Study of effects of agroclimatic factors on sugar beet seed production in Ardabil region

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Abstract

To determine the possible effects of climatic parameters on sugarbeet seed yield, the correlation between seed yield and different meteorological parameters during 1955-2002 was determined and the parameters which had significant correlation with seed yield were fitted by multivariate models. To scrutinize the effective climatic factors, the growth period of sugarbeet seed-bearing plants (from early-April to late-July) was divided into fifteen-day intervals during planting-bolting, bolting-blooming, blooming-full bloom, full bloom-maturity and total growth period. Then, simple correlation coefficients of each period with seed yield were estimated and finally multiple regression model was fitted. The results showed that the seed yield significantly correlated with mean temperature during the first half of May (-0.591*) and first half of July (-0.584*), mean sunny hours during the first half of May (-0.544*) and first half of June (-0.550*), total precipitation during the second half of April (0.565*) and first half of June (0.624**) and total received growing degree days (GDDs) during the first half of May (-0.505*) and first half of July (-0.584*). On the other hand, sugarbeet seed yield had significant correlation with total precipitation (0.574*) during the planting-bolting period, sunny hours (-0.511*) during the bolting-blooming period and precipitation (0.526*) during the growth period.

Keywords: agroclimatic factors; sugarbeet seed; Ardabil.

Introduction

Sugar beet seed in Iran is mainly produced in Ardabil for domestic consumption. Its production, which started in 1955 in an area of about 180 hectares, has on average reached to annual seed production of 5000-6000 tones in an area of 3000-4000 hectares (Unpublished Data, Sugar beet seed institute, Karaj, Iran).

Climate is an important factor in sugarbeet seed production. In addition to favorable climatic conditions required during blooming and seed ripening, the conditions for vernalization and bolting are crucially important too. Sugarbeet is a biennial crop that produces root in the first year and seed in the second year. It has special needs for commencing reproductive growth and seed production including required temperature for vernalization and subsequent long days for bolting and blooming (Longden, 1986). Environmental conditions for seed production in field as well as the post-harvest processes carried out on seeds are very important factors in determining seed quality, germination and seedling establishment for producing high root yield (Apostolidas and Goulas, 1998). According to the theory of phasic development, to stimulate blooming, plants need two phases, i.e. thermophase and photophase, so that the former should precede the latter (Kawasaki et al., 1997).

No specific growth stage in sugarbeet has been detected for vernalization. Indeed, it may vernalize at all growth stages. The plants usually need longer vernalization period at their early growth stages (Sadeghian, 1993). The factors affecting vernalization are more effective at these stages, so that a great deal of vernalization may occur at early growth stages or even before that (Smith, 1982). Plants may also partly vernalize...
when seeds are on plants and are ripening under cold conditions (Sadeghian, 1993). Different researchers have confirmed the bolting due cool temperature during seed ripening on parental plant (Bosemark, 1970; Lexender, 1980; Smith, 1982; Wood et al., 1982).

Photoperiod and temperature interaction controls assimilates allocation, too. Wallence et al. (1993) showed that photoperiod and temperature interaction, which is controlled by photoperiod gene, regulates assimilates allocation to blooming and ripening in perennials. Blooming period in sugarbeet is often 35-50 days long because of indeterminate growth of its blooming stems (Wood et al., 1982). Long days after vernalization play important role in stimulating blooming in sugarbeet (Sadeghian, 1993). Blooming period in sugarbeet must be as short as possible to ensure uniform ripening of seeds. Atmosphere humidity should not be very low, too (Cook and Scott, 1993). During blooming, specially pollination, temperature should not exceed 35°C since it injures gametes. Pollens are maximally released under the relative humidity of 60-70% (Wood et al., 1982).

Temperature affects sugarbeet seed ripening duration. Wood et al. (1982) showed that seed ripening duration shortened with the increase in temperature, so that sugarbeet seeds ripened 40-60 days after full blooming at day/night temperatures of 20/12°C. They indicated that during seed ripening, the best condition is the average temperature of 15-20°C with the maximum temperature of 35°C and minimum temperature of 12°C.

Temperature and relative humidity affect sugarbeet seed yield at all growth stages, particularly from pollination to seed ripening. Snader and Hoagboom (1963) studied the effects of temperature during pollination and seed ripening on seed germination in sugarbeet. The results showed that pollination-seed ripening duration was affected by temperature, so that the mean required duration was 71 days (61-90 days) at the temperature of 19°C and 57 days (44-69 days) at the temperature of 24.5°C. The seeds ripened at higher temperature showed faster germination. Low temperature (about 19°C) provides the best condition for production of maximum seed yield. On the other hand, the seeds produced under this condition had slower germination than those produced under higher temperature (about 24°C).

Scott et al. (1973) studied the effects of day/night temperatures of 20/12°C, 16/8°C and 12/5°C on sugarbeet seed production and seed characteristics and showed that seed ripening was significantly retarded as day/night temperature decreased. Also, as day/night temperature decreased during seed ripening, sugarbeet seed yield increased due to the production of oversized seeds. Seeds produced at day/night temperatures of 12/5°C produced less and smaller seedlings than those produced at day/night temperatures of 20/12°C. They had higher bolting percentage and lower sugar yield despite having early-maturity. In fact, cooler temperature is suitable for pericarp growth, but injures shoots and seeds (Wood et al., 1982). Under cooler temperature, empty seed percentage increases (Heide, 1973). Pericarp growth under cool condition thickens seed coat and increases the accumulation of hardeners between pericarp and seed cap (Snader and Hoagboom, 1963). Under cool condition, in addition to higher solidity of seed cap, germination inhibitors are increased (Wood et al., 1982). Chegini (1999) reported that average temperature of less than 15°C during blooming and seed ripening prolongs the ripening duration and increases 1000-seed weight. However, in total it does not increase the yield. In Czechoslovakia, the highest seed yield was obtained at the temperature of 16.8°C, and at the temperatures exceeding 19.3°C, multigerm seed yield decreased by about 0.7 t/ha (Peter, 1991).

Bosemark (1970) studied the effect of seed production conditions on the yield of two mono-germ hybrid cultivars produced in the Netherlands and Sweden. According to the results, environmental conditions under which the seeds had been produced affected root yield by 0.9-3.3 t/ha and root sucrose by 0.2-0.3%. He concluded that the Netherlands had better climate for producing seed than Sweden. Chegini (1999) showed that the effect of temperature on root yield during seed production was due to germination and seedling establishment and finally plant density, so that the seeds produced under adverse conditions had lower germination and seedling establishment and the yield decreased because of the decrease in plant density. In total, environmental conditions during seed production do not considerably affect sugarbeet yield in the subsequent year (Longden, 1986).

The studies using X-ray on seeds produced under hot and cool conditions indicated that the seeds produced under cool conditions had lower germination potential, whereas seeds produced under hot conditions had considerably faster germination (Heide, 1973; Snader and Hoag-
boam, 1963). Chegini (1999) reported that the seeds produced at the temperature of 19-21°C had the highest germination percentage. Moreover, the factors that affect seed quality during its production in field and also its ripening can affect seed quality during post-harvest operations on seeds such as winnowing, grading, storing, etc.

Materials and Methods

In order to determine the potential effect of each climatic parameter on sugarbeet seed yield, the correlation of seed yield with different climatic parameters during 1955-2002 was determined by Software SPSS-WXP. The parameters having significant correlations with seed yield were multivariately modeled by the software using Backward Method. The graph showing the significant effects of climatic parameters on seed yield were plotted by Software QPRO-WXP (for one-dimensional graphs) and Software STATISTICA (for two-dimensional graphs). Finally, final multiple regression model of seed yield prediction was fitted by numerical values of the effective climatic factors.

To scrutinize the effective climatic factors, growth period of sugarbeet seed plants (early-April to late-July) was divided into fifteen-day intervals. Firstly, simple correlation coefficients were calculated between seed yield and the values of climatic parameters including daily temperature, mean relative humidity, mean sunny hours, total precipitation, soil surface temperature, day/night temperature difference, GDD (with a base temperature of 6°C), heat thermal unit (HTU) and photo thermal unit (PTU) and then, multiple regression model was fitted by Backward Method. The values of GDD (Equation 1), HTU (Equation 2) and PTU (Equation 3) were calculated for each interval.

\[
GDD = \sum_{i=1}^{n} (T_{AVG_i} - T_{base})
\]

(1)

\[
HTU = \sum_{i=1}^{n} (T_{AVG_i} - T_{base}) \times SH
\]

(2)

\[
PTU = \sum_{i=1}^{n} (T_{AVG_i} - T_{base}) \times DL
\]

(3)

where, GDD was the required growth degree day, \(T_{AVG_i}\) was the mean daily temperature, \(T_{base}\) was the growth base temperature of sugarbeet seed plants (6°C), \(SH\) was sunny hours and \(DL\) was day length (from sunrise to sunset).

The growth period of sugarbeet seed plants was divided and correlation coefficients were determined. Multiple regression models were fitted in two ways: (1) growth period (from early-April to late-July) was divided into 8 fifteen-day intervals and then firstly, correlation coefficients between seed yield and climatic parameters were calculated and then, multiple regression model was fitted by Backward method; and (2) growth period was divided into five stages, namely planting-bolting, bolting-blooming, blooming-full bloom, full bloom-maturity and total growth period; then, simple correlation coefficients of each stage with seed yield was estimated and finally, multiple regression model was fitted.

Results and Discussion

The correlation between sugarbeet seed yield and different climatic parameters (Table 1) showed that seed yield was significantly correlated with mean temperature during the first half of May (-0.591*) and the first half of July (-0.584*), mean sunny hours during the first half of May (-0.544*) and the first half of June (-0.550*), total precipitation during the second half of April (0.565*) and the first half of June (0.624**) and total received GDDs. Scott et al.

Table 1. Linear correlation coefficients of sugarbeet seed yield with meteorological parameters at fifteen-day intervals from April 1 to July 3 in Ardabil Region on the basis of meteorological data for 1985-2001.

<table>
<thead>
<tr>
<th>Intervals</th>
<th>(T_{mean})</th>
<th>(TGTG)</th>
<th>Sunny Hours</th>
<th>RH (T_{mean})</th>
<th>Precipitation</th>
<th>GDD</th>
<th>HTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr. 1-15</td>
<td>-0.107</td>
<td>0.155</td>
<td>-0.287</td>
<td>0.054</td>
<td>0.300</td>
<td>-0.140</td>
<td>-0.128</td>
</tr>
<tr>
<td>Apr. 16-30</td>
<td>-0.012</td>
<td>0.278</td>
<td>-0.448*</td>
<td>0.287</td>
<td>0.565*</td>
<td>0.035</td>
<td>-0.205</td>
</tr>
<tr>
<td>May 1-15</td>
<td>-0.591*</td>
<td>-0.098</td>
<td>-0.544*</td>
<td>0.467+</td>
<td>0.372</td>
<td>-0.505*</td>
<td>-0.488+</td>
</tr>
<tr>
<td>May 16-30</td>
<td>-0.309</td>
<td>-0.218</td>
<td>-0.217</td>
<td>0.232</td>
<td>-0.206</td>
<td>-0.306</td>
<td>-0.392</td>
</tr>
<tr>
<td>Jun. 1-15</td>
<td>-0.154</td>
<td>0.054</td>
<td>-0.550*</td>
<td>0.370</td>
<td>0.624**</td>
<td>-0.155</td>
<td>-0.302</td>
</tr>
<tr>
<td>Jun. 16-30</td>
<td>-0.230</td>
<td>0.014</td>
<td>-0.041</td>
<td>0.115</td>
<td>-0.002</td>
<td>-0.230</td>
<td>-0.171</td>
</tr>
<tr>
<td>Jul. 1-15</td>
<td>-0.584*</td>
<td>-0.235</td>
<td>-0.192</td>
<td>0.110</td>
<td>-0.077</td>
<td>-0.584*</td>
<td>-0.465+</td>
</tr>
<tr>
<td>Jul. 16-30</td>
<td>-0.226</td>
<td>0.018</td>
<td>0.120</td>
<td>0.076</td>
<td>-0.159</td>
<td>-0.231</td>
<td>-0.065</td>
</tr>
</tbody>
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References