A Study on Weeds Management Methods and Their Effect on Corn Forage Yield and Yield Components

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ABSTRACT
The effect of integrated management of weeds on yield and yield components of corn forage was examined in a factorial split experiment in 2012-2013 in Khuzestan, Iran on the basis of a Randomized Complete Block Design with three replications in which the main plot was devoted to cultivator at two levels of cultivator use and disuse and the sub-plots were devoted to density at two levels of 100 000 and 150 000 plants ha⁻¹ and to reduced (recommended) dosage of Lumax herbicide at four levels of 0, 1.5, 3.0 and 4.5 L ha⁻¹. It was found that the increase in density from 100 000 to 150 000 plants ha⁻¹ increased total dry yield by 8.7%. Means comparison for the interaction between cultivator and herbicide revealed that when cultivator is applied, the treatment of only 1.5 L ha⁻¹ herbicide resulted in total dry yield and total fresh yield of forage of 23 020 and 103 705 kg ha⁻¹ which were 66.2 and 65.8% higher than that under the treatment of cultivator with no herbicide usage. Therefore, given the fact that sustained farming is aimed at reducing the application of chemicals in farming systems, the rate of using Lumaxcan be reduced by 66.6% by integrated management of weeds. Thus, the adverse effects of herbicides on environment and the resistance of weeds to herbicides can be reduced.

INTRODUCTION

The last report of Statistics and Technology Office of Iranian Ministry of Agriculture in 2010 estimated the cultivation area of irrigated and rain-fed forage corn as to be about 160 400 and 3 800 ha and the production rate of irrigated and rain-fed forage corn as to be about 9 200 000 and 67 000 t, respectively [1]. Corn is a crop that needs heat for optimum growth. Therefore, in spring plantings the weeds have appropriate chance and space for growth due to the slow growth of the plants at their early vegetative stage and the high inter-plant spacing. Therefore, if the weeds are not controlled, the corns will be damaged severely [8, 10].

Fontemlum et al. stated that post-emergence application of herbicides at low dosages allowed the control of weeds with lower environmental hazards [6]. Rostami et al. reported that the application of cultivator within the corn rows controlled weeds by their complete or partial burial preventing their rooting or cutting the touch of roots with soil [9]. SadrabadiHaghighi et al. reported that as the planting density was increased from 100 000 to 120 000 and 140 000 plants ha⁻¹, despite the decrease in herbicide dosage to 40 and 60 g essential oil per ha, respectively, increased the yield of silo corn at daught stage of grains by 42 and 40% as compared to control [11]. In a study on the efficiency of Lumaxin different provinces of Iran, Zandand Rahimian Mashhadi found that Lumaxmanu factured in Syngenta Co. of Poland which is a mixture of three herbicides (375 g S-metolachlor + 37.5 g mesotrione+ 125 g terbumylazineper litre) with different uptake mechanisms was the superior choice for integrated weeds management and the delay in the occurrence of resistance [2,14, 15].

The present study aims at studying the effect of controlling methods (chemical and mechanical) alone and integrated with each other on the extent of weeds control and their resulting effect on forage corn yield and at
finding the most optimum herbicide dosage with and without the application of cultivator with the most appropriate density for weeds management.

MATERIALS AND METHODS

The study was carried out as a factorial split plot on the basis of a Randomized Complete Block Design with three replication in Khuf of Southern Khorasan Province, Iran (Lat. 32°38’ N., Long. 59°13’ E., Alt. 1749 m) in 2012-2013.

The replications were composed of two main plots (the use and not-use of cultivator) and the main plots were composed of eight sub-plots (mixture of Lumaxherbicide and density). The studied factors included cultivation at two levels (the use and not-use of cultivator), reduced rates of Lumaxat four levels (0, 1.5, 3.0 and 4.5 liters per ha) and corn plant density at two levels (100 000 and 150 000 plants ha⁻¹).

The experimental plots were 6 × 1.5 m² in dimensions (with 75 cm spacing between the furrows). Each plot was composed of four planting rows (two rows per ridge) with the inter-row spacing of 37.5 cm. The studied cultivars was Persia 545 (the line originated from the US and the hybrid originated from Iran). The seeds were dry-planted on July 7, 2013 according to the density treatments. The herbicide Lumaxwas applied as post-emergence treatment.

The dosage recommended by the manufacturer was 4.5 L ha⁻¹. The herbicide was applied by pump backpack sprayer with torrential nozzle with the pressure of 2-2.5 bars. It was calibrated on the basis of 300-400 L water per ha. The herbicide was applied on July 28, 2013 when the corn plants were at four-leaf stage. Cultivation was conducted by narrow-track tractor on August 15, 2013 when the corns were 40 cm high. The traits of forage corn including total fresh yield, total dry yield, leaf dry yield, stem dry yield and ear dry yield were measured on September 24, 2013.

In the end, the data were analyzed by MSTAT-C software package and the diagrams were drawn by MS-Excel software. The means were compared by Multi-range Duncan Test at 5 and 1% levels.

RESULTS AND DISCUSSION

Total fresh yield:

Results of analysis of variance revealed that the simple effects of cultivator and herbicide rate and their interactions were significant for total fresh yield of forage corn, but the simple effect of density and other interaction were not significant for this trait (Table 1). The application of cultivator resulted in 36.8% higher total fresh yield (Table 2). According to the results of mean comparison for the interaction between cultivator and herbicide, the fresh forage yield of 103 705 kg ha⁻¹ can be obtained by applying 1.5 L ha⁻¹ herbicide under the application of cultivator which although it was 65.8% higher than that under no-cultivator and no-herbicide application treatment, it was ranked in the same statistical group with the treatment of cultivation and the application of 3.0 and 4.5 L ha⁻¹ herbicide. Although both conditions of using and not using cultivator, the application of herbicide at the rate of 1.5 L ha⁻¹ resulted in significantly higher forage corn fresh yield than when it was not applied, it resulted in markedly higher corn fresh yield under no-cultivator use treatment (Fig. 1) implying that when the farm is cultivated, the herbicide dosage can be safely reduced to 66.6%. Donald reported that tillage can well control summer weeds in corn field [5]. Armel et al. recommended pre-tillage application of Atrazine for better management of weeds and stated that its dosage can be reduced to 50% under tillage [3].

<table>
<thead>
<tr>
<th>SOV</th>
<th>df</th>
<th>Total fresh yield</th>
<th>Total dry yield</th>
<th>Leaf dry yield</th>
<th>Stem dry yield</th>
<th>Ear dry yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>762580158.333</td>
<td>377820625.000</td>
<td>12572968.750</td>
<td>53358527.083</td>
<td>73471527.085</td>
</tr>
<tr>
<td>Cultivation</td>
<td>1</td>
<td>817869653.333</td>
<td>336391352.083</td>
<td>1125028.333</td>
<td>4366302.083</td>
<td>979808.333</td>
</tr>
<tr>
<td>Error a</td>
<td>2</td>
<td>213782533.333</td>
<td>9156608.333</td>
<td>22069.583</td>
<td>1107527.083</td>
<td>2265814.583</td>
</tr>
<tr>
<td>Herbicide (B)</td>
<td>3</td>
<td>1016613811.667</td>
<td>40295707.639</td>
<td>12674085.55</td>
<td>5911835.41</td>
<td>125407583.333</td>
</tr>
<tr>
<td>A × B</td>
<td>3</td>
<td>835384972.222</td>
<td>40368107.639</td>
<td>560358.333</td>
<td>2658974.306</td>
<td>1381325.256</td>
</tr>
<tr>
<td>Density (C)</td>
<td>1</td>
<td>98957633.333</td>
<td>27105252.083</td>
<td>72075.000</td>
<td>3337052.083</td>
<td>3966875.576</td>
</tr>
<tr>
<td>A × C</td>
<td>1</td>
<td>124033.333</td>
<td>318502.083</td>
<td>9633.333</td>
<td>115052.083</td>
<td>104533.333</td>
</tr>
<tr>
<td>B × C</td>
<td>3</td>
<td>42977616.667</td>
<td>56674.306</td>
<td>691.667</td>
<td>196402.083</td>
<td>151225.576</td>
</tr>
<tr>
<td>A × B × C</td>
<td>3</td>
<td>1088683733.333</td>
<td>26568.750</td>
<td>11872.222</td>
<td>9368.750</td>
<td>31072.222</td>
</tr>
<tr>
<td>Error b</td>
<td>28</td>
<td>59090263.31</td>
<td>29152833.333</td>
<td>73881.548</td>
<td>351038.988</td>
<td>739780.357</td>
</tr>
<tr>
<td>CVv (%)</td>
<td></td>
<td>9.56</td>
<td>9.46</td>
<td>8.27</td>
<td>8.66</td>
<td>10.87</td>
</tr>
</tbody>
</table>

* ** and ns show significance at 5 and 1% level and non-significance, respectively.

Table 2: Results of means comparison for the simple effects of cultivation on corn forage yield components.

<table>
<thead>
<tr>
<th>Cultivation Trait</th>
<th>Total fresh yield (kg ha⁻¹)</th>
<th>Total dry yield (kg ha⁻¹)</th>
<th>Leaf dry yield (kg ha⁻¹)</th>
<th>Stem dry yield (kg ha⁻¹)</th>
<th>Ear dry yield (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease</td>
<td>67628.3 b</td>
<td>15393.3 b</td>
<td>2872.9 b</td>
<td>5989.2 b</td>
<td>65513.3 b</td>
</tr>
<tr>
<td>Use</td>
<td>93735 a</td>
<td>20687.9 a</td>
<td>3702.1 a</td>
<td>7688.8 a</td>
<td>9297.1 a</td>
</tr>
</tbody>
</table>

Means with the same letter(s) showed no significant differences at 5 and 1% probability level according to Duncan Test.
Fig. 1: Effect of weeds management method on total fresh yield of forage corn.

Total dry yield:
As analysis of variance indicated, the simple effects of cultivator and herbicide application and plant density as well as the interactions between cultivator and herbicide application were significant for total dry yield of corn forage, but other interactions were not found to be significant for it (Table 1). The application of Lumax herbicide significantly increased total dry yield through reducing the interference of weeds (Table 3). The increase in density from 10 to 15 plants m⁻² resulted in 8.7% increase in total dry yield (Table 4) which can be related to appropriate distribution of plants per unit area and maximum use of environmental parameters like light, moisture and temperature. Also, it can be associated with corn competitiveness under appropriate density per unit area showing that the increase in corn plant density up to optimum level can considerably reduce the intervention of weeds and even can tolerate or suppress them by improving the competition potential of the crop. Means comparison for the interaction between cultivator and herbicide revealed that under the condition of applying cultivator, forage total dry yield of 23 020 kg ha⁻¹ can be obtained by applying only 1.5 L ha⁻¹ herbicide which although was 66.2% higher than that under the application of cultivator with no herbicide application, it was ranked in the same statistical group with the treatments of the application of cultivator + 3 or 4.5 L ha⁻¹ herbicide. Although under the application of cultivator and its disuse, the application of herbicide at the rate of 1.5 L ha⁻¹ was significantly superior over its disuse, total dry yield of corn forage was considerably increased under the application of 1.5 L ha⁻¹ herbicide with no cultivator use (Fig. 2). This finding is in agreement with those reported by Mohammadi and Salehi and Fathi [4, 12].

Fig. 2: Effect of weeds management method on total dry yield of forage corn.

Leaf dry yield:
Results of analysis of variance indicated showed the significant effect of cultivator and herbicide application and their interactions on leaf dry weight, but the simple effect of density and other interactions were found to be insignificant for its trait (Table 1). Means comparison for the interactions between cultivator and herbicide application revealed that when the farm was cultivated, leaf dry weight of 4 112 kg ha⁻¹ was obtained
by the application of 1.5 L ha$^{-1}$ herbicide which although was 65.4% higher than that under the application of cultivator with no herbicide use, it was ranked in the same statistical group with the treatment of cultivator + 3 and 4.5 L ha$^{-1}$ herbicide. Although under both cultivator use or disuse, the application of 1.5 L ha$^{-1}$ herbicide was significantly superior over its disuse, leaf dry yield showed considerably higher increase under the treatment of 1.5 L ha$^{-1}$ herbicide with no cultivator application (Fig. 3).

Table 3: Results of means comparison for the simple effects of herbicide on corn forage yield components.

<table>
<thead>
<tr>
<th>Herbicide (L ha$^{-1}$)</th>
<th>Total fresh yield (kg ha$^{-1}$)</th>
<th>Total dry yield (kg ha$^{-1}$)</th>
<th>Leaf dry yield (kg ha$^{-1}$)</th>
<th>Stem dry yield (kg ha$^{-1}$)</th>
<th>Ear dry yield (kg ha$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>37070 b</td>
<td>8455 b</td>
<td>1747 b</td>
<td>3604 b</td>
<td>3104 b</td>
</tr>
<tr>
<td>1.5</td>
<td>93340 a</td>
<td>21380 a</td>
<td>3813 a</td>
<td>7999 a</td>
<td>9568 a</td>
</tr>
<tr>
<td>3</td>
<td>96440 a</td>
<td>21290 a</td>
<td>3833 a</td>
<td>7966 a</td>
<td>9490 a</td>
</tr>
<tr>
<td>4.5</td>
<td>95880 a</td>
<td>21040 a</td>
<td>3758 a</td>
<td>7787 a</td>
<td>9495 a</td>
</tr>
</tbody>
</table>

Means with the same letter(s) showed no significant differences at 5 and 1% probability level according to Duncan Test.

Fig. 3: Effect of weeds management method on leaf dry yield of forage corn.

Stem dry yield:

Results of analysis of variance showed that the simple effect of cultivator, density and herbicide and the interaction between cultivator and herbicide and between density and cultivator were significant for stem dry yield, but other interactions were not significant for it (Table 1). The increase in density from 10 to 15 plants m$^{-2}$ increased stem dry yield by 13.5% (Table 4). Zand et al. stated that the increase in density to 8 plants m$^{-2}$ resulted in significant differences in stem dry weight as compared to other densities (5 and 7.5 plants m$^{-2}$) [14]. Means comparison for the interaction between cultivator and herbicide showed that the application of only 1.5 L ha$^{-1}$ herbicide under the application of cultivator gave rise to stem dry weight of 8570 kg ha$^{-1}$. Although it was 66.1% higher than that under the application of cultivator with no herbicide usage, it was ranked in the same statistical group with the treatments of cultivator use and 3.0 and 4.5 L ha$^{-1}$ herbicide as well as cultivator use and 4.5 L ha$^{-1}$ herbicide application (Fig. 4), which is in agreement with the results reported by Iskandari et al. [7, 13].

Table 4: Results of means comparison for the simple effects of plant density on corn forage yield components.

<table>
<thead>
<tr>
<th>Density (Plant m$^{-2}$)</th>
<th>Total fresh yield (kg ha$^{-1}$)</th>
<th>Total dry yield (kg ha$^{-1}$)</th>
<th>Leaf dry yield (kg ha$^{-1}$)</th>
<th>Stem dry yield (kg ha$^{-1}$)</th>
<th>Ear dry yield (kg ha$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>79248.8 a</td>
<td>17268.3 b</td>
<td>3324.8 a</td>
<td>6406.7 b</td>
<td>7632.9 b</td>
</tr>
<tr>
<td>15</td>
<td>82117.5 a</td>
<td>18792.9 a</td>
<td>3326.3 a</td>
<td>7271.3 a</td>
<td>8195.4 a</td>
</tr>
</tbody>
</table>

Means with the same letter(s) showed no significant differences at 5 and 1% probability level according to Duncan Test.

Ear dry yield:

Analysis of variance indicated that the simple effects of cultivator, density and herbicide rate and the interactions between cultivator and herbicide were significant for ear dry yield, but the other interactions were not significant for it (Table 1). The increase in density from 10 to 15 plants m$^{-2}$ resulted in 7.4% higher ear dry yield (Table 4). Means comparison for the interaction between cultivator and herbicide revealed that under the application of cultivator, ear dry yield of 10 340 kg ha$^{-1}$ can be obtained only by applying 1.5 L ha$^{-1}$ herbicide. Although it was 66.5% higher than that obtained under the treatment of cultivator with no herbicide use, it was ranked in the same statistical group with the treatments of cultivator use and 3 L ha$^{-1}$ herbicide as well as cultivator use and 4.5
L ha\(^{-1}\) herbicide. Although under both cultivator use and disuse, the application of herbicide at the rate of 1.5 L ha\(^{-1}\) performed significantly better than no herbicide application, ear dry yield showed a markedly higher increase under the treatment of no cultivator use and 1.5 L ha\(^{-1}\) herbicide (Fig. 5).

**Fig. 4:** Effect of weeds management method on stem dry yield of forage corn.

**Fig. 5:** Effect of weeds management method on ear dry yield of forage corn.

**Conclusion:**

It was found that under the use of cultivator, forage total dry yield of 23 020 kg ha\(^{-1}\) can be obtained by applying only 1.5 L ha\(^{-1}\) herbicide which is 66.2% higher than that under the use of cultivator with no herbicide usage. In the end, given the fact that sustained farming requires the chemicals to be used less in farming systems, it can be concluded that the application of herbicide Lumaxcan be reduced by 66.6% under the application of cultivator and using appropriate density. It is of crucial importance in the light of the adverse impacts of herbicides on environment and the resistance acquired by weeds against herbicides.

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