalent PTO power is estimated as follows:

$$Equivalent\text{PTO power} = \frac{Px3.61x0.85}{0.80}\text{, MJ} \qquad (5)$$

Where: **0.80 is PTO loading per the maximum tractor PTO power.**

$$Specific\ energy\ requirements = \frac{EquivalentPTO\ power}{AFC}\text{, MJh/fed} \qquad (6)$$

Soil moisture content

According to El-Serafy and El-Ghamry (2006), the soil moisture content (d.b.) was determined from each plot three times during the growing season at 7, 30 and 60 days after planting.

Weed control efficiency

The weed samples were collected from each plot three times during the growing season at 7, 30 and 60 days after planting. According to Sengh *et al.* (2017), the weed samples were dried at 60ºC for 18 hrs. Then, the weed control efficiency was estimated as follows:

$$\text{Weed control efficiency} = \frac{M_b - M_a}{M_b} x100\text{, \%} \qquad (7)$$

Where: **M_a is weed dry mass after soil mulching, g.**
M_b is weed dry mass before ploughing, g.

Sesame seed yield

At harvesting time, across each plot, an area of 1 m^2 was taken randomly to determine sesame seed yield. Then, it was calculated on basis of 14% moisture content (db.).

Statistical analysis

SPSS (Version 20.0) computer software package is used to employ the analysis of variance test and the LSD tests for both weed control efficiency and sesame seed yield data.

RESULTS AND DISCUSSION

Tillage implement performance

Table (2) demonstrates that the rotary plough accomplished the higher actual field capacity of 0.92 fed/h. It is may be explained that the rotary plough creates an elemental leveled soil surface with one operation. While, the moldboard and the chisel ploughs achieve uneven soil surface, requiring a secondary tillage using the disc harrow, utilizing more time to prepare the seed bed. While, the conventional tillage utilized more time to achieve the prepared soil bed, recording the lower field capacity.

The obtained soil mean weight diameter could be arranged as the descending order: conventional system > moldboard and disc harrow system > rotary plough. This trend may be illustrated that the rotary plough cuts, breaks down and throws up behind the soil, fulfilling an excessive soil pulverization, creating a loose structure of smaller soil clods. While the moldboard plough cuts, crumbles, lefts and turns up the soil slice. This implies that the disc harrow may penetrate easily the soil. Whilst, the chisel plough breaks up the soil without converting, then, the soil clods has to be pushed only, then, the shares either penetrate it or transfer them to the sides, resulting in larger soil clods size. Then, the large clods left after chiseling reduced the disc harrow ability to penetrate the soil.

Table 2. Tillage systems performance.

Tillage system	Actual field capacity, fed/h	Soil mean weight diameter, mm	Specific energy requirements, MJ/fed
Moldboard plough + disc harrow	0.75	84	64.74
Rotary plough	0.92	46	25.43
Chisel plough (2 passes) + disc harrow	0.67	93	52.95

The recorded specific energy requirements could be arranged as the ascending order: rotary plough< conventional system < moldboard and disc harrow system. This finding is due to the proportional of energy requirements with the tilled cross-sectional area and the amount of operating the tillage implement. Using the rotary plough as a minimum tillage expended the lower specific energy requirements of 25.43 MJ/fed. The shallow tillage of the rotary plough diminishes the normal loads on the tillage elements. This decreases the soil cutting and breaking down resistance and the friction forces between the soil and the tillage elements, expending lower equivalent draught. Meanwhile, using disc harrow after 2 passes of the chisel increased the required specific energy. While, the multi functions of the moldboard plough (cutting, crumbling, lifting and turning up the soil slice) and using the disc harrow increased the expended specific energy.

Soil Moisture Content

Figures (1), (2) and (3) reveals that the moldboard plough and the disc harrow system accompanied with the transparent polyethylene sheets achieved the higher soil moisture content values of 26, 22 and 20% at 7, 30 and 60 days after planting, respectively. This result may be illustrated that the moldboard plough and disc harrow system beaks the soil aggregates, creating soil particles of moderate pore spaces with grater free pore spaces per unit of soil volume. This phenomenon leads to lowering the mechanical connections between the soil particles. So, the soil resistance to the moisture diffusion decreases. While, the rotary plough creates soil particles of smaller pore spaces, which slides one to another, creating a incorporated structure of higher resistance to moisture diffusion, On the contrary, the conventional tillage consummated higher soil mean weight diameter values due to the tillage intensity which encloses the soil pore spaces of higher surface tension that increases the soil bonding forces, leading to pore spaces increment, that create an aggregated structure of the lower soil moisture content values.

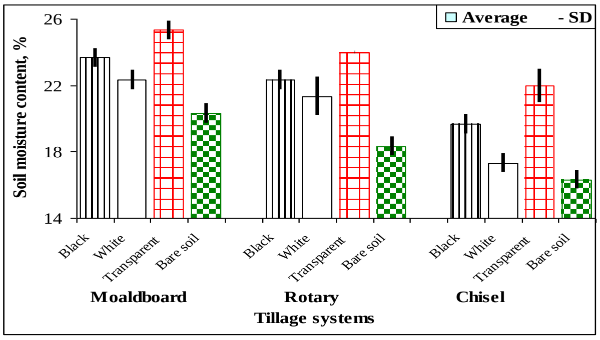

Fig. 1. Effect of tillage systems and soil mulching on soil moisture content at 7 days of planting.

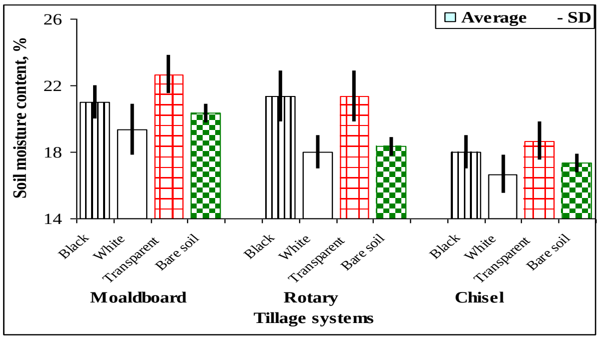

Fig. 2. Effect of tillage systems and soil mulching on soil moisture content at 30 days of planting.

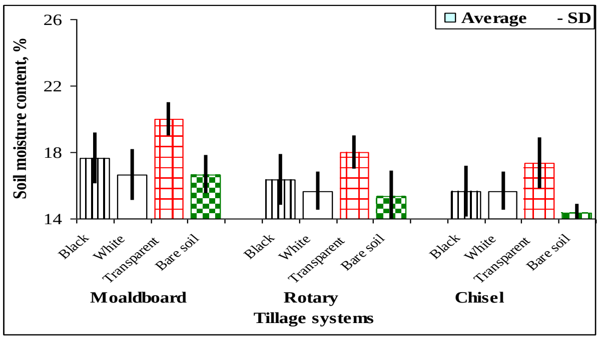

Fig. 3. Effect of tillage systems and soil mulching on soil moisture content at 60 days of planting.

The figures indicate that the polyethylene sheet mulch improved soil water storage during all the studied periods, comparing with the bare soil which loses a large amounts of soil water by evaporation. The reduction of water loss by evaporation was closely related to the polyethylene sheets color that governs the capturing solar insolation. However, transparent polyethylene sheet was more effective for conserving soil water. The black polyethylene sheets absorbs most UV, visible and infrared wavelengths of incoming solar radiation and re-radiates absorbed energy in the form of thermal radiation or long-wavelength infrared radiation. Much of the solar energy absorbed by black polyethylene mulch is lost due to the atmosphere through radiation and forced convection. While, the white polyethylene sheets suck less radiant energy and it reflect back into the plant shade most of the incoming solar radiation.

Weed Control Efficiency

Figures (4), (5) and (6) declare that the moldboard plough and the disc harrow system accompanied with the transparent polyethylene sheet recorded the higher weed control efficiency values of 98, 91 and 87% at 7, 30 and 60 days after planting, respectively. This finding may be explained that the moldboard plough cuts, crumbles, lefts and turns up the soil slice which is associated with weeds, burying the weed species that are propagated by seeds, preventing or slowing down their emergence. Then, the disc harrow increases the amount of the buried weeds. While, the rotary plough cuts, breaks down and throws up behind the soil that associated with weeds. Then, the sequent beating blades cuts, removes, distributes and buries weeds across the tilled soil profile. On the other hand, some of the propagules may be brought up to the soil surface, where they will be exposed and regrown directly. Whilst, the chisel plough pushes the disturbed soil which associated with weeds in front of the shares then, the disturbed soil moved by one of the discs gang to the other in sequential motion at a horizontal direction and a shallow depth. Hence, the propagules do not buried and their emergence may increase.

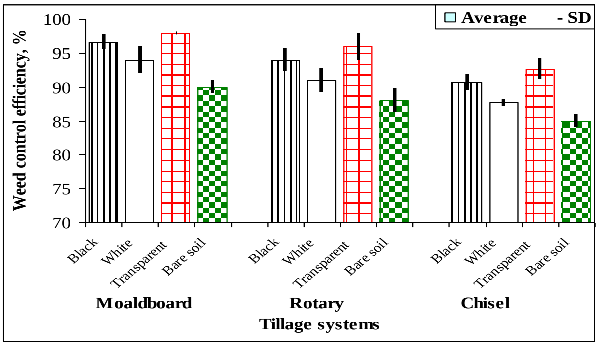

Fig. 4. Effect of tillage systems and soil mulching on weed control efficiency at 7 days of planting.

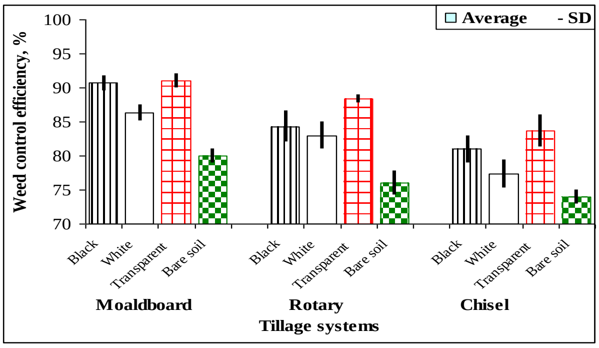

Fig. 5. Effect of tillage systems and soil mulching on weed control efficiency at30 days of planting.

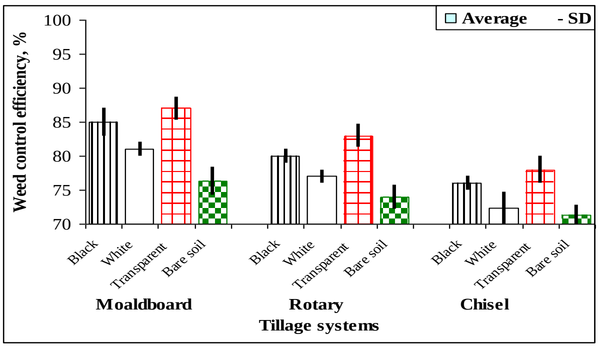

Fig. 6. Effect of tillage systems and soil mulching on weed control efficiency at 60 days of planting.

There is a significant reduction in weed infestation with the transparent sheet was due to the heat collected from solar radiation to raise soil temperature to levels that are lethal to weed seeds and seedlings. Also, the higher soil moisture content is essential to heat conductivity and for keeping seeds in a more susceptible imbibed state.

The figures exhibit the ability of the polyethylene sheets to combat weed infestation, comparing with the bare soil. The mechanism of weed control by solar radiation are thermal killing of seeds, thermal killing of seeds induced to germinate, breaking seed dormancy and killing the germinating seeds. Consequently, the weed population reduces.

The figures indicate that there is a reversibly proportion of the weed control efficiency. The effect of solar radiation on weed emergence decreases with the time after planting.

The analysis of variance test indicated that there is a significant difference in weed control efficiency at all the studied periods due to the tillage system and the soil mulching (r^2 = 0.77), LSD test at 0.05 level shows that the moldboard plough accompanied with the transparent polyethylene sheet achieved the higher value of the weed control efficiency.

Sesame Seed Yield

Figure (7) indicates that the moldboard plough and disc harrow system accompanied with the transparent polyethylene sheet recorded the higher sesame seed yield value of 1.26 ton/fed. This result may be indicated that the soil properties are influenced strongly by the moisture content level. In case of the moldboard plough and the disc harrow system, the higher soil moisture content of the higher surface tension degree increases the soil bonding forces, leading to the pore spaces increment. Consequently the soil properties improves. In addition, the higher ability of the moldboard plough and the disc harrow system to combat weed infestation would contribute to increase the sesame seed yield.

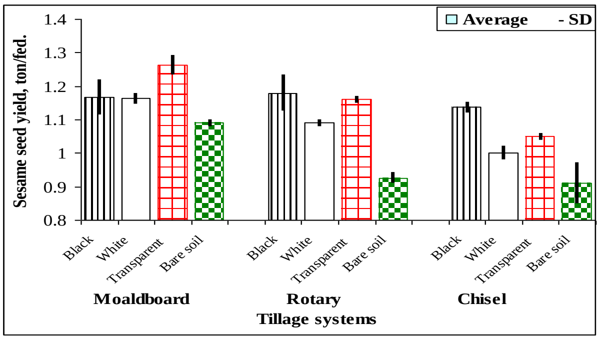

Fig. 7. Effect of tillage systems and soil mulching on sesame seed yield.

While, the rotary plough creates a loose structure which encloses relative smaller pore spaces, resulting in the reduction of the oxygen diffusion rate at the root zone, leading to the lower relative seedlings emergence. Meanwhile, the conventional tillage achieved the lower degree of soil pulverization that associated with the lower soil moisture content as a result of soil drying causes higher soil cohesion between the soil particles, leading to diminishing the pore spaces volume, causing the degradation in soil characteristics.

The polyethylene sheets, especially the transparent sheet affect the field microclimate by modifying the radiation budget of the surface and suppressing soil water evaporation. This means more availability of water to plants. Then, the high soil moisture content increased root proliferation and thus enhanced availability of nutrients to crop roots. The mulch layer prevents weed seedling growth by inhibiting light penetration to the soil surface. So, it is easy to spread and prevents the emergence of most annual weed seedlings, ultimately increases the sesame seed yield.

The analysis of variance test indicated that there is a significant difference in sesame seed yield due to the tillage system and the soil mulching. LSD test at 0.05 level shows that the moldboard plough accompanied with the transparent polyethylene sheet achieved the higher value of the sesame seed yield.

CONCLUSION

From the above results may be concoluded the following

The rotary plough recorded the higher actual field capacity and the lower specific energy requirements. The moldboard plough achieved the moderate mean soil weight diameter. The moldboard plough followed by disc harrow and accompanied with the transparent polyethylene sheet achieved the higher values of soil moisture content, weed control efficiency and sesame seed yield.

So, it is recommended to apply the moldboard plough followed by disc harrow and accompanied with the transparent polyethylene sheet as a proper sesame weed control method.

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تأثير نظام الحرث وتغطية التربة على مكافحة حشائش السمسم

أسامة طه بهنس

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أجريت هذه الدراسة لتطبيق المكافحة المتكاملة لحشائش السمسم باستخدام الحرث والشرائح البلاستيكية لتغطية التربة وذلك لتجنب الأضرار التي قد تصيب النباتات عند إجراء العزيق الآلي وللمحافظة على البيئة من أضرار مبيدات الحشائش. وقد تم تصميم وتنفيذ التجربة إحصائياً في قطع منشقة في ثلاثة مكررات, وقد تضمنت القطع الرئيسة معاملة نظام الحرث (محراث دوراني كحرث أدنى ومحراث قلاب مطرحي يعقبه مشط قرصي ومحراث حفار في حرثتين متعامدتين يعقبهما مشط قرصي "كحرث تقليدى") بينما إشتملت القطع الشقية على معاملة تغطية التربة (شرائح بلاستيكية بيضاء وشرائح بلاستيكية سوداء وشرائح بلاستيكية شفافة بالمقارنة مع التربة غير المغطاة). وقد أظهرت النتائج أن المحراث الدوراني قد حقق أعلى قيمة للسعة الحقلية الفعلية بمقدار 0.92 فدان/ساعة وأقل قيمة لمتطلبات الطاقة النوعية بمقدار 25.43 ميجا جول/فدان. بينما حقق المحراث القلاب المطرحي يعقبه مشط قرصي قيمة متوسطة لقطر متوسط الوزن. وكذلك حقق المحراث القلاب المطرحي يعقبه مشط قرصي في التربة المغطاة بالشرائح البلاستيكية الشفافة أعلى قيمة للمحتوى الرطوبي للتربة وأعلى قيمة لكفاءة مكافحة الحشائش خلال فترات الدراسة (7 و 30 و60 يوماً عقب الزراعة). وحققت نفس المعاملة أعلى محصول لبذور السمسم بمقدار 1.26 طن/فدان. ولذا فإنه يوصى باستخدام المحراث القلاب المطرحي يعقبه مشط قرصي مع تغطية التربة بالشرائح البلاستيكية الشفافة كوسيلة مناسبة للمكافحة المتكاملة لحشائش السمسم.