USING AGROCLIMATIC MODELS TO MATCH PHENOLOGY WITH ENVIRONMENTAL FACTORS FOR CUMIN PRODUCTION IN IRAN

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Cumin (*Cuminum cyminum*), an annual herbaceous species grown in arid and semiarid Iran, has a wide range of uses including medicinal, cosmetic and food industry (Kafi et al, 2006). Variability in climatic factors plays an important role in crop production. Sowing takes place between Decembers to March. The crop grows mainly on stored moisture which is progressively depleted with crop growth. The crop experiences drought stress from late vegetative stage until maturity. The intensity of drought stress varies from year to year, depending on the amount and distribution of rainfall and on spring and early summer temperatures. Thus, large responses in grain yield are expected when supplemental irrigations are applied. In wet years with high spring rainfall, damage due to fungal diseases is extremely high and crop yield may be reduced considerably (Israel et al., 2005; Tawfil and Allam, 2004, Hajian and Jafarpour, 1996). Therefore, water requirements of cumin should be scheduled in relation to these pathogens. Results using climatic models to evaluate alternate decisions by examining the interactions between environmental and phenological stages in increasing and stabilizing cumin production are presented.

Methodology

Agroclimatic models were developed using data from Mashhad. Daily climate data were obtained from Iran Metrological department for 1961-2005 for Mashhad, Iran (Lat/Lon: 36.3° N 59.6° E. and Elevation: 989 m). Thermal time concept was used to quantify phenological stages of cumin. Based on data obtained from Kafi (1990) and Tatari (2003), three different phonological stages of cumin were defined as:

a) Phase 1: Sowing to emergence (when 85% of the seedling emerges)
b) Phase 2: Emergence to flowering (when 50% of plants flourished) and
c) Phase 3: Flowering to maturity (when the seeds matured and dried and the color of plant changes to brown).

Based on different base temperature (0, 1, 2, 3, 4, 5 ^{o}C) the degree days requirements for each phenological stages were calculated using formula 1.

$$GDD = [(Tmax + Tmin)/2] - T_b \quad \text{if } (Tmax+Tmin)/2 > Tb \qquad (1)$$

Where GDD is the growing degree days, Tmax., and Tmin. are daily maximum and minimum air temperature, respectively, and T_b is the base temperature.

Based on the analysis, the base temperature of 4 ^{o}C was used in further calculation. The mean duration of phase 1 based on 45 years data for four sowing dates (1st January, 1st February, 1st March and 1st April) and in addition, the seasonal accumulated precipitation were calculated. The first of March was selected as the best sowing date. The duration of phases 2 and 3 using first of March sowing date were calculated. The seasonal accumulated precipitation and the average daily and weekly precipitation and evapotranspiration (Penman method) were used. Probability of receiving 2.5 mm precipitation per day or more and 5 and 10 mm per week or more were examined to assess how much evaporative demand are met by the rainfall.

Results

Information on base temperature of cumin is not well documented in the literature. Sadeghi (1992) stated that the minimum temperature for seedling emergence of cumin is between 2-5 °C. Our results showed that 4 ºC is the best base temperature for cumin. Using these base temperature cumin needs 49.5, 488 and 876 thermal units for phase 1, 2, and 3, respectively. The average number of days from sowing to emergence was 80, 50, 26 and 10 days, for 1st January, 1st February, 1st March and 1st April sowing dates.

Because of cooler temperature during January and February seeds need longer time to achieve the amount of GDD needed to emergence and because of that seed damage would be high. For April 1 sowing although the seeds would emerge quicker compared with other sowing dates, the seedlings would face shortage of water because of less rain. The average seasonal precipitation was 105, 77, 46 and 18mm for 1st January, 1st February, 1st March and 1st April sowing dates, respectively. Therefore, the first of March was the best sowing date for cumin in Mashhad. In the first of March sowing date, the average number of days from sowing to emergence, emergence to flowering and flowering to seed maturing were 26, 58 and 51 days respectively.

Model application:

Model results in choosing appropriate planting dates match well with the common experience by the farmers and agronomists in the Mashhad region. This is particularly relevant in controlling fungal diseases, and choosing optimum time and amount for supplemental irrigation. Our results are in agreement with those of Israel et al. (2005), Tawfil and Allam (2004) who suggested that controlling fungal disease is one of the most important aspect to reduce crop failure mainly during rainy years. Kamkar (2005) suggested that sowing date could be one of the most important manageable options to decrease cumin grain yield gap. Alavi (1969) indicated that delaying planting date from December to March reduces the disease damage to cumin in some areas of Khorasan. The disease agent usually attacks the plant mainly during late March. Fungal infection generally occurs when the temperature rises and humidity increases as a result of more rain. By changing the planting date to the first of March, chances of fungal infection of cumin were minimized. Another impact of the model was in choosing supplemental irrigation to optimize cumin yield as a function of planting dates. The probability of receiving 10 mm or more precipitation per week in Mashhad for March 1 sowing date (50%, 15% and 1% at emergence, flowering and seed maturing) were used to demonstrate that supplemental irrigation (1 to 2) provided better farm yields.

Conclusions

Based on our results the first of March is best sowing date for cumin in Mashhad because of lower fungal infection associated with more reliable rainfall during emergence to flowering. The model showed promise for its use in farm decision-making in terms of resource allocation and we recommend further testing of the model with additional sites, and more interactions with the potential users.

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