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Research Article

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Determination of Stoma Index, Leaf Hairiness and Some Agricultural Characteristics of Seventeen Different Second Crop Corn Varieties

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Abstract The present study was carried out to determine the agromorphological properties, stoma indices and leaf hairiness of seventeen second crop hybrid maize varieties under Kahramanmaras ecological conditions. Although the corn plant, which demands high temperatures demand and cultivated in the summer season, employs water economically during dry matter production, the water loss of the plant due to evaporation from the soil and leaves is high. Stoma and leaf hairiness are effective on dehydration by transpiration. Thus, the stoma indices, leaf hairiness, 3. leaf area, number of rows on ear and seeds per ear row were investigated in commercial hybrid maize varieties. The study was conducted with random blocks trial pattern in 2016. After the pollination, the third leaf under the top tassel was collected and the under and upper surface stoma index, the mean stoma indices and leaf hairiness were examined. It was determined that the upper stoma index was between 14.5 and 18.9, the under stoma index was between 15.8 and 22.1, the stoma index was between 0.7 and 1.1, leaf hairiness was between 28.5 and 35.7, the third leaf area was between 273.9 and 432.5 cm^2, the number of rows per ear was between 14.5 and 16.9, and the seed number on ear row was between 31.6 and 44.9 in hybrid corn variety.

Keywords Second crop, hybrid corn, stoma index, leaf hairiness

Introduction

The struggle in life begins with nutrition. Production is required for nutrition. Considering the basic elements of production, the soil and the plants grown in the soil are at the forefront. In plant cultivation, plants that grow in short period of time with high yield are preferred. Corn plant is one of the major among grown crops. Due to the versatile use and uncomplicated hybridization of the corn plant, usually breeding study continues as frequent. Thus, hybrid corn varieties are commercially supplied to the market by private corporations. The lowest germination temperature should be above 10 ºC for the corn plant. The optimum germination temperature is 18-20 ºC and optimum growth temperature is 28-32 ºC. As the ambient temperature rises above 40 ºC, the corn plant slows physiological activities and pollination stopping, preventing fertilization [1]. Prevention of the fertilization leads to ears without seeds. The relative air humidity is also important during this sensitive period. Irrigation intervals should be increased to reduce the plant temperature and to provide relative humidity [2, 3]. The soil moisture should be kept above the wilting point. Thus, water loss by evaporation from the soil and plant transpiration would be balanced. Stoma and hairiness of the plant leaves could be effective on

transpiration. The stomatal structure, leaf hairiness and soil water uptake of the plant affect the crown temperature of the corn plant. In plants, transpiration decreases and the stomata close due to the occurrence of water stress, so the increasing plant temperatures cause decreasing of yield [4, 5]. The stoma and hairiness of the commercially cultivated corn varieties have not been investigated. No study conducted on multiple genotypes is available. Investigation of stoma index and hairiness on 17 genotypes cultivated as second crops by farmers would contribute to the literature and guide future studies on the topic.

Materials and Methods

Material

The study material included 17 hybrid corn varieties: Tavascan, Motri, Calgary, Sancia, P.573, P.32T83, Hydro, Performer, Capuzi, 72MAY80, Simon, Macha, PL712, Torro, Bolsan, KB5562 and KB3961. The study was conducted with random blocks experimental design in the second crop season under Kahramanmaras ecological conditions. Corn varieties were sown on July 1, 2016, with 70 cm row spacing over 20 cm. Plants were fertilized with 6 kg da^{-1} phosphorus, 25 kg da^{-1} nitrogen fertilizer and harvested manually on November 9. Leaf hairiness and stoma index samples were collected after fertilization of the plant. The samples collected to determine the stoma index were transferred to the laboratory in 70% alcohol and stored in a fridge at 4^oC. To determine the leaf hairiness, the leaf surfaces were photographed under a microscope, where the image included two-thirds of the leaf length and at a distance equal to the main vein starting from the leaf base. Superficial sections were obtained from the same regions for the stoma index and photographed under a microscope. It was determined that in the soil sample collected from 0-30 cm depth of the trial area, the organic matter content was 1.52, the pH was 7.55, the lime content was 15.71%, the potassium content was 74.72 kg da^{-1}, the available phosphorus content was 5.44 kg da^{-1}, and the soil was loamy and clayey [6]. In the growth period of corn plant (July, August and September), relative humidity was 36-42%, average minimum temperature was 14-24 ºC, average maximum temperature was 23-38 ºC, the mean temperature varied between 24 and 30 ºC, no precipitation was observed in July and August, and precipitation in September was 23.7 [7]. Thus, the plants were irrigated 8 times at 10-day intervals with the surface irrigation method.

Method

Determination of the stoma index

The 40X magnified images of the superficial cross-sections of the leaf under and upper epidermis samples that were stored in 70% alcohol at 4^oC to determine the stoma index and stoma index ratio were taken with a Nikon Digital Sight DS-FI2 camera in the Nikon E200 trinocular research microscope. On these images, 1 mm^2 regions were determined with an objective micrometer and stoma index and stoma index ratios were determined by counting the stoma cells and epidermal cells in these regions [8].

Determination of the leaf hairness

The leaf samples collected from 17 hybrid corn varieties during the flowering period were examined under a stereo microscope and epidermal hairs in five images were counted and averages were calculated for each variety. The surface area of each image taken with the microscope was 2.1X2.8 = 5.88 cm^2. Leaf surface photographs were taken in an Olympus SZX16 stereo microscope available at the Plant Preservation laboratory in Kahramanmaras Sutcu Imam University, Faculty of Agriculture and with a DP25 camera installed in the above-mentioned microscope. In the statistical analyses conducted in the study, the variety averages were analyzed with analysis of variance in SAS software. The means were compared with Duncan ($P < 0.05$) multiple range test.

Results and Discussion

Leaf Under and Upper Surface Stoma Index and Stoma Index Ratio

It was determined that the under leaf surface stoma index, upper leaf surface stoma index, mean stoma index, leaf hairiness, the area of the 3rd leaf from the top tassel under, the number of rows of ear, the number of seeds on ear row were statistically significant at 1% significance level (Table 1 and 2).It was determined that the under leaf surface stoma index of 17 hybrid maize varieties employed in the study varied between 15.83 and 22.11, the

upper surface stoma index varied between 14.50 and 18.87, the stoma index ratio varied between 0.75 and 1.05, and the mean stoma index was 19.13, the upper stoma index was 17.48, and the mean stoma index ratio was 0.92.

Table 1: The averages and groups of the under leaf surface stoma index, upper leaf surface stoma index, mean stoma index, leaf hairiness of second crop hybrid corn varieties

Varieties	The mean under leaf surface stoma index	Upper leaf surface stoma index	Mean stoma index	Leaf hairiness (units)
1.Tavascan	15.83 j	16.67 bc	1.05	34.00 ab
2.Motri	17.25 hı	16.31 c	0.95	32.46 bc
3.Calgary	19.12 defg	17.87 abc	0.93	35.60 a
4.Sancia	17.98 ghı	18.30 ab	1.02	31.40 cd
5.P.573	20.60 bcd	16.70 bc	0.81	28.53 ef
6.P.32T83	20.88 ab	18.11 ab	0.87	30.53 cde
7.Hydro	20.66 bc	17.15 abc	0.83	34.66 ab
8.Performer	19.20 cdefg	18.88 a	0.98	28.53 ef
9.Capuzi	19.76 bcdef	17.31 abc	0.88	29.20 def
10.72May80	22.11 a	17.98 abc	0.81	28.83 ef
11.Simon	18.78 efg	18.07 abc	0.96	30.00 de
12.Macha	19.25 cdefg	14.50 d	0.75	29.93 de
13.PL712	20.08 bcde	16.60 bc	0.83	27.33 f
14.Torro	18.49 fgh	18.63 a	1.01	29.73 def
15.Bolsan	18.42 fghı	18.54 a	1.01	29.26 def
16.KB 5562	19.79 bcdef	18.87 a	0.95	29.60 def
17.KB 3961	17.01 ıj	16.65 bc	0.98	35.73 a
	19.13	**17.48**	**0.92**	**30.90**

The highest under stoma index was 22.11 in 72May80 variety. Based on under stoma index, 72May80 variety was statistically significantly different when compared to other cultivars except P.32T83 (20.88). It was noted that there were statistically significant differences between Tavascan variety under stoma index (15.83) and other varieties except the KB 3961 (17.01) variety. It was determined that Performer and Macha hybrid maize varieties were statistically in the same transition group with sub-stoma index figures of 19.20 and 19.25, while Capuzi and KB5562 varieties were statistically in the same transition group with 19.76 and 19.79. Based on the lower stoma index, two transition groups included P.32T83, Hydro, PL 712 varieties (20.88, 20.66, 20.08) and Calgary, Simon, Torro, Bolsan, Sancia, Motri verieties (19.12, 18.78, 18.49, 18.42, 17.98, 17.25).The lowest upper leaf surface stoma index was recorded in Macha variety (14.50) and it was statistically significantly different from the other varieties. The Motri variety with a 16.31 upper stoma index was in a separate group with the Macha variety. The highest upper stoma index was determined in Performer, KB 5562, Torro and Bolsan (18.88 18.87, 18.63 and 18.54, respectively) and these varieties were considered in the same group. Tavascan, P.573, PL712, KB 3961 varieties (16.67, 16.70, 16.60, 16.65), Calgary, Hydro, Capuzi, 72MAY80, Simon varieties (17.87, 17.15, 17.31, 17.98, 18.07), and Sancia and P.32T83 varieties (18.30, 18.11) formed the transition groups. The highest stoma index rate was observed in Tavascan hybrid corn variety (1.05), while the lowest stoma index rate was observed in Macha hybrid corn variety (0.750). It was recorded that other varieties had figures that varied between the above-mentioned limits with statistically significant differences (Table 1).The appearance of stomata cells in the section prepared from corn leaf surface (Fig. 1). Bozyel (2011) determined that the upper corn leaf surface stoma index varied between 7.60 and 23.23 and the lower surface stoma index varied between 19.76 and 30.52. Dereboylu and Sengonca (2011) investigated the effect of Acetamiprid administration to leaf anatomical structure in corn cultures, and reported that leaf upper surface stoma index was 10.23 and under leaf surface stoma index was 18.25 in popcorn kernel, upper leaf surface stoma index was 11.55 and under leaf surface stoma index was 18.52 in flint corn. Yeni (2013) reported that the upper stoma index varied between 20.8 and 33.0 and under stoma index varied between 17.8 and 27.8 in twenty-day corn seedlings in aluminum medium, and the upper stoma index varied between 20.8 and 33.4, and the

under stoma index varied between 17.8 and 26.7in cadmium medium. It was noted that the highest mean leaf hairiness values were observed in KB 3961, Calgary (35.73, 35.60) in Table 1.

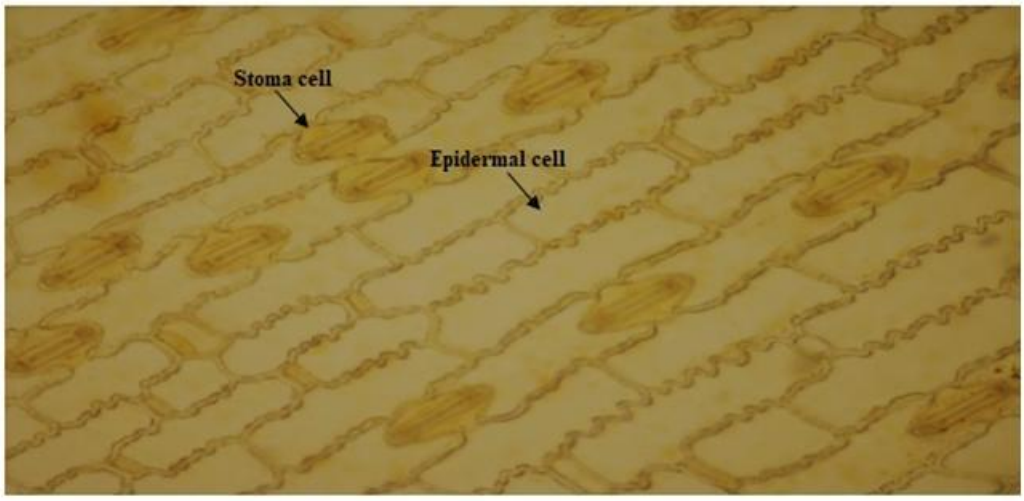

Figure 1: An image of stoma and epidermal cells leaf

Second crop hybrid corn varieties and exhibited statistically significant differences with other varieties except Hydro (34.66) and Tavascan (34.00). It was determined that PL712 (27.33) variety had the lowest mean leaf hairiness. There were no statistically significant differences between PL 712, P.573 and Performer (28.53), 72MAY80 (28.83), Capuzi (29.20), Bolsan (29.26), KB5562 (29.60), and Torro (29.73) varieties based on leaf hairiness, while there were significant differences between other varieties. Based on leaf hairiness, there were no statistically significant differences between Motri (32.46), Sancia (31.40 pcs) and P.32T83 (30.53 pcs) varieties, it was determined that there was a significant difference between Simon (30.00) and Macha (29.93) varieties (Table 1). The views of the leaf surface hairiness are given in Figure 2. Doroshkov *et al.* (2011) reported that leaf hairiness could predict the plant's response to abiotic stress during growth and development in phenolic classification.

The Third Leaf Area (cm^2)

The third leaf area under the hill tassel of 17 second hybrid corn varieties varied between 273.9 and 432.5 cm^2, and the mean third leaf area for all cultivars was 363.3 cm^2. The lowest third leaf area under the hill tassel was 273.9 cm^2 in P.573 variety (Table 2).

There were statistically significant differences between P.573 hybrid corn variety and all other varieties except Capuzi (297.3 cm2) based on the third leaf area. There were no statistically significant differences between Performer (371.6 cm^2), Tavascan (380.6 cm2) Motri (367.4 cm^2), PL 712 (352.1 cm^2), Macha (350.7 cm2), KB3961 (361.9 cm2) varieties and these were included in transitional groups. Sancia hybrid corn variety was in a different group with 396.6 cm^2 leaf surface. Torro and P.32T83 hybrid corn varieties were in the same group with 384.0 and 386.1 cm^2 surfaces, respectively. It was determined that there were no statistical difference between Bolsan (331.7 cm2) and Simon (341.5 cm2) varieties and they were included in the transition group. Based on the third leaf area under the top tassel, the 72MAY80 (323.7 cm2) hybrid corn variety was statistically different from other varieties. The highest third leaf area under the top tassel was in Hydro variety (432.5 cm^2), there were no statistically significant differences between Hydro and KB5562 (418.6 cm^2) and Calgary (405.7 cm2) hybrid corn varieties, and it had statistically different among other varieties (Table 2). Yururdurmaz (2007) reported that the single leaf surface in first crop corn was between 271.1 and 318.8 cm^2, Lambert *et al.* (2014) reported that that the leaf area varied between 646 and 677 cm^2. They also found that the corn leaf surface was an important factor in planning the plant density, dense planting of plants with low leaf surface could increase yield under stress conditions, while this was not always valid, and would be effective if other complex factors are determined. The leaf surface values determined in the present study were consistent with previous research findings.

The Number of Rows on Ear

It was determined that the number of rows on ear for 17 after crop hybrid corn varieties cultivated under Kahramanmaras conditions varied between 14.5 and 16.9, and the mean number of rows for all varieties was 15.2. The lowest number of rows on ear was determined in Hydro and 72MAY80 varieties (14.5). The Hydro and 72MAY80 varieties were followed by KB 5562 (14.9), Motri and P.573 (15.3), and KB 3961and Sancia varieties (15.5), and there were statistically significant differences between the remaining varieties. The highest number of rows on ear was recorded in PL712 and Bolsan (16.9) varieties. There were no statistically significant differences between PL712 and Bolsan (16.9) varieties and Tavascan (16.8),P.32T83 (16.5) Macha and Capuzi (16.1), Calgary, Simon and Torro (16.0) varieties the in terms of the number of rows; however there were significant differences between PL712 and Bolsan (16.9) varieties and others. In Performer variety, the number of the rows on ear was 15.7 (Table 2).Budak *et al.* (2014) reported that the number of rows of ear varied between 11.6 and 15.3, Yururdurmaz (2007) reported the same figure as 15.4 - 17.7, Idikut *et al.* (2012) reported that the number of rows on ear varied between 14.66 and 17.5 in popcorn variety. Becher (2018) reported that the number of rows on ear was between 14.4 and 19.2, and may vary based on the variety, plant density and environment.

The Seed Number on Ear Row

It was determined that the seed count on ear row varied between 31.6 and 45.0 for the 17 hybrid corn varieties analyzed in the present study, and the mean value for all varieties was 39.6. It was observed that the highest seed count on ear row was determined on Simon (45.0) and KB 3961 (44.9) varieties and they were considered in the same group. Simon and KB 3961 hybrid corn varieties were statistically significantly different from all varieties the in terms of the seed number on ear row except for Blosan (42.9), Calgary (42.1), Sancia (41.9), Hydro (41.1) hybrid corn varieties. The lowest seed count on ear row was recorded on P.573 variety (31.6). Based on the seed count on ear row, there were statistically significant differences between P.573 hybrid corn variety and other varieties except Capuzi hybrid corn variety (34.3). There were no statistically significant differences between Tavascan, Motri, 72MAY80, Macha, PL712, Torro P.32T83, Performer, KB 5562 hybrid varieties (40.5, 38.9, 40.2, 38.7, 39.3, 38.9, 38.3, 38.1, 37.2, respectively) and included in the transitional group (Table 2). Idikut *et al.* (2012) reported that the seed count of ear row varied between between 28.56 and 37.66 in popcorn genotype and Becher (2018) reported the same figure between 21.6 and 37.6. Zhan *et al.* (2018) stated that the seed count of ear row was one of the yield factors, it is a breeding target to improve the seed yield, and the seed count of ear row varied between 29.95 and 32.63. Environmental factors are more effective on the development of seeds on corn ears when compared to than genetic factors. Air temperature, available nutrients and soil moisture, plant density affect the seed count per ear row [19].

Table 2: The averages and groups of the area of the third leaf under the top tassel, the number of rows of ear, the number of seeds on ear row of second crop hybrid corn varieties

Varieties	The thirdleaf area (cm^2)	The number of rows of ear (units)	The number of seeds on ear row (units)
1. Tavascan	380.6 cdef	16.8 ab	40.5 bcd
2. Motri	367.4 defg	15.3 def	38.9 bcd
3. Calgary	405.7 abc	16.0 abcde	42.1 abc
4. Sancia	396.6 cd	15.5 cdef	41.9 abc
5. P.573	273.9 k	15.3 def	31.6 f
6. P.32T83	386.1 cde	16.5abc	38.3 cd
7. Hydro	432.5 a	14.5 f	41.1 abcd
8. Performer	371.6 defg	15.7 bcde	38.1 cde
9. Capuzi	297.3 jk	16.1 abcd	34.3 ef
10. 72May80	323.7 ıj	14.5 f	40.2 bcd
11. Simon	341.5 ghı	16.0 abcde	45.0 a
12. Macha	350.7 fghı	16.1 abcde	38.7 bcd
13. PL712	352.1 fghı	16.9 a	39.3 bcd

14. Torro	384.0 cde	16.0 abcde	38.9 bcd
15. Bolsan	331.7 hı	16.9 a	42.9 ab
16. KB 5562	418.6 ab	14.9 ef	37.2 de
17. KB 3961	361.9 efgh	15.5 cdef	44.9 a
	363.3	**15.2**	**39.6**

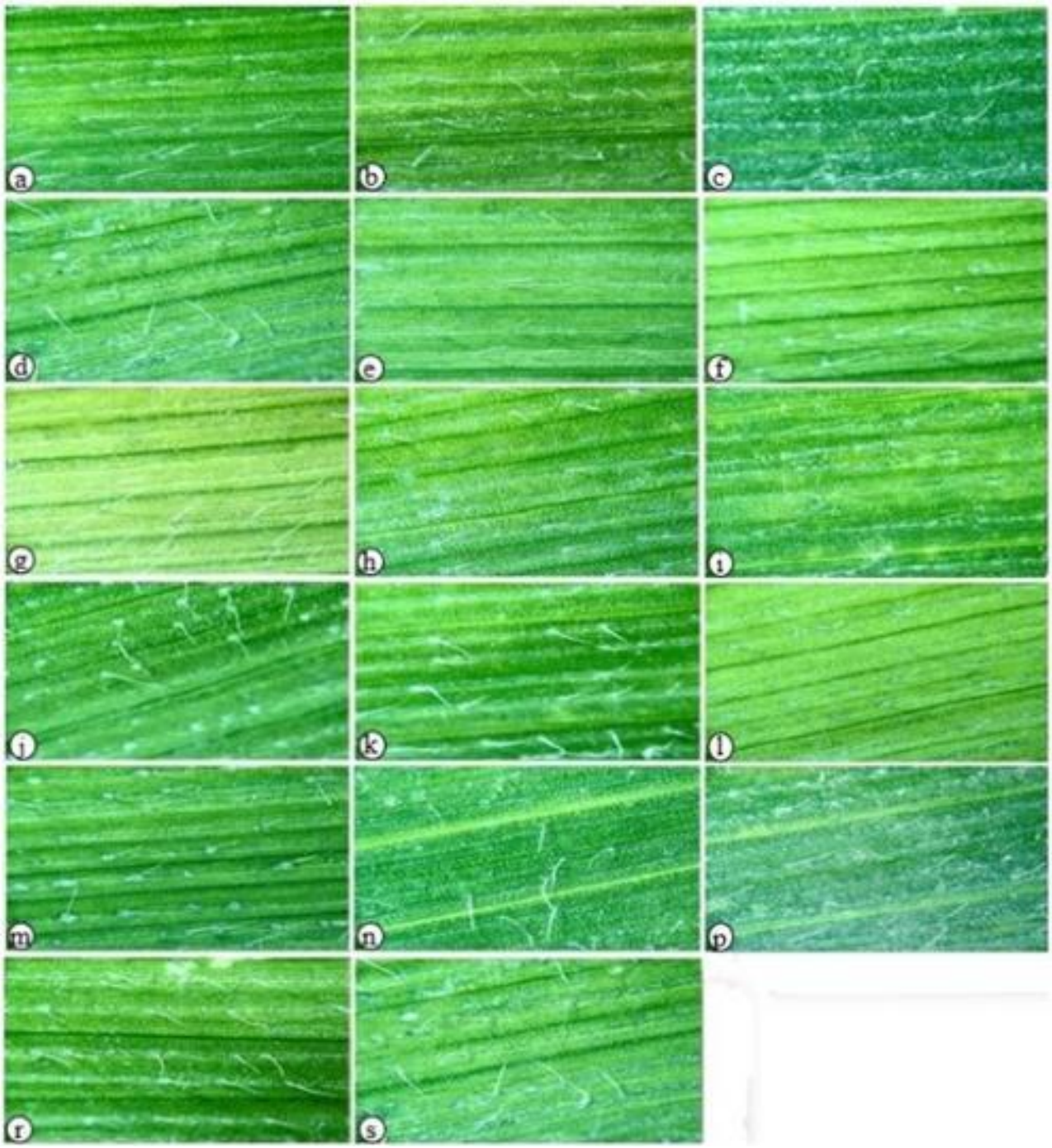

Figure 2: Examples of leaf hairiness on second hybrid corn varieties: a-Tavascan, b-Motri, c- Calgary, d-Sancia, e- P.573, f- P.32T83, g- Hydro, h- Performer, i- Capuzi, j- 72MAY80, k- Simon, l- Macha, m- PL712, n-Torro, p- Bolsan, r- KB 5562, s- KB 3961.

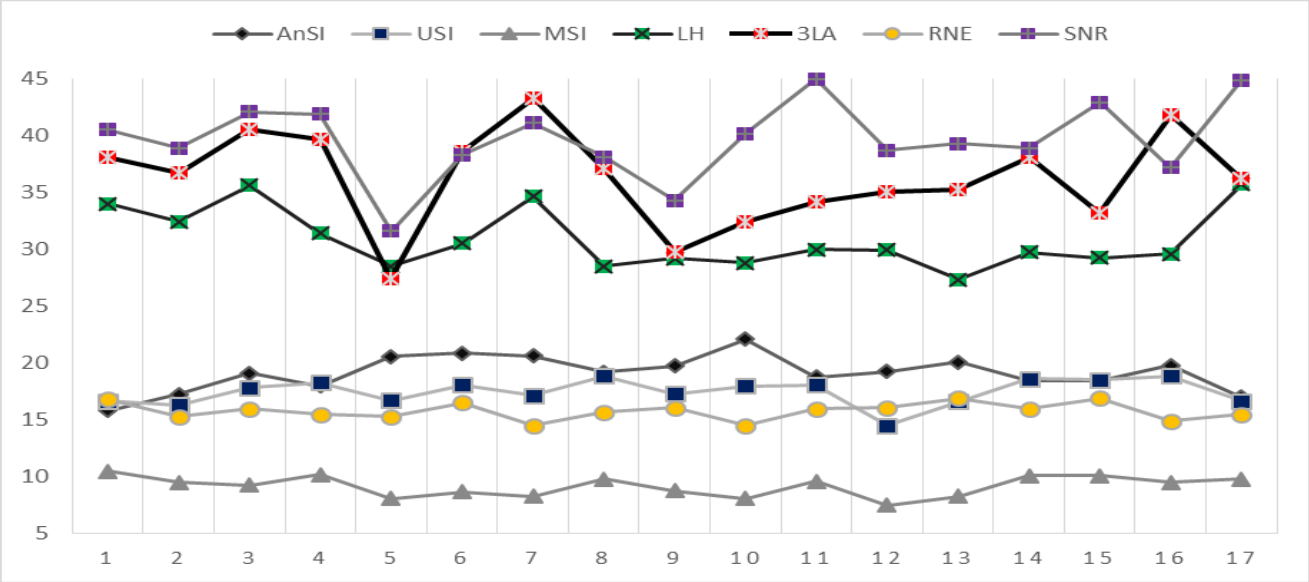

Figure 3: Graphical presentation of the analyzed properties

Under stoma index (AnSI), upper stoma index (USI), mean stoma index 10-1 (MSI), leaf hairiness (LH), 3rd leaf area x10 (3LA), the number of rows of ear (RNE) and seed number of ear row (SNE). The mean stoma index values (MSI) were multiplied by 10 and 3rd leaf area values (3LA) were divided into 10 so that the examined features can be displayed in a single figure (Fig. 3). As shown in Fig. 3 there were a positive agreement among the seed count on ear row, 3rd leaf area, and leaf hairiness for varieties 1, 2, 3, 4 7, 8, 10, 11, 12, 13. Also the under stoma index, upper stoma index, the number of rows on ear had positive agreement for varieties 2, 3, 6, 7, 9. There were negative agreement between the under stoma index and the 3rd leaf surface with the seed count of ear row for varieties 5 and 11 varieties. The between leaf hairiness and 3rd leaf surface had a general linear convenient.

Conclusion

While stoma indices, leaf hairiness, leaf area and seed count properties of 17 second crop hybrid corn varieties under Kahramanmaras conditions had certain positive effects on certain varieties, while these effects were not observed for others. It was suggested that this could be due to the nature of the field conditions, and future studies could reveal more significant effects.

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