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YIELD PERFORMANCE OF SEVERAL CUCUMBER (*CUCUMIS SATIVUS* L.) HYBRIDS AND SELECTION OF SUPERIOR HYBRIDS UNDER GREENHOUSE CONDITIONS

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Abstract. A trial was carried out to compare the performance of a set of cucumber *(Cucumis sativus L.)* hybrids in three plastic greenhouses. The goals were to compare the yield performance and fruit quality characteristics, and to identify the better hybrids that will be competitive with the preferred ones in Laylan sub-district of Kirkuk Governorate. Three check hybrids (Saif, Rony and Almdar) with 25 test hybrids (from six companies and one individual breeder) were grown in each greenhouse (a total of 7, 9 and 9 test hybrids in the first, second and third greenhouses, respectively). The plant yield, fruit length, fruit diameter, degree of fruit ribbing and fruit colour were recorded. The greenhouses were unreplicated experimental units and the test hybrids were different in each greenhouse so the results were analysed descriptively. The performance of each hybrid was expressed as a relative index with respect to the mean of the check hybrids in its own greenhouse, in order to remove the greenhouse effect. Yield per plant ranged from 4.654 to 9.105 [unit]. The hybrid S-210 was definitely better, having 145.4 % of the check mean and 130.7 % of the best check in its greenhouse and fruits were ribbed and dark coloured. It was followed by S-212 (114.0%), S-218 (108.5%) and S-183 (103.2%), which were the only hybrids to exceed the best check hybrid in their greenhouses. Other hybrids (S-155, S-196, S-64, S-60 and S-184) gave yields superior to the check mean and was similar to the best checks. The study suggests re-testing these hybrids in the second season in a replicated design before any of them are released commercially.

Keywords: Cucumber, hybrids, protected cultivation, productivity (yield), hybrid selection

Introduction

Cucumber (*Cucumis sativus* L.) is a member of Cucurbitaceae family. A herbaceous annual, climbing with fleshy juicy fruits eaten fresh or pickled. It has a somatic chromosome number of 2n = 14 [1]. Based on evolution studies, it is believed that its centre of origin was South Asia, from where its cultivation extended to different parts of the world, and it is one of the most widely cultivated vegetable crops in open fields, under plastic coverings and greenhouses [2],[3].

In the case of cucumber planting, protected cultivation is increasingly gaining importance, as it can extend the production period, minimise the impact of heat stress, frost and frost delay, and yield better fruit quality and higher crop yields than open field planting. First generation hybrids (F1) with strong vegetative growth and uniformity and early fruiting and high yielding are another important factor for these systems besides desirable marketable fruit characteristics (length, coloring, ribbing) [4], [5].

In Iraq, a lot of protected cucumber hybrids of various seed companies are present in the markets. The performance of these hybrids is very variable depending on the environment, planting date, and management practices. So the only thing that can be relied on, is the performance of a specific seed producing company, which requires local evaluation before its use is recommended to farmers [6], [7]. For plant breeders and seed distribution firms, it is important to have dependable data on the degree of superiority that new cultivars have over the currently popular cultivars, which can be provided by comparative tests conducted with some of the more widely grown standard cultivars [8], [9].

Therefore, the present study was designed to compare the productive performance of a set of protected cucumber hybrids with the productivity of three popular cucumber hybrids in the region, and to record the leading qualitative fruit traits (length, diameter, ribbing, and color) and to choose better cucumber hybrids which can be competitive with desirable cucumber hybrids in northern Iraq.

Methods

2.1. Experimental Site and Date

This experiment was carried out on 22nd April 2024 in Laylan Subdistrict of Kirkuk Governorate, with three plastic greenhouses. Three normal comparison hybrids (Saif, Rony, Almdar) were present in each of the two greenhouses. A total of seven, nine, and nine hybrids were planted in the first, second and third greenhouse respectively. The greenhouses were not replicates due to the fact that the hybrids were different among the greenhouses. The main selection criteria for the best performing hybrids for competition with the preferred hybrids in northern Iraq were recorded.

2.2. Agricultural Practices

50 g m^{-2} of compound NPK fertilizer (15-15-15) was applied before sowing and mixed into the soil. Starting from the flowering stage, calcium nitrate was applied at 2 g $plant^{-1}$ $week^{-1}$ and potassium nitrate at the same rate (2 g $plant^{-1}$ $week^{-1}$) until the end of the production period. Split doses of fertilizers were applied using the drip irrigation method. Fertilizer rates varied depending on the plant and soil and water properties.

Drip irrigation system was used, duration and frequency of irrigation was varied according to temperature, humidity and growth stage of the crop. Vertically trained with trellising strings. Lateral shoots and yellow leaves were periodically pruned and the diseased leaves were removed, leaving functional leaves. In addition to the fruit load outlined above, excess fruit was removed to comply with the adopted training system depending on the test hybrids grown in each greenhouse, when fruit load was managed: 34 entries (28 different hybrids) were grown, 7 in the first greenhouse, 9 in the second, and 9 in the third. Hybrids were derived from the following companies: Bride Seeds, National Seeds, Nunhems, Enza Zaden, Global Seeds and an individual breeder (hybrid 117).

These hybrids were different in each greenhouse but not the same in the other two greenhouses and therefore the greenhouses were not replicates, but experimental units.

Performance of the standard comparison hybrids was shared between all three greenhouses to compare greenhouse performance.

Planting was 40 cm within row and 100 cm between rows for an average of 2.5 plants m^{-2}. Seedlings were grown in germination trays on suitable growing medium and then transplanted to their permanent position in the plastic greenhouses when 3-4 fully expanded true leaves had been formed and at the age of 20-25 days. Transplanting was done by hand, making sure to keep the root system intact. Irrigation was immediately after planting to assure seedling establishment and establishment in soil.

Pesticides were applied as needed when infested by pests and diseases, with consideration of the approved use rate and pre-harvest interval for the crop, Fruits were picked at the desired marketable size. Harvesting was done on alternate days as the fruit grew. The frequency and weight of fruit per harvest for each experimental unit was recorded and the data from successive harvests added to give the total yield for the growing season..

2.3. Studied Traits

The following traits were recorded: average yield per plant (kg $plant^{-1}$), average fruit length (cm), average fruit diameter (cm), fruit ribbing score (1 = slight ribbing, 2 = moderate ribbing, 3 = pronounced ribbing), and fruit color score (1 = light, 2 = medium, 3 = dark).

2.4. Data Analysis

Inferential statistical analysis (analysis of variance and multiple comparison tests) were not possible for these data because of the lack of replicates in the greenhouses and the differences in test hybrids among the greenhouses. Hence, descriptive analysis was used. A relative yield index was determined for each test hybrid as follows to isolate the greenhouse effect [10], [11].

Relative yield index (%) = (Yield per plant of the hybrid ÷ Mean yield per plant of the three standard comparison hybrids in the same greenhouse) × 100.

The ratio of yield of each hybrid compared to the highest yield comparison hybrid grown in the greenhouse was also determined. Within each greenhouse, the hybrids were ranked by their mean yield per plant. A hybrid was rated as superior if it produced more than the best yield of the standard comparison hybrid in its greenhouse and as a promising hybrid if it produced more than the average yield of the standard comparison hybrids, but not more than the highest-yielding hybrid [12].

Results and Discussion

3.1. Greenhouse Effect and Performance of the Standard Comparison Hybrids

The performance of the three standard comparison hybrids in the three greenhouses is given in Table (1). The mean yield of the standard comparison hybrids ranged from 6.262 in the second greenhouse to 7.689 in the first and the third, with the mean yield in the third being about 23% higher than in the second greenhouse. The yield of Rony alone ranged from 5.776 to 8.238 (a variation of 42.6%), while that of Almdar ranged from 6.041 to 7.463. Saif, on the other hand, was more stable ranging from 6.598 to 7.366 [13], [14].

The results also suggest that the different locations, management practices, and ventilation of the greenhouses as well as, perhaps, the time of harvest, all had a significant influence on yield. It is therefore not suitable to compare raw yield of the different hybrids raised in different greenhouses, thus the necessity of using a relative yield index [15], [16].

Table 1. Yield per Plant of the Standard Comparison Hybrids in the Three Greenhouses (kg $plant^{-1}$)

Standard Comparison Hybrid	Company	Greenhouse 1	Greenhouse 2	Greenhouse 3
RONY	National Seeds	6.750	5.776	8.238
SAYF	Nunhems	6.598	6.968	7.366

Standard Comparison Hybrid	Company	Greenhouse 1	Greenhouse 2	Greenhouse 3
ALM DAR	Enza Zaden	6.679	6.041	7.463
Mean of the Standard Comparison Hybrids	—	6.676	6.262	7.689

3.2. Productive Performance of the Hybrids

Table (2) The results of all entries are presented in order of yield in each greenhouse; in Figure (1), the relative yield index of the test hybrids is presented. Yield ranged from 4.654 (hybrid RAY-011) to 9.105 (hybrid S-210).

The only hybrids that outyielded the highest yielding of the standard comparison hybrids in the first greenhouse were S-183 (6.887 or 103.2% of the mean yield of the standard comparison hybrids). The hybrid 0-01 was about the same as hybrids that were used in the standard comparison (99.8%), while the other hybrids recorded smaller yields. The greenhouse with S-190 had the lowest yield (4.662 or 69.8%).

S-210 yielded significantly higher than the other greenhouse hybrids in the second greenhouse, with a yield of 9.105 compared to mean yield of the standard comparison hybrids of 145.4% and highest-yielding of the standard comparison hybrid Saif at 130.7%. This was the largest ever in the entire experiment. Four other hybrids (S-155, S-64, S-60 and S-184) yielded well, yielding 6.2–10.4% above the mean yield of the standard comparison hybrids, but did not exceed Saif.

S-212 (114.0%) and S-218 (108.5%) surpassed the best standard comparison hybrid, Rony (8.238) in the third greenhouse. Hybrid S-196 also was good with a yield of 8.061, which was 104.8% of the average yield of the standard hybrids used in the tests. Hybrid S-194 (7.031) produced only 91.4% of the mean yield of the standard comparison hybrids, however.hybrids.

Table 2. Average Yield per Plant and Fruit Characteristics of the Studied Hybrids in the Three Greenhouses

Greenhouse	Hybrid	Yield per Plant	Relative Index (%)	Fruit Length (cm)	Fruit Diameter (cm)	Ribbing	Color
1	S-183	6.887	103.2	19.31	2.65	3	3
1	RONY (م)	6.750	—	19.50	2.66	3	3
1	ALM DAR (م)	6.679	—	18.00	2.43	2	2
1	01-0	6.664	99.8	18.84	2.70	2	3
1	SAYF (م)	6.598	—	18.87	2.58	2	3
1	9-0	6.493	97.3	20.03	2.74	2	3
1	MARID	6.356	95.2	19.25	2.60	2	2
1	DS97-32	6.257	93.7	19.62	2.68	1	3
1	8-0	6.059	90.8	18.84	2.70	2	3
1	S-190	4.662	69.8	19.50	3.61	2	3

Greenhouse	Hybrid	Yield per Plant	Relative Index (%)	Fruit Length (cm)	Fruit Diameter (cm)	Ribbing	Color
2	S-210	9.105	145.4	19.71	2.66	3	3
2	SAYF (م)	6.968	—	19.18	2.71	2	3
2	S-155	6.915	110.4	18.90	2.66	2	2
2	S-64	6.681	106.7	18.03	2.76	2	3
2	S-60	6.664	106.4	19.78	2.63	2	3
2	S-184	6.653	106.2	19.34	2.73	3	3
2	ALM DAR (م)	6.041	—	19.50	2.70	2	2
2	R-07	6.012	96.0	19.28	2.69	2	2
2	S-182	5.858	93.6	19.00	3.91	3	3
2	RONY (م)	5.776	—	19.71	2.72	3	3
2	S-100	5.428	86.7	17.59	2.55	2	3
2	RAY-011	4.654	74.3	14.96	2.16	1	3
3	S-212	8.766	114.0	19.03	2.55	3	3
3	S-218	8.345	108.5	18.46	2.56	2	3
3	RONY (م)	8.238	—	18.81	2.55	3	3
3	S-196	8.061	104.8	18.84	2.70	2	3
3	ALM DAR (م)	7.463	—	19.50	2.82	2	3
3	SAYF (م)	7.366	—	18.81	2.63	2	3
3	S-194	7.031	91.4	18.43	2.65	2	3
3	S-118	6.683	86.9	17.37	2.58	2	3
3	S-191	6.602	85.9	19.81	2.70	1	3
3	S-189	6.463	84.1	18.21	2.61	2	2
3	S-188	5.735	74.6	18.84	2.70	2	3
3	117	5.110	66.5	18.81	2.67	1	3

(C) = Standard comparison hybrid. Relative index = Hybrid yield ÷ Mean yield of the standard comparison hybrids in the same greenhouse × 100. Ribbing: 1 = slight, 2 = moderate, 3 = pronounced. Color: 1 = light, 2 = medium, 3 = dark.

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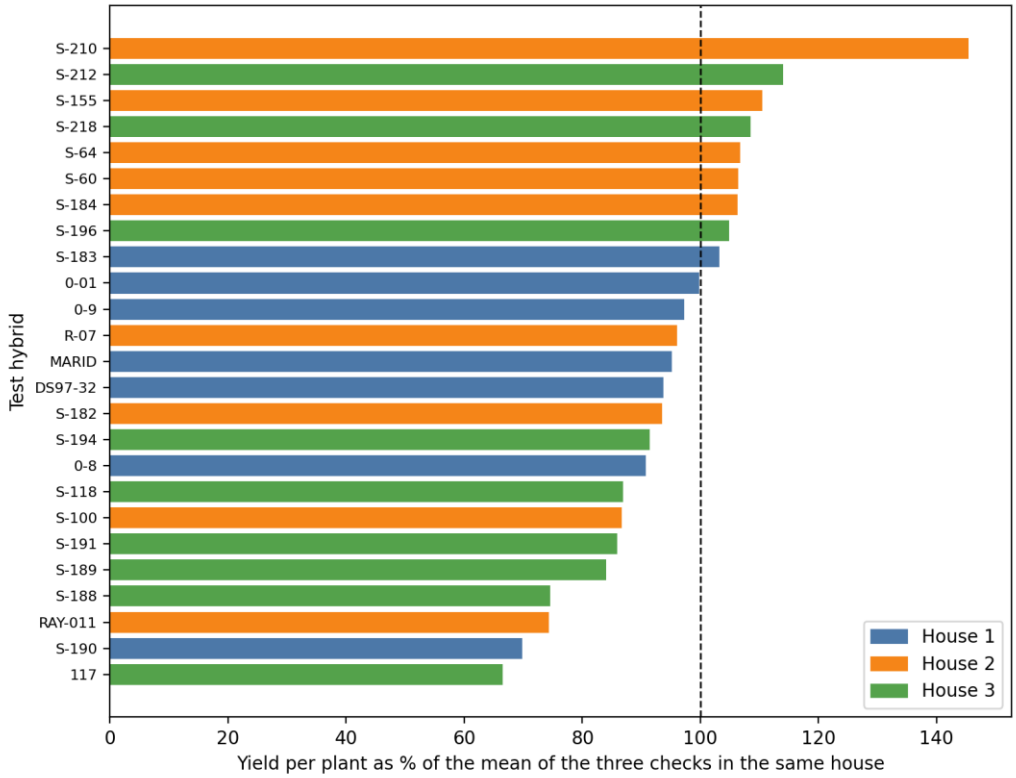


Figure 1. Relative Yield Index of the Test Hybrids (% of the Mean Yield of the Standard Comparison Hybrids in the Same Greenhouse; Dashed Line = 100%)

3.3. Selection of Superior Hybrids

Table (3) lists the selected hybrids according to the selection criteria given in Section 2.5. The longest fruits were produced by the four hybrids S-210, S-212, S-218 and S-183 which were similar with average fruit lengths ranging from 17.4 to 20.0 cm. The exception was hybrid RAY-011 (14.96 cm) which also produced the lowest yield in the second greenhouse experiment. Most entries had fruit diameter between 2.43 and 2.82 in, while higher fruit diameter was obtained on the hybrids S-190 (3.61) and S-182 (3.91). These values were significantly higher than the other measured values and need to be checked for the correctness of the recording, or thicker fruit with fewer fruit numbers could be the reason.

Dark fruit color (score 3) was the predominant hybrid type observed (Table 2). According to the experimental report, the four hybrids S-210, S-212, S-183 and S-184 were characterized by strong ribbing (3), dark colour which are the desirable characteristics for the local market. Moderate ribbing and dark color were observed in hybrid S-218. Therefore, the higher yielding superior hybrids had good fruit characteristics and the yield superiority was not at the expense of fruit length or color.

They were compared in their respective greenhouses and found that S-210 shows the highest level of superiority.

The hybrids S-155, S-196, S-64, S-60 and S-184 out-yielded the mean of the standard comparison hybrids and yielded 95.5-99.2% of that of the top yielder of the standard comparison hybrids. As a consequence, they were deemed to be promising hybrids and were included for further assessment.

Table 3. Selected Hybrids (Superior and Promising)

Hybrid	Greenhouse	Yield per Plant (kg plant^{-1})	% of the Mean Yield of the Standard Comparison Hybrids	% of the Highest-Yielding Standard Comparison Hybrid	Length (cm)	Ribbing	Color	Classification
S-210	2	9.105	145.4	130.7	19.71	3	3	Superior
S-212	3	8.766	114.0	106.4	19.03	3	3	Superior
S-218	3	8.345	108.5	101.3	18.46	2	3	Superior
S-183	1	6.887	103.2	102.0	19.31	3	3	Superior
S-155	2	6.915	110.4	99.2	18.90	2	2	Promising
S-196	3	8.061	104.8	97.9	18.84	2	3	Promising
S-64	2	6.681	106.7	95.9	18.03	2	3	Promising
S-60	2	6.664	106.4	95.6	19.78	2	3	Promising
S-184	2	6.653	106.2	95.5	19.34	3	3	Promising

These findings partially agree with the station report, which recommended hybrids S-210, S-212, S-218, S-196, and S-194 according to their absolute ranking in yield per plant. The selection in the present study differs with respect to hybrid S-194, which did not exceed the mean yield of the standard comparison hybrids in its greenhouse (91.4%). Conversely, other hybrids in the second greenhouse emerged as promising after adjustment for the greenhouse effect. This discrepancy highlights the importance of relative comparison, as ranking hybrids according to absolute yield favors those grown in the third greenhouse, which had the highest mean yield, while disadvantaging those grown in the second greenhouse.

3.4. Study Limitations

The results should be interpreted with caution for several reasons: the absence of within-greenhouse replicates precludes the estimation of experimental error and the performance of significance tests; therefore, the reported differences are descriptive, and their statistical significance cannot be determined [17] ; differences in the test hybrids among greenhouses confound hybrid effects with greenhouse effects, which were only partially accounted for using the relative index based on three standard comparison hybrids [18] ; the experiment was conducted during a single growing season, and the performance of the hybrids cannot be generalized to other growing seasons or production cycles [19] ; and the hybrids may differ in other important traits, such as earliness, disease tolerance, and storage quality, which were not included in the present dataset [20].

Conclusions and Recommendations

1. Hybrid S-210 recorded the highest yield per plant in the experiment, outperforming the highest-yielding standard comparison hybrid in its greenhouse by 30.7%. It also produced dark-colored, ribbed fruits of appropriate length, making it the best candidate for release.
2. Hybrids S-212, S-218, and S-183 outperformed the highest-yielding standard comparison hybrids in their respective greenhouses. Hybrids S-155, S-196, S-64, S-60, and S-184 also demonstrated promising performance, approaching that of the highest-yielding standard comparison hybrids.
3. It is recommended that the Bride Seeds hybrids that have not been evaluated in other growing seasons be retested during the spring growing season using a replicated experimental design (a randomized complete block design with at least three replicates), with the same

standard comparison hybrids included in each greenhouse, followed by statistical analysis and mean comparison tests.

4. It is recommended that a limited quantity of S-210 hybrid seeds (500 packets, as proposed in the report) be imported for distribution and performance monitoring in central and northern Iraq, as a preliminary step toward commercial adoption.

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