Effects of previous legume crop levels of nitrogen and sowing date on yield components and some morphological characteristics of corn

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ABSTRACT

This study was conducted in order to determine the effect of different previous crops and sowing dates on the grain yield and some other yield components of corn under typical Mediterranean climatic conditions during summer period of 2013 and 2014. The experiment was laid out in a split-plot design in the form of randomized complete blocks with three replications. The main plots were allocated to three sowing dates (Early Spring, Mid Spring and Late Spring) and sub-plots to previous crops (Vicia sativa, Vicia villosa, Lathyrus sativus, Trifolium resupinatum and Pisum arvense) and three different controls without previous crop (control-1: 100 kg ha$^{-1}$ N; control-2: 200 kg ha$^{-1}$ N and control-3: 0 kg ha$^{-1}$ N). Corn grain yield, yield components (number of ears per plant, number of seeds per ear, ear length, ear diameter, 1000-grain weight) and plant height were assessed. The results showed that late planting date had a significantly negative effect on tested traits and second planting date (mid-spring) produced higher corn grain yield compared to the other dates. The highest corn grain yield (11011 kg ha$^{-1}$) also occurred in control-2 (200 kg ha$^{-1}$ N without previous crop) treatment and was significantly different from the other previous crop treatments with 100 kg ha$^{-1}$ N and controls except Vicia villosa as previous legume crop of which corn grain yield was comparable with it.

Key words: Grain yield, Nitrogen fertilizer, Previous legume crop, Sowing date, Zea mays L.

INTRODUCTION

One of the fastest and most effective ways to increase yield per unit area is the application of fertilizer in corn. Corn dominates field cultivation world wide and nitrogen is one of the most crucial nutrients for corn production (Finck, 1991). Activities in the field may vary the results, but a large amount of fertilizer could be required and as the amount used increases so may economic losses along with a rise in environmental pollution (Adesoji et al., 2013).

More and more interest is being shown in the use of organic fertilizer to improve soil fertility and reduce environmental pollution which is so often the results of the none-stop application of chemical fertilizers. The symbiotic nitrogen fixation that occurs in plants that nitrogen-fixing bacteria within their tissues can prevent the resulting pollution from the use of mineral nitrogen and provide sustainability. Used in crop rotation legumes can contribute to a diversification of cropping yield systems and act as N2-fixing plant thus reducing the mineral nitrogen fertilizer demand (Lemlem, 2013). Should there be a need to intensify agricultural production, then methods for maximizing the use of crop land must be found, which do not lead to degradation of the soil and more pollution. Methods of maximizing the use of agricultural land are frequently the results of forage legume application. The first step of rotation studies is the identification of the major crop group which will be suitable for the existing environmental and climate conditions. Various studies were conducted on previous crop for corn by many researchers (Gul et al., 2008; Mohammadi and Ghabadi, 2010). They also reported that common vetch (Vicia sativa L.), berseem clover (Trifolium alexandrinum L.), Hungarian vetch (Vicia pannonica L.) and alfalfa (Medicago sativa L.) might be beneficial for crop rotation to increase yield of corn. These plants increased productivity in the control plots by 46%, 17%, 8% and 16%, respectively.

Many studies for corn indicated that the grain yield depends on the sowing date. These are aimed at discovering the optimum planting dates world-wide. The optimum sowing date is crucial for the potential of each rotation. It has special importance in crop plantation and management in corn since it affects growth and crop traits at the various development stages. This could enhance environmental factors which

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impact the ultimate yield. Jasemi et al. (2013) reported from Iran, the highest corn grain yield (11654 kg ha$^{-1}$) obtained on May 22 planting date and the lowest grain yield (6502 kg ha$^{-1}$) on July 13. Azadbakht et al. (2012) found that the best growth, highest yields (14060 kg ha$^{-1}$) and thousand grain weight (331.7 g) were obtained on the corn sown on May 11 and that yield decreased as the sowing date was delayed.

The main aim of this research was to evaluate the influence of previous crops and different sowing dates on the grain yield and some yield components of corn under the conditions of Mediterranean ecology.

**MATERIALS AND METHODS**

This experiment was performed during spring and summer growing seasons of 2013 and 2014 at Bornova experimental fields (38º27 N, 27º13 E; 20 m a.s.l) in Ege University, Izmir, Turkey.

Mediterranean climate is dominant in this region. The total rainfall was 87.7 mm and daily mean temperature was 23.6 ºC as long year average in April-May-June-July and August period. The soil was silty-clay loam soil with the following characteristics; pH: 7.6; CaCO$_3$: 19.6%, total N: 0.13% and organic matter 1.15%. The experiment was repeated on three previous crops (Vicia sativa, Vicia villosa, Lathyrus sativus, Trifolium resupinatum and Pisum arvense) and three different controls without previous crop [control-1 (N$_{100}$): 100 kg ha$^{-1}$ N; control-2 (N$_{50}$): 200 kg ha$^{-1}$ N and control-3 (N$_{0}$): 0 kg ha$^{-1}$ N].

The experiment was laid out in a split-plot design in the form of randomized complete blocks with three replications. The sowing dates were the main plots and the previous crop were subplot. All previous crops were seeded on 11 Oct. 2012 and 11 Oct. 2013 at seeding rates of 120 kg ha$^{-1}$ common vetch, 120 kg ha$^{-1}$ hairy vetch, 150 kg ha$^{-1}$ grass pea, 30 kg ha$^{-1}$ Persian clover and 150 kg ha$^{-1}$ field pea. Previous crops were grown for nearly 5-6 months and harvested at stubble height of 5 cm and then the residue were incorporated into the soil after harvest. In the experiment years (2013 and 2014) previous crops were harvested in the last week of March, mid of April and in the last week of April, respectively. The corn was planted about ten days after each plots of previous crops was harvested.

Traditional methods of soil tillage for each plot were used: including mouldboarding, ploughing and rototilling with a mini-cultivator before sowing. Each subplot consisted of four rows; 4 m long with 0.70 m between rows and 0.20 m intra-row spacing. The corn cultivar used was ‘colonia’ (FAO 650) and planted by hand and the sowing date was April 8 and April 9 for early spring, April 25 and April 24 for mid spring and May 8 and May 9 for late spring in 2013 and 2014, respectively. The soil was harrowed 5 days before planting, after which the fertilizer treatments for corn crop were as following:

In the experiments, weeds were controlled by hand and harrowing. Since any epidemic symptoms of corn disease or pest during growing periods were not detected, only preventive spray (Alphacypermethrin) were applied twice at 6-7 leaf stage of corn crops to control Ostrinia nubilalis. All plots were irrigated at intervals of 7-10 days. Corn plots were harvested cutting the mid-rows of plots in order to avoid border effects when the seeds in each plot measured at 13 % humidity (Zscheischler et al., 1990).

In the experiment, plant height, ears per plant, seeds per ear, ear diameter, ear length, 1000 grain weight and grain yield parameters were studied. Agronomical traits of corn were measured at harvest time in 10 plants. The ears were dehusked and threshed and grain weight was recorded.

<table>
<thead>
<tr>
<th>Previous Crop</th>
<th>Ammonium sulfate (21% N)</th>
<th>Triphosphate super phosphate (42% P$_2$O$_5$)</th>
<th>Potassium sulfate (50% K$_2$O)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At corn sowing date</td>
<td>4 weeks after sowing</td>
<td>At corn sowing date</td>
</tr>
<tr>
<td>Vicia sativa (Common vetch)</td>
<td>50 kg ha$^{-1}$</td>
<td>50 kg ha$^{-1}$</td>
<td>100 kg ha$^{-1}$</td>
</tr>
<tr>
<td>Vicia villosa (Hairy vetch)</td>
<td>50 kg ha$^{-1}$</td>
<td>50 kg ha$^{-1}$</td>
<td>100 kg ha$^{-1}$</td>
</tr>
<tr>
<td>Lathyrus sativus (Grasspea)</td>
<td>50 kg ha$^{-1}$</td>
<td>50 kg ha$^{-1}$</td>
<td>100 kg ha$^{-1}$</td>
</tr>
<tr>
<td>Trifolium resupinatum (Persian clover)</td>
<td>50 kg ha$^{-1}$</td>
<td>50 kg ha$^{-1}$</td>
<td>100 kg ha$^{-1}$</td>
</tr>
<tr>
<td>Pisum arvense (Field pea)</td>
<td>50 kg ha$^{-1}$</td>
<td>50 kg ha$^{-1}$</td>
<td>100 kg ha$^{-1}$</td>
</tr>
<tr>
<td>Control-1 (N$_{100}$, no previous crop)</td>
<td>50 kg ha$^{-1}$</td>
<td>50 kg ha$^{-1}$</td>
<td>100 kg ha$^{-1}$</td>
</tr>
<tr>
<td>Control-2 (N$_{50}$, no previous crop)</td>
<td>100 kg ha$^{-1}$</td>
<td>100 kg ha$^{-1}$</td>
<td>100 kg ha$^{-1}$</td>
</tr>
<tr>
<td>Control-3 (N$_{0}$, no previous crop)</td>
<td>No Nitrogen</td>
<td>No Nitrogen</td>
<td>100 kg ha$^{-1}$</td>
</tr>
</tbody>
</table>
hundred dry seeds from each plot were sampled and weighed
to determine the 1000-grain weight.

All data of two years mean were statistically analyzed
using TOTEMSTAT (Acikgoz *et al.*, 2004). Probabilities equal
to or less than 0.05 were considered significant. If,
TOTEMSTAT indicated LSD differences between treatments
means, a LSD test was performed to separate them.

**RESULTS AND DISCUSSION**

**Plant height:** The results showed that plant height for corn
was significantly affected by both the previous crop and the
sowing date (Table 2). The average corn plant heights of
control-2 (without previous crop) and treatment after *Vicia
villosa* as previous crop were 247.34 and 245.36 cm,
respectively and higher than other previous crops in two year
average. Forage legume species can fix a substantial amount
of atmospheric N$_2$, which allows them to be grown in N-
impoverished soils without fertilizer or N inputs. In this study,
when *Vicia villosa* was used as a previous crop instead of
other plants, plant height in corn was at its highest. These
results were in agreement with some researchers like Dogan
and Bilgili (2010); Idikut and Kara (2011) displaying that
considerable variation in N fixation can occur even among
legume species as previous crop.

The highest plant height (239.75 cm) was from the
early spring sowing date, whereas the lowest value (233.49
cm) was found on the late sowing date in both years. Plant
height increases during the vegetative period and the plant
reaches its maximum height when the tassel is fully emerged.
The beginning of the tasseling stage determines the end of
the vegetative period which depends on cultivar and weather
conditions. In late spring vegetative period was reduced
because of high air temperature in the spring and the height
of corn decreased, while the early planting resulted in even
taller plants. The results of this study were similar to
Azadbakht *et al.* (2012); Casini (2012) and Jasemi *et al.*
(2013) who showed; the more delayed the date of sowing,
the more reduced plant height was.

**The number of ears per plant:** Year, previous crop, sowing
date and their interactions had no significant effects on the
number of ears per plant of corn (Table 2). The effect of
previous crop on number of ears per plant was not significant,
while the same highest number of ears per plant by average
of 1.19 ears was obtained both corn after *Vicia villosa* and
control-2. Since the maximum number of ears per plant value
of first sowing date (1.20 ears) and the minimum number of
ears per plant value of third sowing date (1.13 ears) were not
significantly different, sowing date was not effective on
number of ears per plant.

According to Dobermann *et al.* (2003) number of
ears per plant is a genetic characteristic and less influenced
by environment.Mohammadi and Ghobadi (2010); Casini
(2012) and Lemlem (2013) reported that different cover crop
and sowing date had no significant effect on the number of
ear per plant for corn and that this number fluctuated between
0.8 to1.23.

**The number of seeds per ear:** While different year and all
two and three factor interactions did not affect the number of
seeds per ear, previous crop and sowing date had an significant
effect (Table 2). The highest number of seeds per ear was
obtained from control-2 as 620.9 seeds and corn planted after
*Vicia villosa* with 603.7 seeds, was not significantly different.
However, the lowest corn seed number per ear was obtained
from control-3 (326.8 seeds). Since the photosynthetic
capacity and the amount of plant growth was increased by
the nitrogen present, the number of seeds per ear was
determined by the nitrogen which plays a key role in the grain
yield. Salem and Ali (1979) recorded that the application of
nitrogen increased the number of seeds per plant. Our research
results supported those of Mohammadi and Ghobadi (2010);
Adesoji *et al.* (2013); Lemlem (2013) who observed
significant differences between corn crops in terms of number
of seeds per ear, depending on the nitrogen-fixing capacity
of forage legumes which had been used as previous crops.

The highest number of seeds per ear (550.2 seeds)
was obtained from the mid spring sowing date and was
significantly different compared with the other two sowing
dates. The corn planted at the last sowing date showed the

**TABLE 1:** Monthly average temperatures and total precipitations at Bornova-Turkey location

<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature (°C)</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>April</td>
<td>17.3</td>
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<td>May</td>
<td>22.7</td>
<td>20.8</td>
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<tr>
<td>June</td>
<td>25.7</td>
<td>24.7</td>
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<tr>
<td>July</td>
<td>28.4</td>
<td>27.5</td>
</tr>
<tr>
<td>August</td>
<td>28.7</td>
<td>28.1</td>
</tr>
<tr>
<td>Mean/Total</td>
<td>24.6</td>
<td>23.6</td>
</tr>
</tbody>
</table>

LA: long year average
TABLE 2. Plant height, number of ears per plant, number of seeds per ear, ear length, ear diameter, 1000-grain weight and grain yield of corn according to year, previous crop and sowing date

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Plant height (cm)</th>
<th>Number of ears per plant</th>
<th>Number of seeds per ear</th>
<th>Ear length (cm)</th>
<th>Ear diameter (mm)</th>
<th>1000-grain weight (g)</th>
<th>Grain yield (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year (A)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>ns</td>
<td>ns</td>
<td>ns</td>
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<td>ns</td>
</tr>
<tr>
<td>2014</td>
<td>236.65</td>
<td>1.17</td>
<td>537.4</td>
<td>19.14</td>
<td>41.8</td>
<td>362.1</td>
<td>8766</td>
</tr>
<tr>
<td>LSD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Previous Crop (B)</strong></td>
<td>*</td>
<td>ns</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td><em>Vicia sativa</em> (Common vetch)</td>
<td>244.95 b</td>
<td>1.19</td>
<td>564.4 bc</td>
<td>19.84 ab</td>
<td>43.1 ab</td>
<td>392.4 ab</td>
<td>9735 c</td>
</tr>
<tr>
<td><em>Vicia villosa</em> (Hairy vetch)</td>
<td>245.36 ab</td>
<td>1.15</td>
<td>603.7 a</td>
<td>19.87 ab</td>
<td>43.7 a</td>
<td>394.6 ab</td>
<td>10111 b</td>
</tr>
<tr>
<td><em>Lathyrus sativus</em> (Sweet pea)</td>
<td>241.55 c</td>
<td>1.12</td>
<td>577.7 b</td>
<td>19.58 bc</td>
<td>42.6 b</td>
<td>376.6 bc</td>
<td>9406 d</td>
</tr>
<tr>
<td><em>Trifolium resupinatum</em> (Persian clover)</td>
<td>239.89 c</td>
<td>1.13</td>
<td>524.8 d</td>
<td>18.83 ed</td>
<td>41.5 e</td>
<td>354.9 ed</td>
<td>8923 e</td>
</tr>
<tr>
<td><em>Pisum arvense</em> (Field pea)</td>
<td>241.70 c</td>
<td>1.13</td>
<td>554.8 c</td>
<td>18.92 ed</td>
<td>40.3 d</td>
<td>350.7 ed</td>
<td>9250 d</td>
</tr>
<tr>
<td>Control-1 (N10)</td>
<td>237.00 d</td>
<td>1.18</td>
<td>519.8 d</td>
<td>18.59 d</td>
<td>40.7 cd</td>
<td>336.3 d</td>
<td>8471 f</td>
</tr>
<tr>
<td>Control-2 (N20)</td>
<td>247.34 a</td>
<td>1.19</td>
<td>620.9 a</td>
<td>20.62 a</td>
<td>43.9 a</td>
<td>407.4 a</td>
<td>11011 a</td>
</tr>
<tr>
<td>Control-3 (N30)</td>
<td>193.64 e</td>
<td>1.16</td>
<td>326.8 e</td>
<td>16.02 e</td>
<td>37.1 e</td>
<td>241.6 e</td>
<td>3604 g</td>
</tr>
<tr>
<td>LSD</td>
<td>2.25</td>
<td>-</td>
<td>20.5</td>
<td>0.83</td>
<td>1.0</td>
<td>26.7</td>
<td>288</td>
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<tr>
<td><strong>Sowing Date (C)</strong></td>
<td>*</td>
<td>ns</td>
<td>*</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>*</td>
</tr>
<tr>
<td>SD₁</td>
<td>239.75 a</td>
<td>1.20</td>
<td>528.2 b</td>
<td>18.62</td>
<td>41.1</td>
<td>352.5</td>
<td>8747 b</td>
</tr>
<tr>
<td>SD₂</td>
<td>236.04 b</td>
<td>1.14</td>
<td>550.2 a</td>
<td>19.12</td>
<td>41.8</td>
<td>363.3</td>
<td>9072 a</td>
</tr>
<tr>
<td>SD₃</td>
<td>233.49 c</td>
<td>1.13</td>
<td>531.5 b</td>
<td>19.35</td>
<td>41.9</td>
<td>354.6</td>
<td>8623 b</td>
</tr>
<tr>
<td>LSD</td>
<td>2.45</td>
<td>-</td>
<td>15.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>AxB</td>
<td>ns</td>
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<td>AxC</td>
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<tr>
<td>AxBxC</td>
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</tr>
</tbody>
</table>

ns: not-significant
lowest number of seeds per ear Suleiman et al. (2014) as a result of the high temperature and drought stress at the grain filling stage. Oktem et al. (2004) and Jasemi et al. (2013) showed that the number of seeds per ear was affected by the planting date.

**Ear length**: The variation analysis of ear length tested in the experiment revealed that only the effect of the previous crop on this trait was significant. The effect of year, sowing date, two and three factor interactions were not significant. The maximum ear length of corn grains for control-2 was highest (20.62 cm) being in same statistical group with which corn crops after *Vicia villosa* and *Vicia sativa* (19.9 cm and 19.8 cm, respectively). These results indicated that there was a positive relationship between nitrogen fixation for forage legume as previous crop and the ear length of corn, probably due to variable plant competition. Similar results were obtained by Idikut et al. (2009); Adesoji et al. (2013); Lemlem (2013) who found that some legume cover crops affected the ear length of corn.

Kwabiah (2004) reported that the sowing date had no significant effect on ear length, however, Namakka et al. (2008); Farsiani et al. (2011); Mashreghi et al. (2014) showed that ear length were affected by the sowing date. The differences between these studies may be due to the different ecological conditions and agronomical practices.

**Ear diameter**: The main effects of previous crops as a factor were significant while the other two and three factor interaction effects were not significant (Table 2). The ear diameter values of control-2 (43.9 mm), corn after *Vicia villosa* (43.7 mm) and after *Vicia sativa* (43.1 mm) were not significantly different. The minimum value of corn ear diameter of 37.1 mm was recorded in corn crop in control-3 (241.6 g) being in same statistical group with which corn crops after *Vicia villosa* and *Vicia sativa* (19.9 cm and 19.8 cm, respectively). These results indicated that there was a positive relationship between nitrogen fixation for forage legume as previous crop and the ear length of corn, probably due to variable plant competition. Similar results were obtained by Idikut et al. (2009); Adesoji et al. (2013); Lemlem (2013) who found that some legume cover crops affected the ear length of corn.

Vicia villosa (394.6 g) and after Vicia sativa (392.4 g) which had the maximum values. The 1000-grain weight of control-3 (241.6 g) was the minimum amount recorded.

These results were in agreement with those of researchers (Idikut et al., 2009; Mohammadi and Ghobadi, 2010; Adesoji et al. 2013) who claimed there was an effect of legume cover crop on 1000-grain weight on corn. The results of variation analysis of corn 1000-grain weight indicated that sowing dates were not significantly effective on this character, although the maximum average weight (363.3 g) was recorded in second planting date. Although the differences were not significant, it was concluded that the lowest 1000-grain weight in early sowing date was mainly due to a lesser number of grains per ear. The thousand grain yield values were found similar with Azadbakhht et al. (2012); Peykarestan and Seify (2012) and Jasemi et al. (2013).

**Grain Yield**: The results showed that corn grain yield was significantly affected by both the previous crop and the sowing date (Table 2). The highest grain yield (11011 kg ha$^{-1}$) occurred in control-2 (200 kg ha$^{-1}$) plots followed by corn crop after *Vicia villosa* (10111 kg ha$^{-1}$) being significantly different from each other. As indicated previously, nitrogen is an important element for corn, but also the one that most often limits the yield. Teasdale et al. (2008) reported that, if more nitrogen is available between definite limits the larger the grain yields. Similar information have been declared by Mohammadi and Ghobadi (2010); Bassegio et al. (2013); Werncke et al. (2014) that the grain yield of corn also increased in relation to the previous legume crop as nitrogen sources. In our study higher and comparable corn grain yield of *Vicia sativa* as previous crop with control-2 (200 kg ha$^{-1}$ nitrogen treatment) may be attributed to the adaptability of *Vicia sativa* to existing conditions and high amount of organic nitrogen provided by this legume.

The highest average grain yield (9072 kg ha$^{-1}$) in terms of sowing dates was obtained from mid-spring sowing date and the lowest grain yield (8623 kg ha$^{-1}$) was recorded in the late spring, whereas the difference between late and early spring sowing dates was not significant. Hall and Twidwell (2002), displayed that there must be a five to ten days time difference between the shedding of pollen by the tassel and the emergence of the silks for fertilization to occur. Shaw (1977), also declared that the corn silk tasseling stage is crucial and heat and drought stress during this phase have been seen to produce lower and lower yields for each day of stress and there is a greater reduction in yield than for all the other potential climatic stresses. Since the duration of the
pollination is reduced by the delay in silk emergence and the hastening of pollen shed, there are fewer kernels which can be filled during and after the pollination stage (Kirtok, 1998). Our results of the highest grain yield of mid-spring sowing date can be attributed to this seasonal period which was the most suitable time in terms of pollination and grain filling stage of corn in the area. Our findings concur partly with the results displayed by Mhike et al. (2010); Azadbakht et al. (2012); Jasemi et al. (2013) who reported that grain yield differences between early sown and late sown plants have been attributed to decreased rate of pollination and limited grain filling.

**CONCLUSION**

In the present study, plant height, number of seeds per ear and the grain yield values were adversely affected on late spring sowing dates; whereas all of the characteristics were positively affected by the previous crop treatments in addition to intensive fertilizer application in control-2 plots. We also concluded that both the planting date and the previous crop are key factors in managing corn crops to optimize productivity. It was found also that the highest corn grain yield was obtained on the mid-spring sowing date (9072 kg ha⁻¹) and hairy vetch was found to be recommended as a previous crop to obtain highest corn grain yield (10111 kg ha⁻¹) after control-2 (11011 kg ha⁻¹).

**REFERENCES**


