Original Research Article

Investigating the correlation and principal component of quantitative traits in mixed cropping of okra and cucumber

Abstract

Aims: With the aim of Choosing the most appropriate treatment and investigating the relationships between the traits and investigating the correlation and principal component analysis (PCA) of the morphological and physiological traits, an experiment was conducted in the form of a randomized complete block design (RCBD) in 3 replications on mixed cropping of okra and 3 varieties of cucumber in greenhouse.
Study design: In order to conduct the experiment, a randomized complete block design was used (RCBD) in three replications.
Place and Duration of Study: This study was conducted in Damavand region of Iran in 2019-2020.
Methodology: This experiment was conducted in a metal frame greenhouse where the average temperature of the greenhouse was 25°C and the relative humidity was 40%. During the harvest season, 3 cucumber plants and one okra plant were randomly sampled and recorded, and the numerical value of each trait was recorded based on the average of 3 random plants.
Results: The results obtained from the correlation coefficients indicated that the trait of dry fruit yield has a positive and significant correlation with the traits of fruit weight and fresh fruit yield. Also, in examining the correlation graph between the traits, dry fruit yield and wet fruit yield traits had positive correlations with chlorophyll a, number of fruits, total chlorophyll and plant height traits. Based on the main components, 4 components accounted for more than 55% of the total variance of the data, respectively, 16% related to the first component, 14% related to the second component, 11% related to the third component, and 10% related to the fourth component. Graphical analysis was used on the data obtained from the experiment. Based on the ranking diagram of treatments in terms of traits, A1B2 (Baker x Mito) and A1B1 (Baker x NEGIN) treatments were selected as suitable treatments.
Conclusion: Comparison of the treatments with the okra single cropping treatment showed that doing mixed cropping of okra: cucumber can have a great effect on increasing the level of desirability in various traits in the target crop.

Keywords: cucumber, okra, correlation, PCA, mixed culture, graphic analysis

1. Introduction

Okra, with its scientific name (*Abelmoschus esculentus* L.) is an annual plant native to America, which has a bush with a thick main stem that produces many secondary branches in some varieties [1]. Mixed cropping is one of the common methods used in sustainable agricultural systems, which plays an important role in increasing production and yield stability in order to improve the use of resources and environmental factors [2]. As a part of sustainable agriculture, intercropping increases diversity, increases yield per unit area, efficient use of resources, stability in the system, and optimal nutrition for humans and livestock, as well as reducing damage caused by pests, diseases, and weeds[3]. Intercropping is the growing of two or more crops together in one plot of land in one crop year, which has attracted many fans in developed countries due to its optimal performance [4].The results of research in different countries have indicated that mixed farming, while increasing ecological diversity, increases production with useful yield, more efficient use of water resources, land, labor and food elements, reducing problems caused by pests, diseases, grass has weeds [5]. One of the most important benefits of mixed cropping is the increase in production per unit area compared to single cropping [6]. In addition to creating diversity and sustainability of production in agricultural ecosystems, intercropping significantly increases the economic income and productivity of the land [7]. Okra and cucumber are among the important fruit vegetables, and therefore research is important in order to achieve a better understanding of the mutual effect of mixed cultivation of these two plants [8]. Many studies have shown that intercropping is superior to pure cropping in various aspects including yield [9,10]. The results of the research on the mixed cropping of cucumber and okra showed that there is a kind of compatibility and harmony between the two cucumber and okra plants, which can be the result of physiological and botanical characteristics and favorable ecological factors that increased the yield of the plant [11]. The aim of the current research is 1) Choosing the most appropriate treatment, 2) investigate the relationship between yield and yield components in mixed crops and to identify the best okra crop: cucumber, 3) investigate the degree of decomposition into main components in the studied traits.

2. Materials and Methods

In order to Choosing the most appropriate treatment and investigate the correlation and principal components analysis in quantitative traits, as well as to investigate the yield and yield components in mixed cropping of okra (*Abelmoschus esculentus* L.): cucumber (*Cucumis sativus* L.) compared to pure culture of okra, an experiment was conducted in the form of a randomized complete block design (RCBD) in three replications. This study was conducted in Damavand region of Iran in 2019-2020. Damavand, with longitude 52°3'31.05"E and latitude 35°42'4.69" N, has an average annual rainfall of 360 mm. The highest temperature in this area is 35 °C in summer and the lowest temperature is -29 °C in winter. This experiment was conducted in a metal frame greenhouse where the average temperature of the greenhouse was 25°C and the relative humidity was 40%. During the harvest season, 3 cucumber plants and one okra plant were randomly sampled and recorded, and the numerical value of each trait was recorded based on the average of 3 random plants. Okra variety named Baker (A1B0) and mixed cropping treatments included Baker: Negin (A1B1), Baker: Mito (A1B2), Baker: Fc-27 (A1B3). The evaluated traits include fruit weight per branch (FWB), plant height (PLH), stem diameter (STD), fresh fruit yield (WFY), dry fruit yield (DFY), number of internode (NI), fruit diameter (FD). , fruit length (FL), fruit number (NF), chlorophyll a (Cha), chlorophyll b (Chb) and total chlorophyll (Ch). The characteristics of the tested soil in the cultivation area presented in Table 1. Table 2 shows the code and characteristics of mixed crops and the evaluated traits.

Table 1. Properties of the soil used in the experiment

OC %	PH	Ec Ds/m	B ppm	Fe ppm	Sand %	Silt %	Clay %	P ppm	K ppm	N %
2.8	6.9	7.5	4.3	19.8	26	54	20	374	2850	0.28

Table 2. Code and specifications of mixed crop compounds in the experiment

Mixed crop code	Mixed crop
A1B0	Baker variety okra
A1B1	Baker x NEGIN
A1B2	Baker x Mito
A1B3	Baker × FC-21

3. Results and Discussion

Based on the table of correlation coefficients obtained from the data the experiment, a positive and significant correlation was observed between the trait of fruit weight in each section with the traits of stem diameter, fruit dry yield and fruit length. Also, a positive and significant correlation was observed between plant height and stem diameter with total chlorophyll. The stem diameter trait had a negative and significant correlation with the chlorophyll b trait. A positive and significant correlation was evident between fresh fruit yield traits and dry fruit yield traits, internode number and fruit number, and between dry fruit yield traits and fruit number trait (Table 3). In the correlation diagram, the biplot of the cosine of the angle between the trait vectors indicates the intensity of the correlation between the traits. If the angle between the vectors is less than 90 degrees, the correlation between the vectors is equal to +1, if the angle between the vectors of the traits is 90 degrees, the correlation between the vectors of the traits is equal to zero, and if the angle between the vectors is 180 degrees, it indicates a correlation of 1 - will be [12]. In examining the correlation graph, there is also a positive correlation between the traits of Chlorophyll a, fruit number, dry fruit yield, fresh fruit yield, total chlorophyll, plant height together, Stem diameter, weight of fruit in each section, number of internodes and length of fruit together. A negative correlation was detected between total chlorophyll trait with fruit diameter and fruit weight trait per plant with chlorophyll b trait (Figure 1).

Table 3. Correlation between physiological and morphological traits evaluated in the experiment

	FWN	PLH	STD	WFY	DFY	NI	FD	FL	NF	Cha	Chb
PLH	0.19										
STD	0.2*	0.17									
WFY	0.07	-0.09	-0.12								
DFY	0.02*	0.08	-0.02	0.75*							
NI	-0.14	-0.1	-0.08	0.45*	0.2						
FD	0.13	0.03	0.13	-0.1	-0.2	-0.2					
FL	0.07*	0.08	0.02	0.09	0.04	-0.06	-0.1				
NF	0.1	-0.07	-0.12	0.2*	0.3*	-0.08	-0.2	0.05			
Cha	0.09	0.14	0.04	-0.03	0.03	-0.04	0.05	-0.05	0.17		
Chb	0.02	-0.11	-0.3*	0.11	0.14	0.009	0.17	-0.03	-0.1	-0.05	
Ch	-0.08	0.05*	0.4*	-0.09	-0.09	0.06	-0.02	0.11	-0.03	0.19	-0.15

FWN: fruit weight per node, PLH: plant height, STD: stem diameter, WFY: fresh fruit yield, DFY: dry fruit yield, NI: internode number, FD: fruit diameter, FL: fruit length, NF: fruit number, Cha: chlorophyll a, Chb: chlorophyll b, Ch: total chlorophyll.

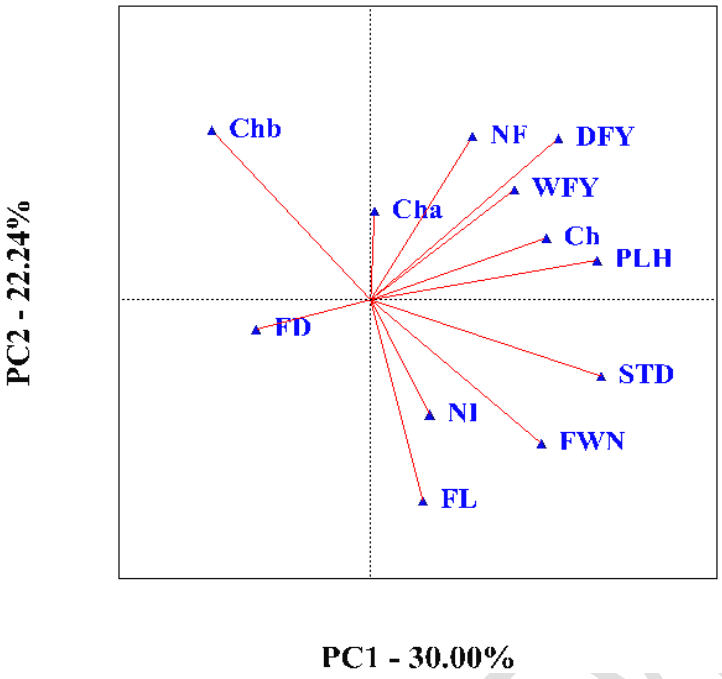

Figure 1. Correlation diagram between the traits evaluated in the experiment

FWN: fruit weight per node, PLH: plant height, STD: stem diameter, WFY: fresh fruit yield, DFY: dry fruit yield, NI: internode number, FD: fruit diameter, FL: fruit length, NF: fruit number, Cha: chlorophyll a, Chb: chlorophyll b, Ch: total chlorophyll.

According to the eigenvalue diagram, in the second year of the experiment, the first four main components explained more than 55% of the data variance (Figure 2). The first component covered more than 16% of the total variance, in which the traits of fresh fruit yield, dry fruit yield, internode number, fruit length, fruit number and chlorophyll b had a positive effect. The most positive effect on this component was related to the traits of fresh fruit yield and dry fruit yield. The second component also covered more than 14% of the variance of the total data, and all traits except fruit diameter and chlorophyll b had a positive effect on this component. The traits of stem diameter and total chlorophyll had the most positive effect on this component. The third component explained more than 11% of the data variance, and except for the traits of stem diameter, internode number and total chlorophyll, the rest of the traits had a positive effect on this component. The most positive effect on this component was related to the characteristics of fruit weight in each section and plant height. The fourth component explained more than 10% of the variance of the data, and all the traits except fruit length, number of fruits and chlorophyll a had a positive effect on this component. The traits of fruit diameter and stem diameter had the most positive effect (Figure 3).

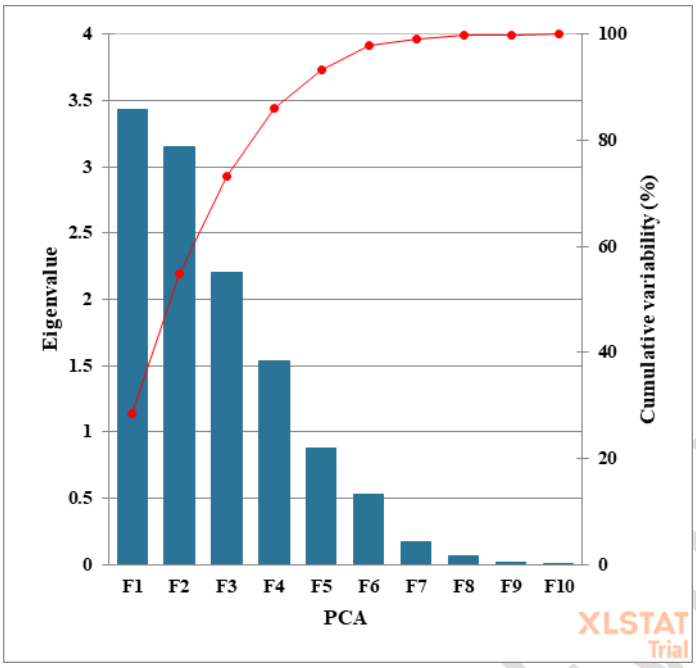

Figure 2. Eigenvalue diagram of attributes evaluated in the experiment

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12
FWN												
PLH												
STD												
WFY												
DFY												
NI												
FD												
FL												
NF												
Cha												
Chb												
Ch												
Proportion	0.19	0.14	0.11	0.1	0.09	0.08	0.07	0.06	0.05	0.03	0.02	0.01
Cumulative	0.19	0.33	0.45	0.55	0.64	0.72	0.8	0.86	0.92	0.95	0.98	1

Figure 3. Heat-map of principal components analysis on the evaluated traits in the experiment

FWN: fruit weight per node, PLH: plant height, STD: stem diameter, WFY: fresh fruit yield, DFY: dry fruit yield, NI: internode number, FD: fruit diameter, FL: fruit length, NF: fruit number, Cha: chlorophyll a, Chb: chlorophyll b, Ch: total chlorophyll

According to the ranking diagram of the investigated treatments in terms of traits, the first component covered 59.32% and the second component covered 30.82% and in total 90.14% of the variance of the total data. In this figure, the axis with a specified arrow (AEC-abscissa) and the resulting mean values (circles) determine the performance of the digits, so that each digit to the right of this axis has more performance. The axis marked with two arrows (AEC-ordinate) confirms the stability or instability of treatments. Treatments distant from this axis's origin (AEC-abscissa) have less stability [13, 14]. Based on this, treatments A1B1 and A1B2 had the highest degree of favorability in terms of all traits, and treatments A1B0 and A1B3 had the lowest degree of favorability in terms of traits (Figure 4). Based on this, the order of the treatments according to the traits from favorable to unfavorable is as follows:

A1B1> A1B2> A1B3> A1B0. Nikzad et al., In their research used this type of diagram to check their treatments and choose the most suitable treatment in terms of traits [15,16,17,18].

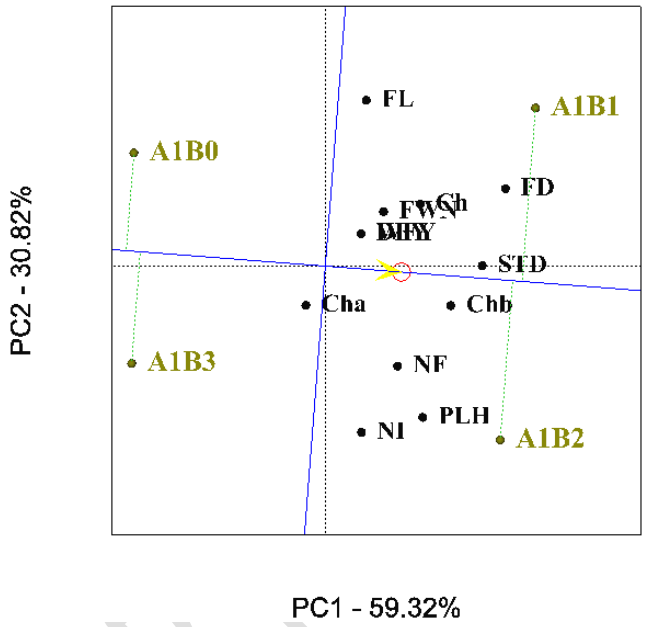

Figure 4. Treatment ranking diagram based on the evaluated traits in the experiment

FWN: fruit weight per node, PLH: plant height, STD: stem diameter, WFY: fresh fruit yield, DFY: dry fruit yield, NI: internode number, FD: fruit diameter, FL: fruit length, NF: fruit number, Cha: chlorophyll a, Chb: chlorophyll b, Ch: total chlorophyll.

In the comparison of A1B0 treatment (control treatment) compared to other treatments, in terms of traits evaluated in the experiment, A1B1 treatment was superior to all traits except Cha and NI compared to A1B0 treatment (Figure 5-a). A1B2 treatment was also more favorable than A1B0 treatment in all traits except FL and Cha traits (Figure 5-b). In the comparison between A1B3 and A1B0 treatments, NF, PLH, NI, WHF, SD and Chb traits were more favorable in A1B3 treatment and Cha, FWN, Ch, FL and FD traits in A1B0 treatment (Figure 5-c). According to the obtained results, A1B0 treatment was highly favorable in terms of Cha traits in all comparisons. It can also be concluded that doing mixed cultivation of okra: cucumber can have a positive effect on increasing the desirability of traits.

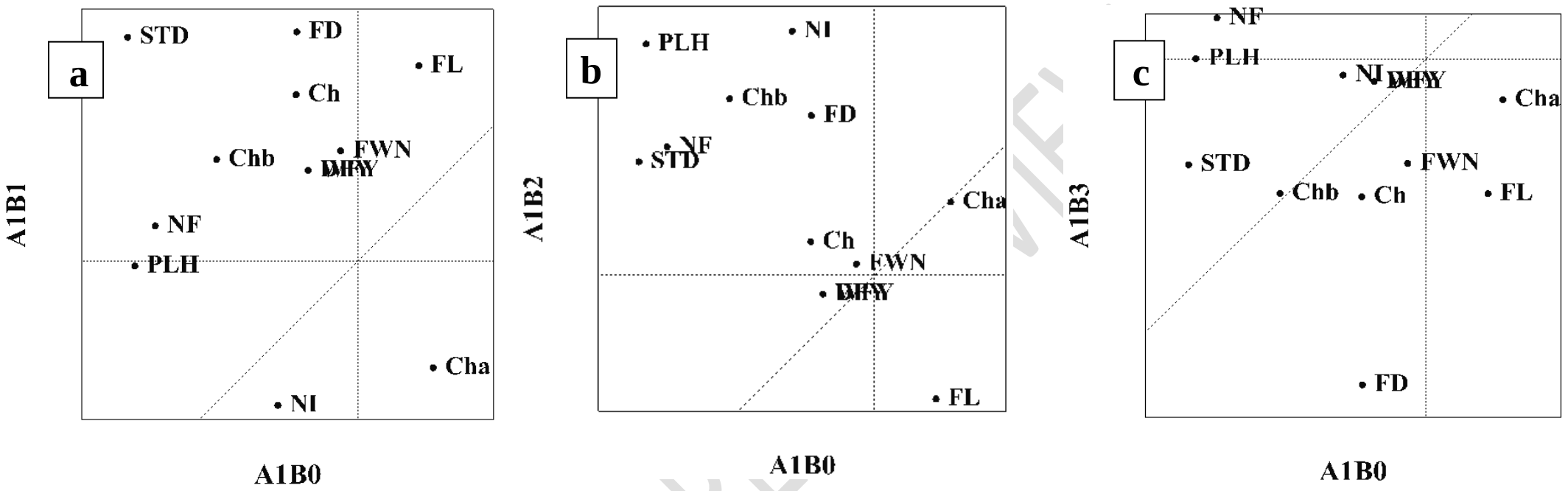

Figure 5. Comparison diagram between treatments in terms of desirability in the evaluated traits in the experiment, a: Comparison of A1B0 and A1B1 treatments, b: Comparison of A1B0 and A1B2 treatments, c: Comparison of A1B0 and A1B1 treatments

FWN: fruit weight per node, PLH: plant height, STD: stem diameter, WFY: fresh fruit yield, DFY: dry fruit yield, NI: internode number, FD: fruit diameter, FL: fruit length, NF: fruit number, Cha: chlorophyll a, Chb: chlorophyll b, Ch: total chlorophyll.

4. Conclusion

Comparison of the treatments with the okra single cropping treatment showed that doing mixed cropping of okra: cucumber can have a great effect on increasing the level of desirability in various traits in the target crop

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