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Quantifying the Yield Gap in Sugar Beet Seed Production: Insights from Ardabil, Iran

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Introduction: Sugar beet seed production, unlike the cultivation of sugar beets which is a key component of sugar production in temperate regions worldwide, is a rare and lesser-known agricultural practice that occurs in specific climatic zones (Sadeghzadeh Hemayati *et al*., 2023). In Iran, the history of sugar beet seed production dates back approximately 70 years to the establishment of the sugar beet production company. Initially, the Ardabil region was selected as the most suitable area for producing high-quality sugar beet seeds due to its climatic conditions (Alavi Samreen, 1998), and a commercial sugar beet seed production station was set up there. This study aimed to assess the difference between the potential or attainable yield of sugar beet seeds and the actual yield achieved by farmers in the Ardabil, and to identify the underlying causes. The research sought to quantify the yield gap in sugar beet seed production, determine the factors contributing to this gap, and assess the impact of each factor on the yield gap.

Materials and methods: The study was conducted during the 2022-2023 growing season in Ardebil, Iran. Four prominent sugar beet cultivars- Shokoufa, Nika, Dena, and Arta- were selected for the investigation. These cultivars were propagated across 87 farms, all of which were included in the study to ensure a comprehensive analysis. To gather the necessary data, a detailed questionnaire was utilized. This questionnaire was designed to capture a wide range of variables, totalling 266, which encompassed various aspects such as soil characteristics, field management practices, climatic parameters, and the quantitative and qualitative attributes of the seeds produced by the farmers. This extensive data collection enabled a thorough examination of the factors influencing sugar beet seed production. The analysis of the yield gap and the contribution of each factor to this gap was performed using the Comparative Performance Analysis (CPA) method (Soltani *et al*., 2000). To determine the yield model, the relationship between all measured variables (quantitative and qualitative) and the packable seed yield was investigated through stepwise regression (Bie, 2000; Torabi *et al*., 2011).

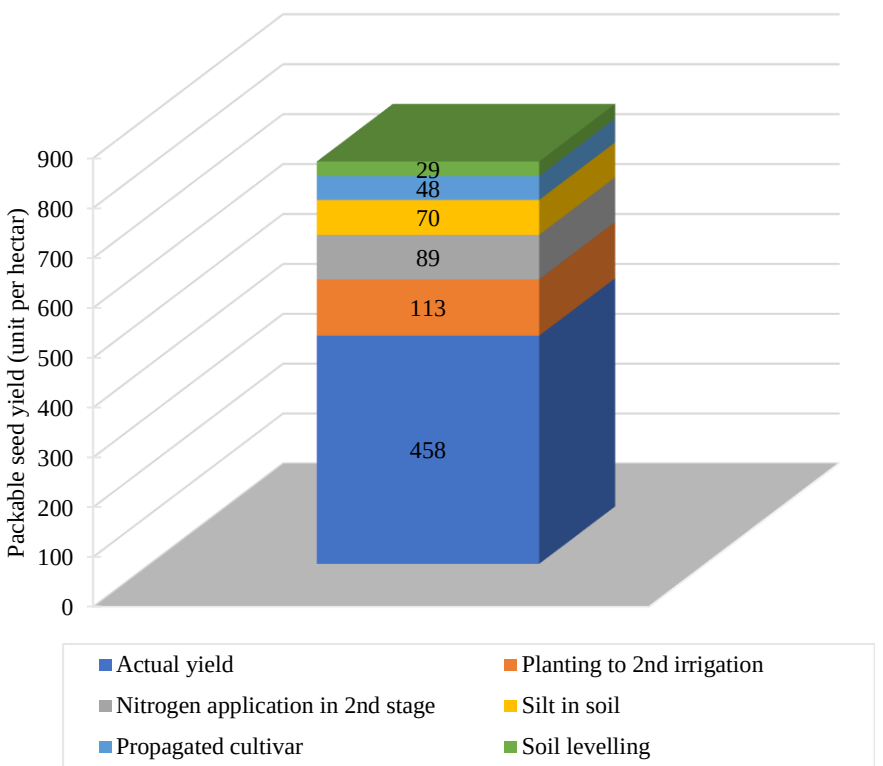

Figure 1: Contribution of the main limitations to the yield gap in packable sugar beet seeds in the Ardabil region

Results and Discussion: After conducting a step-by-step regression analysis, the production model for the packable seed yield variable was estimated in the form of Equation 1. This model allowed for the estimation of the constituents of the packable seed yield gap and the contribution of each yield-limiting factor. The average and maximum yields of packable seeds for the studied farmers were determined to be 457.57 and 869.68 units per hectare, respectively. The yield model, as depicted in Figure 1, estimated the average (actual) and maximum (attainable) yields of packable seeds as 457.57 and 806.29 units per hectare, respectively. The total estimated yield gap was equal to 348.73 units per hectare, representing 43.3% of the potential yield. This indicates that there is a gap of 348.73 units per hectare between the actual yield achieved by Ardabil farmers and the yield they could achieve with optimal management. Among the various agronomic variables affecting the packable seed yield, the factors with the greatest impact on creating the yield gap were identified. These included the distance between planting and the second irrigation (32.28%), the amount of nitrogen application in the second stage (25.51%), the amount of silt in the soil (20.14%), the propagated cultivar (13.77%), and soil levelling (8.31%). These findings highlight the significant influence of these variables on the yield gap and suggest areas where improvements in management practices could lead to increased productivity.

Conclusion: The study identified a substantial yield gap in sugar beet seed production in Ardabil, Iran, with a significant difference between actual and attainable yields. Key factors contributing to this gap include the timing of irrigation, nitrogen application, soil silt content, cultivar selection, and soil levelling. Improving these aspects of farm management could significantly enhance productivity, reducing the yield gap and increasing the efficiency of sugar beet seed production in the region.

Keywords: Actual yield, Agronomic management, Attainable yield, Comparative performance analysis.

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$$PS = 841.2 + (88.04 \times X_1) + (-11.71 \times X_2) + (127.46 \times X_3) + (0.33 \times X_4) + (-3.79 \times X_5) \quad (1)$$

where, PS is the packable seed yield (units per hectare), X_1 is the propagated cultivar (1= Shokoufa, 2= Nika, 3=Dena and 4= Arta), X_2 is the amount of silt in the soil (percentage), X_3 is the soil levelling (1= good and 2= moderate), X_4 is the amount of nitrogen application in the second stage (kg of nitrogen per hectare) and X_5 is the distance between planting and the second irrigation (day).