Influence of cattle manure and plant density on the Leaf Area Index (LAI) and Green Ear yield of sweet corn in second cultivation by different culture methods

1Amir Haghighat and Amir Hossein Shirani Rad

1Department of Agronomy, Takestan Branch, Islamic Azad University, Takestan, Iran.
2Associate professor, Department of Agronomy, oil seed crops Institute, Karaj, Iran.

A R T I C L E  I N F O

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A B S T R A C T

In order to investigate the effect of different cattle manure levels and plant densities as well as comparing two culture methods on the leaf area index (LAI) and green ear yield related to sweet corn, a split-factorial design was conducted as base of randomized complete block design with four replications at the research farm of Takestan, Iran, in 2009. Cattle manure rates were assigned to main plots at three levels (m1=0, m2=25 and m3=50 ton/ha) and plant density in two levels (d1=75000, d2=85000 plant/ha) with culture method in 2 levels (c1=on ridge and c2=on furrow) as sub plots were considered. From 20 day after emergence (DAE), Leaf Area Index (LAI) was measured every 10 days. Furthermore, at the end of the growth season, green ear yield was calculated. The result showed that, in all sampling times, LAI was increased significantly by increasing cattle manure. Also the results indicated that plant density had significant effect on LAI and increased LAI with the increased plant density (at the 50, 60, 70 and 80 DAE) and the results demonstrated that culture method significant effect on LAI at the 20, 30, 40 and 50 DAE.

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INTRODUCTION

The plant growth involves various environmental and agronomical factors, such as water, temperature, light, nutrients, and etc [35,55,56]. The nitrogen (N) is a vital nutrient for the activity of plant organs. It is a fraction of many components such as; amino acids, nucleic acids, chlorophyll and etc. Thus, plant growth can be affected by the amount of nitrogen [41,53]. Previous studies have shown that nitrogen fertilizer can increase the growth characteristics, such as; plant height, shoot dry matter, and Leaf Area Index (LAI) [15,28,30,48,50,57]. Nitrogen is an essential mineral nutrient for plant growth. High rate of nitrogen application leads to more rapid leaf area development prolongs life of foliage, increases leaf area duration after flowering and enhance on the whole crop assimilation, consequently contributing to increase in seed production [32,33]. Nitrogen is one of the main plant nutrients affecting plant growth and yield [51].

Leaf area and LAI increase with increase in N level [44]. Maize crop differs in its ability to maintain LAI, CGR and above ground dry matter production at different levels of N application [45].

The animal manure (such as cattle manure) is another source of nitrogen and other nutrients, which can decrease the demand of chemical fertilizer, and it has been used for many centuries to increase soil fertility [19,34,36,38,54,58,59]. Except for the supply of nitrogen fraction, animal manure can improve chemical, physical and biological characteristics of soil [13,18,22,41,47,61].

Cattle manure is generally used in two forms: fresh or composted. Fresh manure has lower C:N ratio than composted manure, but it is more difficult to store and transport if it is not from on-farm livestock. There is evidence that at least 50% of N in manure is lost in storage and transport, and another 25% is lost after application [21]. Many researchers have reported that manure application has positive effects on the physicochemical properties of soil and improves crop yields [14,12,29]. Animals and green manure are prospective organic fertilizer resources when it is well managed. Cow manure contains of 1% N, 0.2% P, and 1% K [37]. Manure application increased wheat P uptake by 23.53% [7].

The effect of organic matter to the sweet corn growth and yield was reported similar to chemical synthetic fertilizer and even better [23,62]. Organic matter, especially cattle manure, affects crop growth and yield directly by supplying nutrients and indirectly by modifying soil physical properties that can improve the root

Corresponding Author: Amir Haghighat, Department of Agronomy, Takestan Branch, Islamic Azad University, Takestan, Iran.
E-mail: A.haghighat63@yahoo.com
environment and stimulate plant growth [9]. Some researchers have also reported positive response of vegetables grown under both organic and inorganic fertilizer management [52,4].

Many researchers have mentioned the beneficial effects of organic fertilizer including the increase of hydraulic conductivity, raising the water holding capacity, changing the soil pH (increase or decrease in the pH, depending on soil type and characteristics of organic fertilizer), elevating the soil aggregation and water infiltration, reducing the frequency of plant diseases and etc [17,22,24,43,54]. The positive effects of organic manure on the plant height, shoot dry matter and LAI have been previously reported [1,5,31,46]. Organic fertilizers such as cattle manure, contain large amount of nutrients and influences plant growth and production via improving chemical, physical and biological fertility [61,13,26,3]. Green leaf area index (LAI) is one of the canopy parameters that plays a major role in vegetation physiological processes, and ecosystems functioning; it has been frequently used by agronomists and crop physiologists to assess crop conditions and growth [10,20,16]. Assessment of crop leaf area index (LAI) and its spatial distribution in agricultural landscapes are of importance for addressing various agricultural issues such as: crop growth monitoring, vegetation stress, crop forecasting, yield predictions, and management practices. Indeed, LAI is a canopy biophysical variable that plays a major role in vegetation physiological processes, and ecosystem functioning. [10,20,16,27].

MATERIALS AND METHODS

This study was conducted at experimental field of Takestan-Iran (Islamic Azad University), during cropping season of 2009 (as of June 20 until October 12). The site is located at 5 kilometers southwest of Takestan (Latitude 36° 04´ N, Longitude 49°39´ E; Mean annual rainfall of 257 mm; Relative humidity: 55 to 65%; Mean annual temperature: 13.8 ºc and 1265 m above sea level). The soil tissue was loamy-clay with pH:7.6 (Table1).

The experimental units were designed as split-factorial on basis of completely randomized block design with four replications. Cattle manure levels were allotted to main plots (m1: non-application of cattle manure, m2: application of 25 ton/ha of cattle manure and m3: application of 50 ton/ha of cattle manure). Factorial application of plant density (d1: 75000 plants/ha and d2: 85000 plants/ha) and culture method (c1: culture on the ridge and c2: culture on the furrow) were also allotted to sub plots.

Soil tillage was done with a tractor. The sweet corn seeds were selected from hybrid sweet corn namely ‘Ksc403su’. The life cycle of this cultivar is about 90 to 100 days and recommended as spring cultivar for many areas in Iran. Cultivation method was based on ridge and furrow system. Weed control was achieved by means of two hoeings, performed at 20 and 40 days after planting (DAP). A thinning operation was performed 26 days after sowing, leaving the more vigorous plants in each plot.

The under study traits in this research included:( Leaf Area Index (LAI) and green ear yield).

From 20 day after emergence (DAE), Leaf Area Index (LAI) was measured every 10 days. After discarding margin plants, the green ear yield was evaluated via total weight of green unhusked ears, and by the weight of both marketable unhusked and husked ears per each plot and expressed as kg/ha. Obtained data were subjected to analysis of variance analysis (ANOVA) and least significant differences (P<0.05) were calculated using statistic software (MSTATC).

Table 1: Physical and chemical properties of experimental soil before planting

<table>
<thead>
<tr>
<th>Soil depth(cm)</th>
<th>O.C(%)</th>
<th>N(%)</th>
<th>P(p.p.m)</th>
<th>K(p.p.m)</th>
<th>Soil texture</th>
<th>pH</th>
<th>EC(ds/m)</th>
<th>S.P(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30</td>
<td>0.81</td>
<td>0.07</td>
<td>5</td>
<td>180</td>
<td>Clay-loam</td>
<td>7.68</td>
<td>0.75</td>
<td>41</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

Effect cattle manure on LAI:

The results showed that the cattle manure had a significant effect on the LAI in the all sampling times (Table 2). Means comparison showed that, with increase in cattle manure application, LAI increased significantly.

In during the growth season and in the all sampling times, maximum LAI was obtained in plots that application of 50 t/ha cattle manure while minimum LAI was obtained in plots that non-application of cattle manure. According to Figure 1, highest the LAI (with mean 2/40) observed at the sampling 6 (70 days after emergence) in plots that received 50 t/h of cattle manure.

Cattle manure enriches the soil and caused more soil fertility that in resulted increased the ability of plants and produced more LAI. Nevertheless, in case of not consuming cattle manure, the soil will get poor and a nutrient-deficient soil has low productivity and decreased the ability of plants that in resulted decreased the LAI.

Animal manure improves soil physico-chemical properties, enhances soil nutrients and organic matter content, improves soil pH and CEC and promotes the activity of soil organisms [25].

The amount of LAI can increase with increasing organic fertilizer [46]. Previous studies have shown that nitrogen fertilizer can increase the growth characteristics, such as: plant height, shoot dry matter, and Leaf Area
Index (LAI) [15, 28, 30, 48, 50, 57]. The animal manure (such as cattle manure) is another source of nitrogen and other nutrients, which can decrease the demand of chemical fertilizer, and it has been used for many centuries to increase soil fertility [19, 34, 36, 38, 54, 58, 59]. Leaf area and LAI increase with increase in N level [44].

The positive effects of organic manure on the plant height, shoot dry matter and LAI have been previously reported [1, 5, 31, 46].

**Effect plant density on LAI:**

The results of variance analysis revealed that LAI was affected significantly by plant density at the 50, 60, 70 and 80 days after emergence (table 2). The mean comparison results revealed that LAI was increased with rising plant density (at the 50, 60, 70 and 80 days after emergence). In this experiment, Plant density of 85000 plants/ha was superior to plant density of 75000 plants/ha and the maximum amounts of LAI was obtained the Plant density of 85000 plants/ha at the 70 DAE (sampling 6) with mean 2/21.

Application of optimum plant density in corn production helps for the proper utilization of solar radiation, which influences leaf area, interception and utilization of solar radiation, and consequently corn dry matter accumulation and biomass produced [40].

Increasing plant density is one of the ways of increasing the capture of solar radiation within the canopy and LAI and increasing of dry matter accumulation [39].

Generally, in suitable plant density, plants are completely use environmental conditions (water, air, light and soil) and inter- or intra-specific competition is minimum. Also Some researchers reported that one of ways of increasing leaf area index is to increase plant density [60, 11]. leaf area index is major factor determining photosynthesis and dry matter accumulation[8].

Fresh and dry weights were increased at high plant density of Pearl Millet (Pennisetum glaucum L.) and high plant density produced the highest leaf area index [6]. with the increase in plant population it significantly increased LAI [2].

**Fig. 1:** Effect of different amounts of cattle manure on LAI as a function of time

**Fig. 2:** Effect of different plant densities on LAI as a function of time

**Effect culture methods on LAI:**

The results indicated that LAI was affected significantly by culture methods at the sampling 1, 2, 3 and 4 (20, 30, 40 and 50 days after emergence)(table 2). The mean comparison results revealed that In the experiment culture on the furrow at the 20, 30, 40 and 50 days after emergence superior than culture on the ridge (Figure 3)
because in the early growth season, plants that were planed on the furrow received more water than plants that were planed on the ridge, as a result, better germinated and faster emergence and indicated more LAI.

According figure 3, maximum amounts of LAI was obtained the Culture on the furrow at the 50 DAE (sampling 4) with mean 2/01.

![Fig. 3: Effect of different culture methods on LAI as a function of time](image)

Green ear yield:

The production of green ears is interesting for several reasons. The ears can be harvested in a very short time (70 to 75 days), and up to four annual crops can be obtained in tropical zone [49]. If the farmer does not intend to sell green ear sweet corn, the dry grain can still be profitable. Totally, green ear yield enhancement is very important in this crop due to being an economic yield and harvested crop mainly is in the form of green ear with milky grains, having moisture content between 70 and 80% [49].

The result of ANOVA showed that effect of cattle manure (P<0.01) was significant on green ear yield, but other treatments and their interactions were not significant (table 2). Means comparison showed that, with increase in cattle manure application, green ear yield increased significantly.

Considering the Figure 4, application of 50 ton/ha cattle manure, produced maximum green ear yield (22130 kg/ha), while non-application of cattle manure, produced minimum green ear yield (10240 kg/ha).

Cattle manure enriches the soil and increases the ability of plants to produce the ear; clearly, enhanced-use of this manure, which caused more soil fertility that in resulted, produced larger ear and increased the green ear yield. Nevertheless, in case of not consuming cattle manure, the soil will get poor and a nutrient-deficient soil has low productivity that in resulted, produced smaller ear and decreased the green ear yield.

The effect of organic matter to the sweet corn growth and yield was reported similar to chemical synthetic fertilizer and even better [23,62].

Organic matter, especially cattle manure, affects crop growth and yield directly by supplying nutrients and indirectly by modifying soil physical properties that can improve the root environment and stimulate plant growth [9].

Nitrogen is one of the main plant nutrients affecting plant growth and yield [51].

Organic fertilizers such as cattle manure, contain large amount of nutrients and influences plant growth and production via improving chemical, physical and biological fertility [61,13,26,3]. Many researchers have reported that manure application has positive effects on the physicochemical properties of soil and improves crop yields [14,12,29].

![Fig. 4: Effect of different amounts of cattle manure on green ear yield](image)
Table 2: Analysis of variance for LAI and green ear yield

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LAI 1</td>
<td>LAI 2</td>
<td>LAI 3</td>
<td>LAI 4</td>
<td>LAI 5</td>
<td>LAI 6</td>
<td>LAI 7</td>
</tr>
<tr>
<td>Replication</td>
<td></td>
<td>3</td>
<td>0.052</td>
<td>0.025</td>
<td>0.090</td>
<td>0.175</td>
<td>0.028</td>
<td>0.168</td>
</tr>
<tr>
<td>Cattle manure</td>
<td></td>
<td>2</td>
<td>0.162**</td>
<td>0.343**</td>
<td>0.869**</td>
<td>2.535**</td>
<td>1.051**</td>
<td>1.943**</td>
</tr>
<tr>
<td>Ea</td>
<td></td>
<td>6</td>
<td>0.011</td>
<td>0.030</td>
<td>0.114</td>
<td>0.085</td>
<td>0.012</td>
<td>0.159</td>
</tr>
<tr>
<td>Plant density</td>
<td></td>
<td>1</td>
<td>0.009</td>
<td>0.001</td>
<td>0.221</td>
<td>0.778</td>
<td>0.677</td>
<td>1.267</td>
</tr>
<tr>
<td>Cattle manure×Plant density</td>
<td></td>
<td>2</td>
<td>0.001</td>
<td>0.010</td>
<td>0.004</td>
<td>0.145</td>
<td>0.040</td>
<td>0.046</td>
</tr>
<tr>
<td>Culture method</td>
<td></td>
<td>1</td>
<td>0.065</td>
<td>0.402</td>
<td>1.880</td>
<td>0.345</td>
<td>0.017</td>
<td>0.001</td>
</tr>
<tr>
<td>Cattle manure×Culture method</td>
<td></td>
<td>2</td>
<td>0.008</td>
<td>0.011</td>
<td>0.045</td>
<td>0.083</td>
<td>0.199</td>
<td>0.045</td>
</tr>
<tr>
<td>Plant density×Culture method</td>
<td></td>
<td>1</td>
<td>0.001</td>
<td>0.015</td>
<td>0.219</td>
<td>0.060</td>
<td>0.035</td>
<td>0.018</td>
</tr>
<tr>
<td>Cattle manure×Plant density×Culture method</td>
<td></td>
<td>2</td>
<td>0.003</td>
<td>0.023</td>
<td>0.034</td>
<td>0.071</td>
<td>0.067</td>
<td>0.032</td>
</tr>
<tr>
<td>Error</td>
<td></td>
<td>27</td>
<td>0.004</td>
<td>0.011</td>
<td>0.065</td>
<td>0.060</td>
<td>0.109</td>
<td>0.089</td>
</tr>
<tr>
<td>CV%</td>
<td></td>
<td>27.55</td>
<td>19.09</td>
<td>19.21</td>
<td>12.76</td>
<td>17.89</td>
<td>14.57</td>
<td>12.71</td>
</tr>
</tbody>
</table>

*, ** = Significant at 5 and 1% probability, respectively. ns= non-significant

REFERENCES


