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Evaluating the Performance of Rotary and Tine Inter-Row Cultivators at Different Working Speeds

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ABSTRACT

An effective inter-row cultivator must destroy the weeds in the inter-row close to crop area without damaging the plants on the rows. Therefore, it is important to understand the soil disturbance of inter-row cultivation tools for optimizing the design and the use of inter-row cultivators. In this study, the performance of two different inter-row cultivators (the rotary inter-row cultivator and the tine inter-row cultivator) was investigated at three different working speeds (3.52, 6.11 and 7.82 km h^{-1}) and at a working depth of 70 mm under corn planted field conditions. The performance indicators of inter-row cultivators included the soil burial Depth on crop (*D*), the unaffected strip Width around crop row (*W*), the Weeding efficiency (W_e), and the Damaged Plant ratio (D_P). The results of the study indicated that the rotary inter-row cultivator could be operated at 6.11 km h^{-1} due to acceptable soil movement and low crop damage. However, the tine inter-row cultivator resulted in unacceptable soil movement and crop damage at 6.11 and 7.82 km h^{-1} working speeds.

Keywords: Plant damage, Soil burial depth, Weeding efficiency.

INTRODUCTION

Weeds can significantly reduce crop yields if they are not controlled (Williams *et al*., 2007). Yield losses in crops due to weeds depend on several factors such as weed emergence time, weed density, type of weeds, and crops, etc. Left uncontrolled, weeds can result in 100% yield loss (Chauhan, 2020). Therefore, weed control has always been one of the most important issues in agricultural production. Several methods are used to control weeds. However, chemical and mechanical methods are known as the main weed control methods (Young and Pierce, 2014). In recent years, there is an increasing interest in use of mechanical weed control methods because the use of chemicals may harm the environment and public health, and cause development of herbicide resistance (Laguë and Khelifi, 2001). The most known mechanical weed control method is inter-row cultivation practices, which control weeds by a combination of soil covering, uprooting and cutting, or separately. There are different inter-row cultivation machines to control weeds. Rotary and tine inter-row cultivators are the most commonly used among these machines (Pullen and Cowell, 1997). A rotary inter-row cultivator is fitted with rotating L-shaped blades on a horizontal axle driven by the tractor PTO. Rathod *et al*. (2010) stated that the rotary inter row cultivators stir the soil more accurately, disturb the weed root and remove them from the soil, and also help in keeping the soil in loose condition for proper aeration. Tine inter row cultivators have the tines spaced to go between the crop rows. The tines can be moved side to side on the

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toolbar to adjust for different row spacing and crop size. They are used for cultivation and weed control operations during the active growth period of rows crops. The effectiveness of these implements that affect both weed and crop depends on their design properties (e.g. rake angle, sweep angle, sweep wide) and working parameters (working speed and depth), soil and weather conditions, and on crop and weed species, plant height, and rooting depth (Gürsoy and Chen, 2017). Home (2003) reported that increased working speed during operating the traditional inter-row hoe blades resulted in crop damage due to higher soil displacement. The author stated that these hoe blades should be re-designed to travel close to the crop, cutting the weeds without throwing soil into the row, which could damage small crop plants.

Inter row cultivation can mostly control weeds by throwing the soil on them because the complete or partial burial of weeds with soil can restrict their growth (Young and Pierce, 2014). However, crop plants can also be buried by excessive soil throw when an inter row cultivator passes over field (Rasmussen *et al*., 2009; Jensen *et al*., 2004). Uprooting and breakage of the weed root contact with the soil can also result in the mortality of weeds (Terpstra and Kouwenhoven, 1981; Cirujeda *et al*., 2003; Zhang and Chen, 2017). Several researchers (Kurstjens *et al*., 2000; Kurstjens and Kropf, 2001) have found that the fraction of uprooted plants is important for the final weed control efficiency. Cutting involves physically shearing off and chopping up all weed tissues, and mixing them into soil. Rotary inter row cultivators are the best tools currently available for chopping up all aboveground weed tissues, root, and rhizomes (Mohler, 2001).

The effectiveness of mechanical weeding mainly depends on factors such as machine design parameters, working depth and speed. More soil disturbance generally results in higher weed control efficiency, but often increases the risk of damaging crop plants (Zhang and Chen, 2017). Paarlberg *et al*. (1998) carried out an experiment under no-till continuous corn production to determine the effects of tool design and speed on effectiveness of cultivation for weed control. They found that the faster cultivation had a positive or neutral effect on weed control and crop yield. The authors determined that increasing cultivation speed did not increase crop damage, although the fast treatment moved the 1.4 cm of soil into the row compared with the slow treatment. Baerveldt and Ascard (1999) stated that soil covering was an important factor for controlling the weeds by the mechanical methods, therefore, the fundamental knowledge on soil disturbance of inter-row cultivators would enable more effective equipment to be developed for mechanical weed. Several researchers (Terpstra and Kouwenhoven, 1981; Baerveldt and Ascard, 1999; Kurstjens and Perdok, 2000; Jensen *et al*., 2004) investigated burying of weed seedlings in soil for weed control mechanism. They stated that the required burial depth for plant mortality depends on plant size and growth habit. For example, Terpstra and Kouwenhoven (1981) found that soil cover of 15 mm depth killed small weeds and a covering of 20 mm killed larger plants. Rasmussen (1991) stated that the increased tine rake angle and tractor speed during inter-row cultivation increased weeding efficiency due to increasing the burial weeds and the cultivated area by thrown soil. However, the soil thrown on row resulted in yield loss due to the increased crop burial and damage. Pullen and Cowell (1997) assessed the ability of different mechanical mechanisms to control weeds at different working speeds. They found that the duck-foot cultivators achieved high levels of control but caused unacceptable soil movement. The powered rotary hoe worked well at all growth stages at 5 km h^{-1} but its performance declined as working speed was increased. Cirujeda *et al*. (2003) found that higher working speed of inter-row hoes did not have higher weed control efficiency, although it caused higher soil movement. However, Kouwenhoven

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and Terpstra (1979) reported that the higher working speeds of inter-row cultivator increased the depth of soil cover on weed and improved the weeding performance. These literature results show that determining soil burial depth on crop row and the unaffected strip width around the crop row is very important factors for maximizing weed control and minimizing crop damage. In summary, an inter-row cultivation system should control weeds in or near the crop row without unacceptable crop damage. In other words, the unaffected strip width around the crop rows must be as narrow as possible; however, the crop should not be damaged by weeding equipment.

In this study, we hypothesized that inter-row cultivation could manage weeds with minimal crop damage by selecting the appropriate inter-row cultivator and travel speed. We aimed to evaluate the performance of two different inter-row cultivators (rotary and tine inter-row cultivator) at different travel speeds and determine the effects of the inter-row cultivators at different travel speeds on the soil burial depth on crop, the unaffected strip width around crop row, the weeding efficiency, and the damaged crop ratio.

MATERIALS AND METHOD

Description of Inter Row Cultivators Used in the Experiment

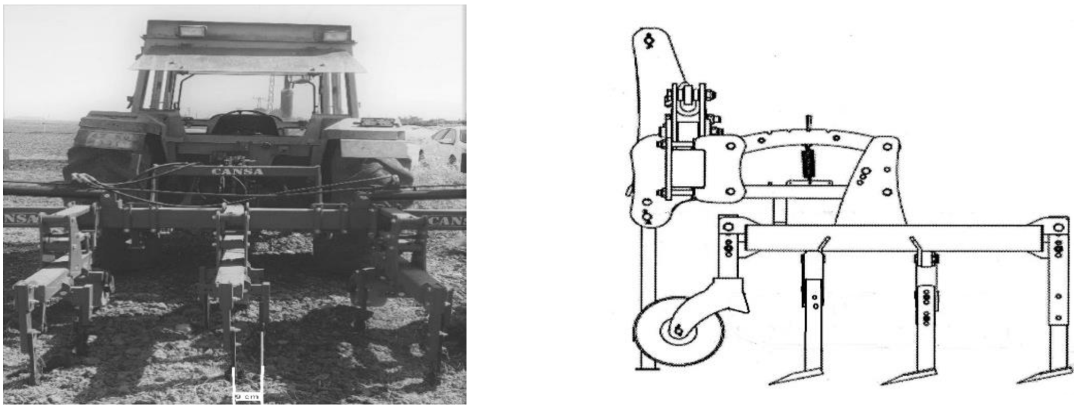
Two types of inter-row cultivators, namely, rotary and rigid tine inter row cultivators, were used in this study. The rotary inter row cultivator, shown in Figure 1, had seven row units with rotating L-shaped blades on a horizontal axle driven by the tractor PTO, which had a speed of 540 rpm (Toscano Machinery Industry and Trade Inc., Turkey). The machine was mounted from tractor's hydraulic lifting unit and universal three-point linkage system. Each unit, individually spring-loaded, could be adjusted to different row widths. Each unit had support wheels for setting the working depth of the units and duck-foot tines to make the blades easier by tilling the soil.

(b)

The rigid tine inter row cultivator, manufactured by Cansa Machinery Industry and Trade Inc., Turkey, had seven row units (Figure 2). Each row unit individually mounted on cultivator frame had 3 rigid tines with 9 cm spacing and the own depth wheel. The rake angle of each tine was 70°. The row space was adjusted as 70 cm by sliding the units on the main frames.

(a) (b)

Figure 1. The rotary inter-row cultivator used in the experiment [rear and front view (a, b)].



(a) (b)

Figure 2. The rigid tine inter-row cultivator used in the experiment [rear and side view (a, b)].

A MF 285S tractor with maximum power of 56 kW at 2,000 rpm was used during operating both inter row cultivators. The target working depth of each inter row cultivator was set approximately 70 mm deep by using the support wheel in front of row units on both inter row cultivators. The inter row cultivator was worked at three different working speeds (3.52, 6.11 and 7.82 km h^{-1}). These working speeds were determined by using Eq. 1 from the distance traveled and the time taken at the fixed tractor engine speed and the chosen gears.

$$V= 3.6\times(L/t) \quad (1)$$

Where, V= Working speed, km h^{-1}; L= Distance traveled, m; t= Time taken, s.

Description of the Experimental Site

The experiment was conducted in July 23, 2019 at farmer's field in the Kızıltepe District of Mardin Province, which are located in the South Eastern Anatolia region of Turkey (lat. 37° 11′ 18″N, long. 40° 34′ 38″ E), at about 498 m above sea level. The soil type in the experiment field was loamy clay with 38% clay, 28% silt, and 34% sand content, organic matter of 18.4 g kg^{-1} and the pH of 7.4. The gravimetric moisture content and bulk density of the 0-10 cm soil depth were 21.76% (dry basis) and 1.184 g cm^{-3}, respectively.

Inter-row cultivation was performed at the V2 grown stage of corn (40 days after seeding, two of the lowest leaves had a visible collar, the second and subsequent leaves had pointed tips). Sowing was done by a pneumatic row crop planter at the rate of 110,000 corn seeds per hectare in 70 cm rows with a theoretical seed spacing of 15 cm, on June 12, 2019. The experimental area was irrigated immediately after planting to ensure corn germination. Corn seedlings began emerging 6-8 days after planting.

Experimental Design

A split-plot design was used for the experiment and included six combinations of the two inter-row cultivators (rotary and tine inter row cultivators) in the main plots and three working speeds (3.52, 6.11, and 7.82 km h^{-1}). Each treatment was replicated three times. Therefore, a total of 18 plots were used in the field experiment. The plots were 5 m wide and 30 m long, which were laid out in parallel with the crop rows. The working depth of the inter-row cultivators was set constant at 70 mm for all the treatments by the support wheels in front of row units.

Measurements

The soil burial Depth on crop (*D*) was measured using the method that Zhang and Chen (2017) used the skewers to simulate

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weeds in a soil-bin experiment. In this study, wooden stakes (300-mm long) was used to present corn plants for the measurement of the soil burial depth on crop. Before the inter-row cultivation, stakes were marked at some distance from the end, and were pushed into the soil on crop row until the marks were leveled with the original soil surface (Figure 3-a). After the inter-row cultivation, the stakes were marked again at the surface of loose soil. Then, stakes were pulled out of the soil, and the distance between two marks was measured as the soil burial depth on crop as illustrated in Figure 3-b. This measurement was randomly repeated at five different locations for each plot.

The unaffected strip Width around crop row (W) was determined by measuring the space between crop row and sideways soil disturbance after the passage of inter-row cultivators (Figure 4-a). Then, this measured space was multiplied by 2 to determine the average size of the unaffected zone around crop row (Figure 4-b). This measurement was randomly repeated at ten different locations for each plot.

To determine the Weeding efficiency (W_e), the numbers of weeds were counted in four randomly located quadrats (50 cm long by 50 cm wide) in each plot, centered over crop row before and after the passing of inter-row cultivators. The weed efficiency was calculated by Equation (2).

$$W_e=[(W_1-W_2)/W_1]\times 100 \quad (2)$$

Where, W_e= Weeding efficiency, (%), W_1= Number of Weeds counted before inter-row cultivation, per square meter, W_2= Number of Weeds counted after operation, per square meter.

The rate of corn Plants Damaged by treatments (D_P) was determined by Equation (3), counting the number of corn plants before cultivation and the number of corn plants damaged by inter row cultivators after cultivation in four 1-m row lengths, randomly chosen in each plot.

$$D_p=(P_2/P_1)\times 100 \quad (3)$$

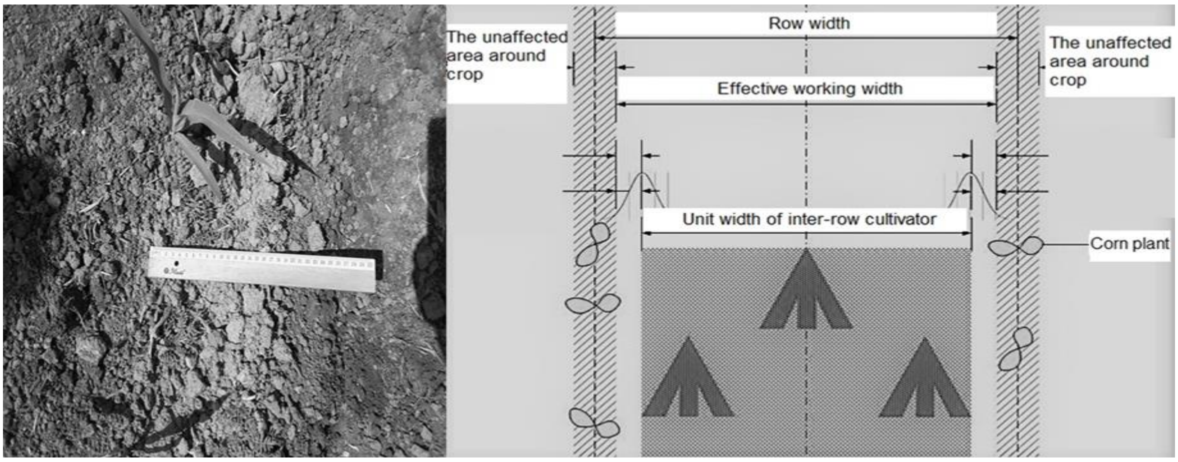
Where, D_P= Damaged corn Plant, (%), P_1= Number of corn Plants in 1 m row length before inter-row cultivation, P_2= Number of corn Plants damaged after inter-row cultivation.

Statistical Analyses

Analysis Of Variance (ANOVA) was performed using the JMP statistical software (SAS Institute Inc., 2002). Treatment means were compared by computing Least Significant Differences (LSDs) to identify significant differences at P< 0.05. The main

(a) (b)

Figure 3. Measurement of the soil burial depth on crop after inter-row cultivation [(a) The wooden stake buried on the corn row; (b) Measuring the soil cover thrown on the stake].



(a) (b)

Figure 4. Measurement of the unaffected strip Width around crop row *(W)* after the passage of inter-row cultivators [(a) Measuring the space between crop row and sideways soil disturbance after the passage of inter-row cultivators; (b) The unaffected zone around crop row].

effects of inter-row cultivator and working speeds were presented when the interaction effects were not significant; otherwise, the simple effects of working speed for both coulters were examined and the mean value of each group and mean's standard error was presented by graphs using Microsoft Excel 2007 software.

RESULTS AND DISCUSSION

Soil Burial Depth on Corn Plant

While the statistical difference between two inter-row cultivators in terms of their effects on the soil burial depth on crop was not significant, the ANOVA results indicated that both the working speeds and the interaction of the working speed x the inter-row cultivator had statistically a pronounced effect. The fact that the statistical difference between two inter-row cultivators was not significant may be due to different effects of inter-row cultivators on the *D* according to working speeds. Therefore, the effects of working speeds were examined within each inter-row cultivator (Figure 5).

While the rotary cultivator resulted in a greater *D* than the tine inter-row cultivator operating at 3.52 km h^{-1}, the tine inter-row cultivator had higher *D* than rotary inter-row cultivator at 6.11 and 7.82 km h^{-1}. For the rotary inter-row cultivator, *D* was 1.5 cm at 3.52 km h^{-1} and increased by 33.33 and 43.75% when the working speed increased from 3.52 to 6.11 km h^{-1} and from 6.11 to 7.82 km h^{-1}, respectively, although the difference between 3.52 and 6.11 km h^{-1} and between 6.11 and 7.82 km h^{-1} were not statistically significant. However, the increase in *D* due to the increase of working speed was higher under the tine inter-row cultivator than under the rotary inter-row cultivator. *D* was 0.6 cm when the tine inter-row cultivator was operated at 3.52 km h^{-1} and the increase of the working speed from 3.52 to 6.11 km h^{-1} and 6.11 to 7.82 km h^{-1} resulted in an increase by 85 and 50% in *D*, respectively. The more soil is thrown, the more likely the weeds in the crop row will be buried by the soil, and also the more likely that crop will be buried and damaged by the soil. Several studies (Terpstra and Kouwenhoven, 1981; Cavers and Kane, 1990; Jones *et al*., 1996) state that a 2 cm thick soil cover kills most young seedlings. However, it is mostly stated that effects of soil covering depth on crop damage change according to crop species, plant size, angle and growth habit (Rydberg, 1994; Cirujeda

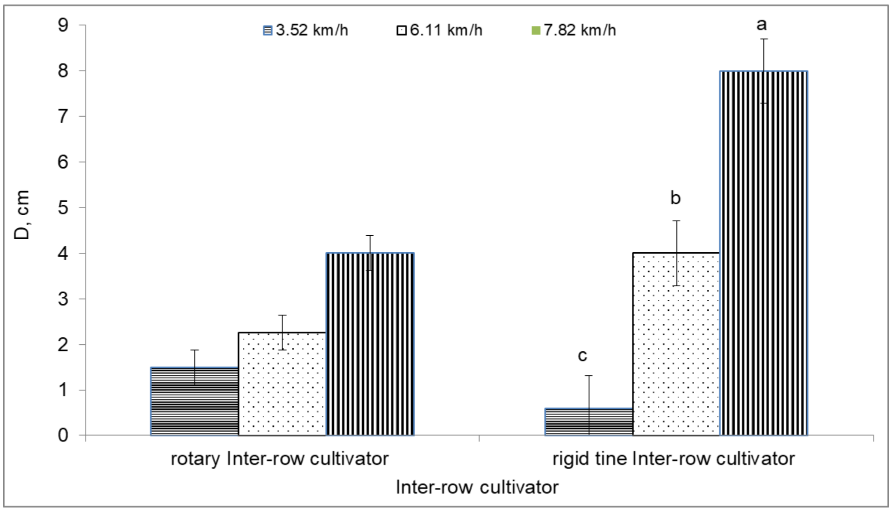


Figure 5. Effects of different inter-row cultivators at different working speeds on the soil burial Depth on corn plant (D); means followed by different lower-case letters are significantly different according to LSD's multiple range test at the significance level of 0.05; error bars are standard errors.

et al., 2003; Cloutier *et al*., 2007). In this study, the 6.11 and 7.82 km h^{-1} working speeds resulted in *D* values higher than 2 cm for both inter-row cultivator types. The maximum soil burial depth on crop was observed as 8 cm when the tine inter-row cultivator was operated at 7.82 km h^{-1}. During operating the rotary inter-row cultivator, metal housing around the tilling blades protected the crops from covering with soil since it prevented aggressively the movement of soil. Sometimes, lateral soil displacement in commercial tine inter-row cultivators is controlled by fitting side shields in either side of the hoe blade. However, side shields can increase capital cost and weight, cause leaf damage at advanced crop growth stages, and increase forces on the equipment (Home, 2003). In this study, the tine inter-row cultivator did not have the side shields. Therefore, the tine inter-row cultivator could result in higher *D* with increased working speed due to a higher lateral soil movement than the rotary inter-row cultivator. Similarly, Pullen and Cowell (1997), who compared the performance of different weeding tools at different forward speeds, found that, among weeding tools, the duck-foot weeder had the highest soil throw that may damage the crops. It is known that the movement and throw of soil during inter-row cultivation is significantly influenced by tool geometry, operating speed, and soil physical parameters as important factors in influencing soil displacement (Hanna *et al*., 1993; Sharifat and Kushwaha, 2000)

The Unaffected Area around Corn Plant

Statistically significant difference ($P< 0.01$) was found among both inter-row cultivator types and working speeds for the unaffected area around corn plant. Also, there was a significant interaction between inter-row cultivator and working speed, indicating that the effect of working speeds on the *W* changed according to inter-row cultivator types. The rotary inter-row cultivator resulted in significantly higher *W* than the rigid tine inter-row cultivator. The highest unaffected strip width around corn plant (17.50 cm) was observed when the rotary inter-row cultivator was worked at 3.52 km h^{-1} and it decreased by 18.31 and 64.22% when the working speed of the rotary inter-row cultivator increased from 3.52 to 6.11 km h^{-1} and from 6.11 to 7.82 km h^{-1}, respectively. The tine inter-row cultivator operating at 3.52 km h^{-1} resulted in the *W* of 6.73 cm, which was 99.99% higher than that of 6.11 and 7.82 km h^{-1} (Figure 6).

The main aim of inter-row cultivation is to cultivate as much of the inter-row area as possible without damaging the crop. Therefore, the uncultivated strip in which the crop grows must be as narrow as possible while minimizing the amount of crop damaged by the weeding equipment. Several researchers (Amonov *et al*., 2006; Gupta *et al*., 2008; Ascard and Fogelberg, 2008) suggested that an unaffected strip of 10 to 12 cm around the crop row was required in order to prevent damage to the crop. The results of this study showed that increased working speed significantly reduced the protected strip width around the crop row due to resulting in laterally greater soil throw, which was consistent with the findings of Dowell *et al*. (1988), Rahman *et al*. (2005), and Gürsoy and Chen (2017). During operating the rotary inter-row cultivator, the protected strip width around the crop row was safe at the 3.52 and 6.11 km h^{-1} working speeds, however, the 7.82 km h^{-1} working speed resulted in lower protected strip width around crop row than that stated by Amonov *et al*. (2006), Gupta *et al*. (2008), and Ascard and Fogelberg (2008). The *W* was approximately zero when the tine inter row cultivator was operated at 6.11 to 7.82 km h^{-1}. This shows that the tine inter row cultivator needs fitting side guards on either side of the hoe blade or the hoe blades should be re-designed to reduce the amount of soil movement. Similarly, Home (2003) stated that the traditional inter-row hoe blades were effective at controlling weeds at speeds up to 5 km h^{-1}. Beyond this speed, soil displacement became a problem, and the hoe blades should be re-designed to reduce the amount of soil displacement.

Weeding Efficiency

The ANOVA results showed that Weeding efficiency (*W*e) was significantly influenced by both inter-row cultivator types and working speeds. However, the interaction effects of the main factors were not statistically significant. The tine inter-row cultivator had a 17.27% higher *W*e than the rotary inter-row cultivator (Figure 7). Lateral soil throw during operating the tine inter-row cultivator may cause burial of more weeds by soil for affecting more of the inter-row area. These results were consistent

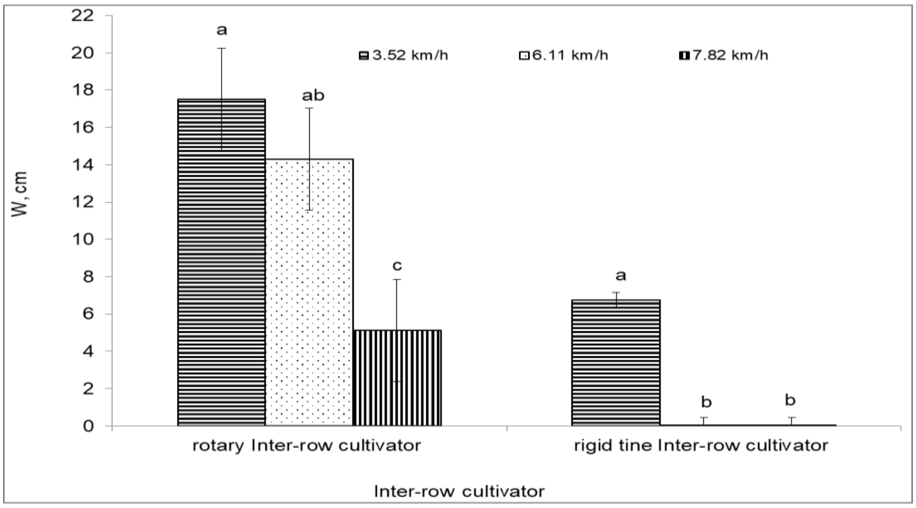


Figure 6. The effects of inter-row cultivator types at different working speeds on the unaffected strip Width around corn plant (*W*). Means followed by different lower-case letters are significantly different according to LSD's multiple range test at the significance level of 0.05; error bars are standard errors.

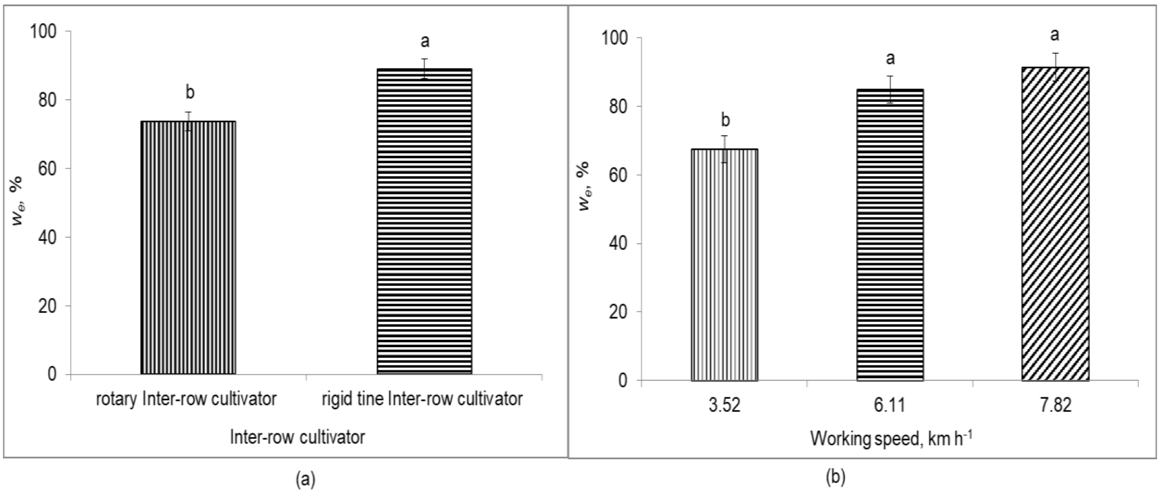


Figure 7. Effects of different inter-row cultivators and working speeds on Weeding efficiency (*W*e). Means followed by different lower-case letters are significantly different according to LSD's multiple range test at the significance level of 0.05; error bars are standard errors.

with the literature findings from Terpstra and Kouwenhoven (1981), Rasmussen (1991), and Zhang and Chen (2017) who found that the increased soil movement increased *W*e due to increasing the burial weeds and the cultivated area by thrown soil. Similarly, Pullen and Cowell (1997) reported that a higher lateral soil movement from a duck-foot inter-row cultivator increased the *W*e due to a combination of uprooting and burial. However, it was also observed that soil thrown onto crop row could cause potential damage to the plants. The researchers stated that reducing the rake angle of the tine would reduce the soil movement, but this might also reduce its ability to control their growth by burying the weeds.

The increased working speeds of the inter-row cultivators raised *W*e, although there was statistically no significant difference between 6.11 and 7.82 km h^{-1} working speeds. The increase of the working speed from 3.52 to 6.11 km h^{-1} resulted in 20.44% increase in the *W*e. However, the increased rate of *W*e due to the increase of working speed from 6.11 and 7.82 km h^{-1} was only 7.20%. This shows that higher working speed than 6.11 km h^{-1} would not be very effective for weeding efficiency. Several researchers (Kouwenhoven and Terpstra, 1979; Pullen and Cowell, 1997) reported that weeding performance of tines and tine like tools increased with working speed because of the design of the tines, which threw the soil to cover all weeds. However, Kankal *et al*. (2014) found that weeding efficiency of a sweep inter row cultivator was the highest at 1.5 km h^{-1} but beyond this speed its performance declined as working speed was increased. Also, Pullen and Cowell (1997) determined that the powered rotary hoe worked well at all growth stages at 5 km h^{-1}, but its performance declined as working speed was increased.

The Damaged Corn Plant Ratio

Both the inter-row cultivator type and the working speed had a pronounced effect on the damaged corn plant ratio after the passage of inter-row cultivators. The interaction effect of inter-row cultivator×working speed was not significant ($P\geq 0.05$). The tine inter-row cultivator had a 75.61% higher D_P than the rotary inter-row cultivator. This result was consistent with the findings of Pullen and Cowell (1997) who observed that the soil thrown from a duck-foot inter-row cultivator onto crop row resulted in the increased crop burial and damage because of the design of its rear blade. Similarly, Rasmussen (1991) stated that the increased rake angle of tines at an inter-row cultivator caused the increased crop burial and damage due to a higher lateral soil movement. During inter-row cultivation, if plants are covered with the soil thrown by sweeps, the soil on top of plant would directly affect the photosynthesis of the plant and cause plant kill. Generally, a greater soil burial depth on crop row can cause a higher plant kill although plant damage also depends on plant size and growth habit and other factors (Zhang and Chen, 2017).

A higher working speed resulted in the higher D_P, which increased by 95.14 and 28.29% when the working speed increased from 3.52 to 6.11 km h^{-1} and from 6.11 to 7.82 km h^{-1}, respectively, although the difference between 6.11 and 7.82 km h^{-1} working speeds was not statistically significant (Figure 8). The increased D_P at higher working speeds might be due to more soil thrown on crop row and higher soil burial depth on crop. Similarly, Rasmussen (1991) stated that the increased tractor speed during inter-row cultivation caused yield loss due to the increased crop burial and damage by thrown soil. Kouwenhoven and Terpstra (1979) have also shown that increasing the working speed of a duck-foot from 3.6 to 10.8 km h^{-1} caused much more plant destruction by resulting in a thicker loose soil cover on crop row. Rueda-Ayala *et al*. (2010) recommended using guidance systems (mechanical or electronic) at greater speeds in order to reduce the risk of crop damage and cultivate more of the inter-row area.

CONCLUSIONS

In this study, the rotary and the tine inter-row cultivators were tested at three different working speeds under corn planted field conditions in order to evaluate their effects on soil disturbance, weeding efficiency, and the damaged crop ratio. The following conclusions were drawn from the study. Based on the soil disturbance results, the soil burial depth on crop was significantly higher under the tine inter-row cultivator than under the rotary inter-row cultivator; although both inter-row cultivators resulted

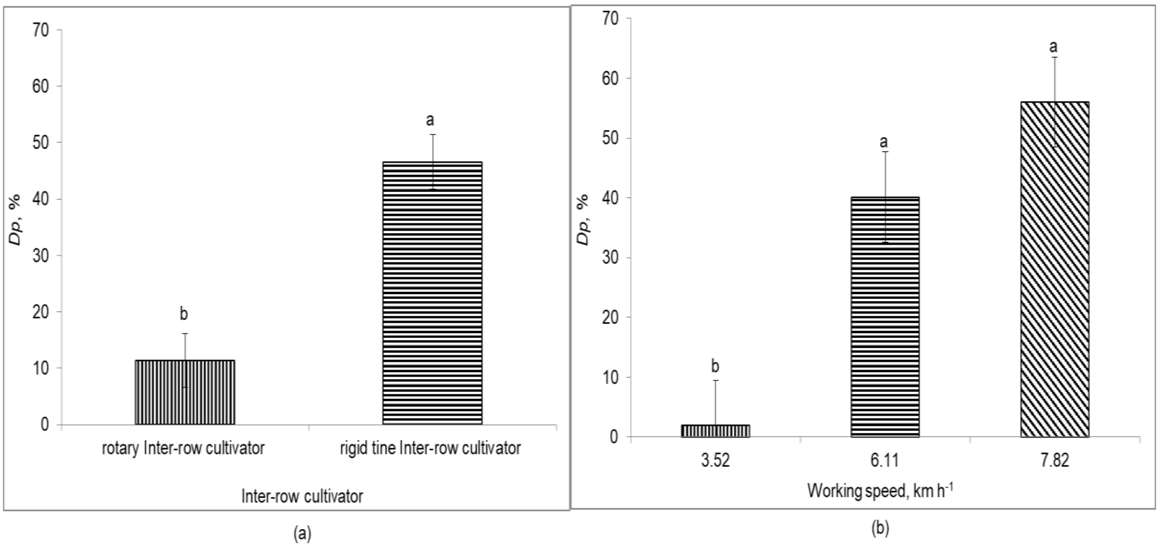


Figure 8. Effects of different inter-row cultivators and working speeds on the Damaged Plant ratio (D_P). Means followed by different lower-case letters are significantly different according to LSD's multiple range test at the significance level of 0.05; error bars are standard errors.

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in a soil cover thickness that can kill young plant seedlings at 6.11 and 7.82 km h^{-1} working speeds.

For both inter-row cultivators, increased working speed significantly reduced the protected strip width around the crop row due to the laterally greater soil throw. The rotary inter-row cultivator resulted in a safe protected strip width around the crop row at the 3.52 km h^{-1} and 6.11 km h^{-1} working speeds. However, the tine inter row cultivator needed fitting side guards on either side of the hoe blade or re-designing its blades to reduce the amount of soil movement at high working speeds, because the soil thrown onto corn plants could cause potential damage to the plants. Based on the weeding efficiency and crop damage results, the tine inter-row cultivator had 17.27% higher weeding efficiency than the rotary inter-row cultivator. The inter-row cultivation at the higher working speeds than 6.11 km h^{-1} was not very effective for weeding efficiency.

The tine inter-row cultivator had 75.61% higher damaged plant ratio than the rotary inter-row cultivator. A higher working speed resulted in the higher damaged corn plant ratio due to more soil thrown on crop row and higher soil burial depth on crop.

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ارزیابی عملکرد پنجه های بین ردیفی دوّار و دارای دندانه در سرعت های کاری مختلف

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چکیده

یک پنجه بین‌ردیفی (inter-row cultivator) موثر بایستی علفهای هرز بین ردیف کاشت ونزدیک به گیاهان روی ردیف کاشت را بدون آسیب زدن به گیاهان ازمیان بردارد. بنا بر این، لازم است برای بهینه کردن طراحی و استفاده از این ابزار خاکورزی از جابجایی و بهم زدن خاک بین ردیف کاشت به وسیله پنجه مزبور درک درستی داشت. در این پژوهش، عملکرد دو پنجه بین ردیفی متفاوت (پنجه بین ردیفی دوّار و پنجه بین ردیفی دارای دندانه) در سه سرعت کاری (3/52، 6/11، و 7/82 کیلومتر در ساعت) در عمق کاری 70 میلی متر در شرایط یک مزرعه ذرت بررسی شد. نمایه های عملکرد این پنجه های بین‌ردیفی شامل بود بر عمق خاک روی گیاه (D)، عرض نواراطراف ردیف کاشت گیاه که خاک آن بهم نخورده بود (*W*)، کارآیی علف کنی (*We*)، و نسبت گیاهان آسیب دیده (Dp). نتایج پژوهش چنین اشارت داشت که پنجه بین‌ردیفی دوّار را می توان با سرعت کاری 6/11 کیلومتر درساعت استفاده کرد زیرا در این سرعت، مقدار جابجایی خاک قابل قبول و آسیب به گیاهان روی ردیف کم بود. اما، با کاربرد پنجه بین‌ردیفی دارای دندانه (tine inter-row cultivator) درسرعتهای کاری 6/11 و7/82 کیلومتر درساعت، جابجایی خاک و آسیب رسانی به گیاهان روی ردیف در حد غیر قابل قبول بود.

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