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Research Article

STATISTICAL ANALYSIS OF WHEAT PRODUCTION IN TÜRKİYE BY YEARS

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ABSTRACT. Wheat is one of the most cultivated plants in the world, and it has increased its importance due to the increasing drought and economic crises in recent years. The acreage, production and seed yield in Türkiye between 1938-2020 were examined and the changes, occurred, were statistically examined. Changes in terms of acreage, production and seed yield in by ten-year periods were analyzed by Correlation, Regression and Principal Component Analysis and results were revealed. The increase in wheat production in Türkiye occurred in two different periods. It is seen that the increase in production in the first period (1938-1970) was largely due to the increase in the acreage. After the 1970s, the increase in seed yield was determined as important factor in total production.

Keywords: *bread wheat, cultivar, acreage, production grain yield, statistical analysis*

INTRODUCTION

Wheat is one of the important crop in cereals, and it is a preferred crop in terms of taste, wide adaptation capability, resistance to biotic and abiotic stresses the easier growing, harvesting and storage, and wide use in the food industry. These factors make wheat one of the important crops in the world [1, 2, 3, 4]. Therefore, bread wheat has a wide acreage and production in Türkiye as well as in the world. The wheat production in the country increased visibly in the last 100 years [5, 6, 7]. The increase in wheat production in Türkiye can be attributed to two reasons. The first one is the increase in acreage by on the years; the second one is the increase in seed yield [8, 9, 10, 11]. The increase in production in Türkiye until 1965 was possible with the increase in acreage. With the foreign mechanization aids to Türkiye, a significant amount of tractor entry was provided and the cultivation areas were plowed. In 1965, the end of cultivation areas was reached and marginal areas were left to be cultivated. Since 1965, considerable advances occurred in wheat breeding, both in the world and in Turkey, high yielding varieties have been developed and the increase in production was due to the increase in the seed yield by using registered cultivars [5, 8, 9, 11, 12, 13, 14].

Although the production increase in bread wheat continued as an increasing trend, since the genetic potentials were reached in the 1990s, the yield could not be increased as much as the previous years, and an increase was recorded at low rates [15, 16, 17]. After reaching a certain level of satisfaction in obtaining high yielding cultivars, the need to increase production has arisen in Turkey since the 1990s. Adequate nutrition of the rapidly increasing population is possible only by increasing crop production [8, 9, 11]. Therefore, to increase crop production, bread wheat cultivars must be resistant to biotic and abiotic stresses, as well as high yielding, quality and stability. In addition, dry farming areas should be made irrigated. In other words, the irrigated areas need to be doubled

urgently. Solving water problem in a world where severity of drought is increasing, is another problem [5, 9, 11, 17, 18]. Therefore, while analyzing the production increase of wheat production based on long years in Turkey, analyzes are carried out based on these principles. In this study, the increase in crop production in Türkiye after the 1930s was examined by using statistical analysis.

MATERIALS AND METHODS

In this study, the acreage, production and seed yield [19] in bread wheat between 1938-2020 in Türkiye were examined and the changes occurred were discussed statistically. The changes on data in ten-year periods were examined by Correlation, Regression [20, 21, 22, 23] and Principal Component Analyzes [24, 25, 26]. These analyzes were made in Minitab 17, SPSS 25 and R programs.

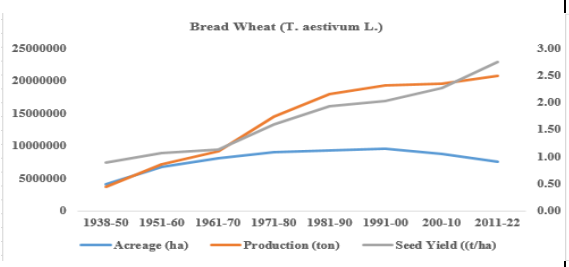
RESULTS AND DISCUSSION

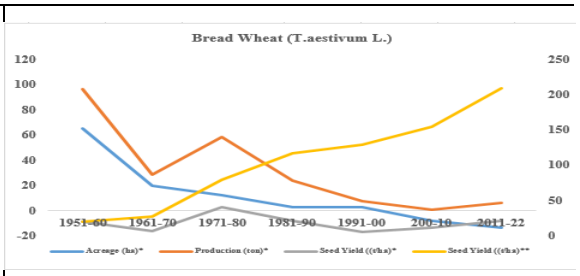
The importance of wheat in human nutrition is an indisputable fact in the world, and crop production needs to be increased in sufficient quantities in order to feed the rapidly increasing population [1, 2]. This is possible either by increasing the acreage or increasing seed yield the yield [5, 10, 11]. Moreover, starting from the republican period in Türkiye,.there has been an tremendous increase in wheat production. It has been revealed that the increase in crop production occured by increase in both acreage and seed yield in Türkiye and in the World [8, 9, 11]. In our study, acreage, crop production and seed yield as a factors were discussed. The use of high yielding cultivars varieties and the increase in agronomic practices were considered together in the seed yield per unit area. The increase and decrease by years in acreage, crop production and seed yield in Türkiye were given in Table 1.

Table 1. *The increase and decrease by years in acreage, crop production and seed yield in Türkiye*

Periods	Acreage (ha)	Production (ton)	Seed Yield (t/ha)	Periods	Acreage (ha)*	Production (ton)*	Seed Yield (t/ha)*	Seed Yield (t/ha)**
1938-50	4077855	3632444	0.89	**1951-60**	64.90	96.56	20.10	20.00
1951-60	6724180	7139900	1.07	**1961-70**	19.86	28.67	6.46	27.75
1961-70	8059700	9187000	1.14	**1971-80**	12.38	58.16	40.63	79.66
1971-80	9057500	14530000	1.60	**1981-90**	2.49	23.68	21.01	117.42
1981-90	9283100	17970000	1.94	**1991-00**	2.44	7.60	5.06	128.43
1991-00	9510000	19335000	2.03	**200-10**	-8.32	1.01	11.61	154.94
200-10	8718340	19530000	2.27	**2011-22**	-13.29	6.07	21.29	209.21
2011-22	7559299	20715000	2.75	***rate in increase compared to the previous period				

****rate in increase compared to the first period





As seen from the table, until 1970, increase in crop production of wheat and barley is due to the increase in acreage. The fact that there is no significant increase in seed yield per unit area supports this. As of 1970's, as a result of the advances in wheat breeding in Türkiye and in the world, the application of modern breeding techniques and the increase in modern agronomic practices caused a noticeable increase in crop production and seed yield per unit area in Türkiye (Table 1). Meanwhile, in this study, the term of increase in seed yield includes use of high yielding cultivars and modern agronomic practices. When both the increase rate compared to the previous period and the first period are examined, that increase in crop production and seed yield per unit area were due to the advances in breeding programs and introduction of high-yielding cultivars after 1970's.

Besides, after the 1990's, a stagnation was observed in seed yield per unit area. The reason for this is that the limit of genetic potentials has been reached in bread wheat. Similarly, studies have shown that the genetic potentials of wheat are now at the limit, and that the increase in yield will not be as expected in the World [1, 2, 11].

Table 2. *Regression and correlation analyzes related to crop production, acreage and seed yield per unit area*

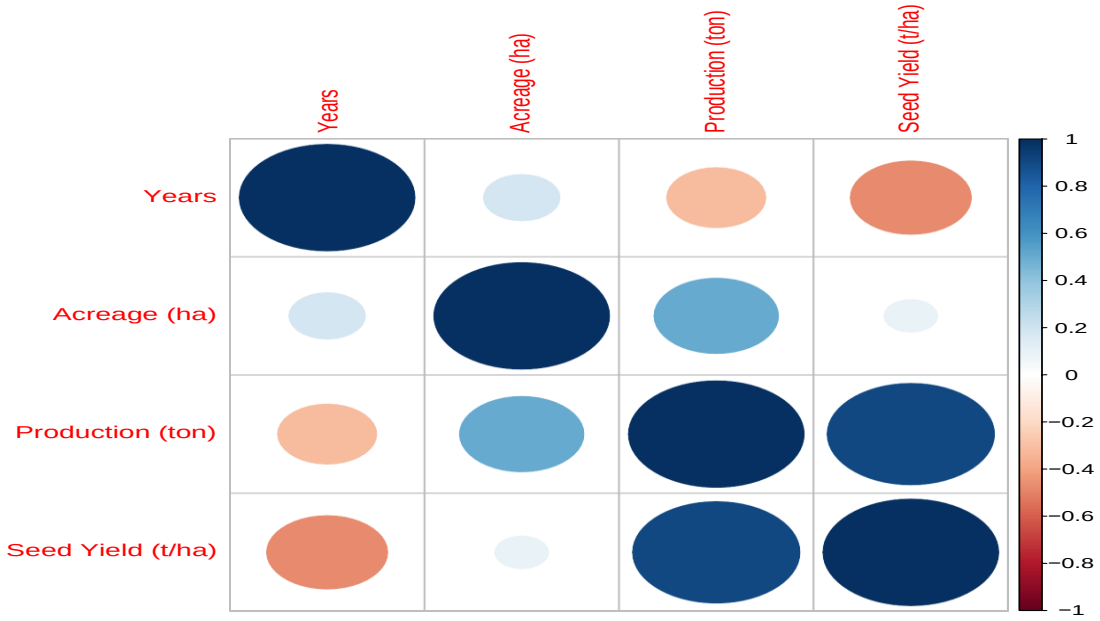
Model 1	**R**	**R^2**	**Adjusted R^2**	**Estimate St. Error**
	0,995[a]	0,991	0,987	0,09845

Model 1	**Sum of Squares**	**df**	**Mean Square**	**F**
Regression	295079654682684,400	2	147539827341342,200	262,670**
Residual	2808460246659,603	5	561692049331,921	
Total	297888114929344,000	7		

Dependent Variable: Crop Production; Predictors: (Constant), SeedYield, Acreage

	Unstandardized Coef.		**Standardized Coef.**	**t**
	B	**Std. Error**	**Beta**	
(Constant)	-9025217,632	1269447,163		-7,110**
Acreage	1,290	0,190	0,356	6,777**
SeedYield	7521502,405	525686,936	0,751	14,308**

Dependent Variable: Crop Production



As revealed in the study, for feeding the tremendously increasing population in the near future, the could only be possible by increasing crop production, extending irrigation in arid areas and developing high yielding cultivars, more resistant to biotic and abiotic stresses. Regression and correlation analyzes related to crop production, acreage and seed yield per unit area were given in Table 2. As seen in Table 2, the effect of independent variables on crop production was found to be significant at the level of 1% in the combined regression analysis. Acreage and seed yield per unit area as an independent variables, and crop production as the dependent variable were considered (Table 2).

In the analysis, the effect of acreage and seed yield in production was found to be significant at 1%; it is clear that the seed yield per unit area (T=14.308) is much more effective on production than the sown area (T=6,777). In other word, the crop production in bread wheat is more likely to be due to the increase in the seed yield per unit area. This shows how effective the use of high yielding cultivars is in increasing production. In the correlation analysis, relationship between the seed yield and crop production was determined as positive and important at 1%, while the relationship between crop production and acreage was positive and significant at 5%. So, especially after the 1970's, increase in production is mostly caused the increase in seed yield per unit area, and this is due to the use of high-yielding cultivars. Principle Component Analysis covering Biplot Analysis explaining the changes in acreage, crop production and seed yield per unit area in wheat from 1938 to the present were given in Table 3 and Figure 1.

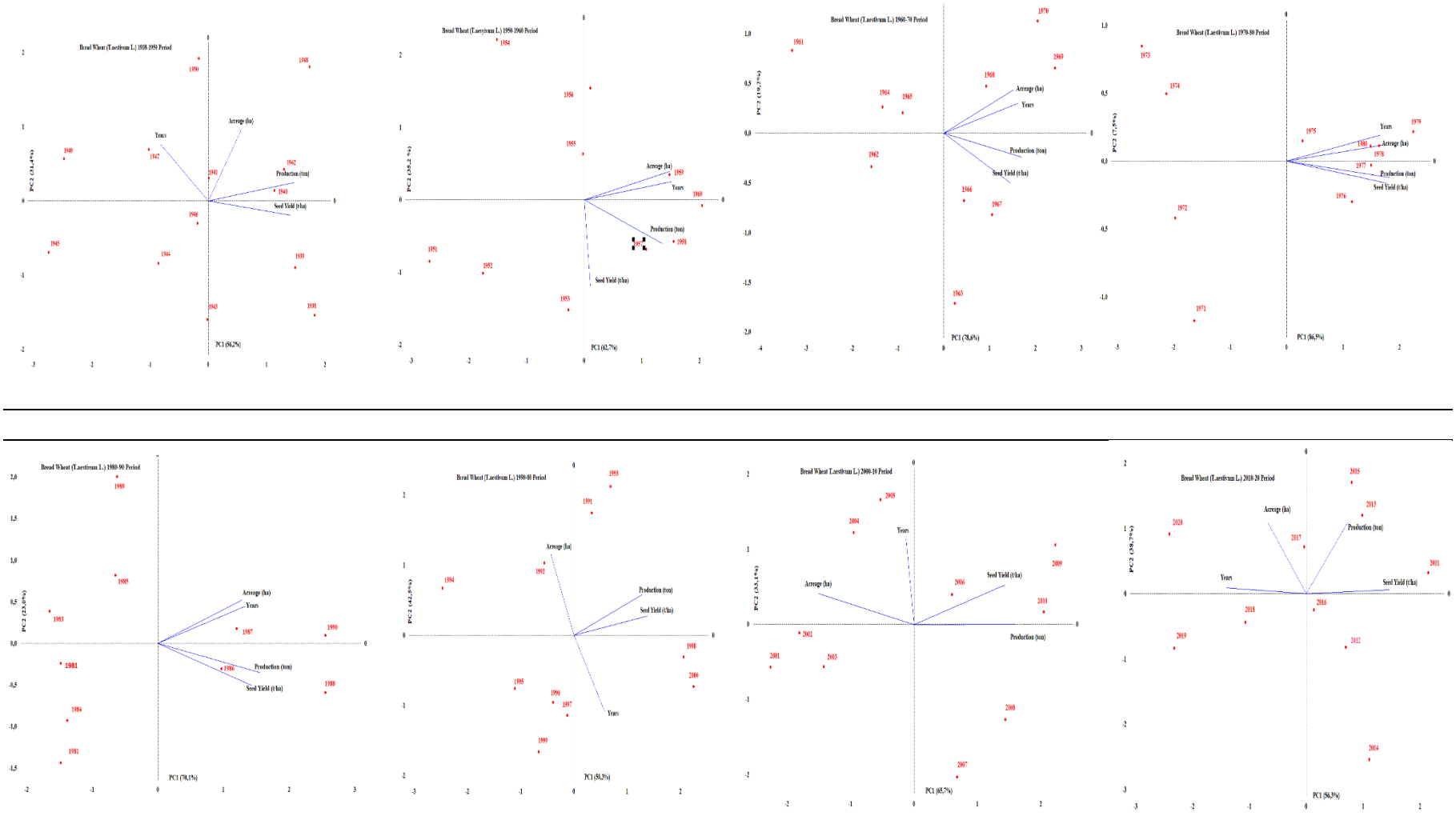
As can be seen in Table 3, which factors were more effective in production in the two PC analysis steps have been revealed. The increase in production in the 1938-50, 1951-60 and 1961-70 periods was mostly based on acreage. From 1970 to the present, acreage was not so effective, but use of high yielding cultivars was mostly liable fır crop production (Table 3). It should also be noted that the increase in production, especially after the 1970's, is not only due to the use of high yielding varieties. In addition, other factors such as agronomic practices may be effective. Because, in the last 50 years, the improving agronomic practices such as fertilization, irrigation, seed rate, soil cultivation and technological advances in agricultural equipment have played an important role in the increase in production as much as high-yielding varieties.

Biplot analysis showed in Figure 1, there was a regular increase in the acreage until the 1970's, with a increase in crop production, no certain increase occurred in seed yield per unit area. Therefore, this situation leads to the conclusion that the increase in production depends on the acreage. After the 1970's (especially the 1980's), there was not much change in the acreage, even a decrease. Especially the seed yield per unit area is an effective factor on production.

Table 3. *Principle Component Analysis, examining the changes in acreage, crop production and seed yield in wheat since 1938*

	1938-50 Period						**1951-60 Period**				
	PC_1	**PC_2**	**Variable**	**PC_1**	**PC_2**		**PC_1**	**PC_2**	**Variable**	**PC_1**	**PC_2**
Eigenvalue	2,249	1,258	**Years**	-0,362	0,602	**Eigenvalue**	2,510	1,407	**Years**	0,601	0,175
Proportion	0,562	0,314	**Acreage (ha)**	0,250	0,759	**Proportion**	0,627	0,352	**Acreage (ha)**	0,589	0,276
Cumulative	0,562	0,877	**Production (ton)**	0,645	0,193	**Cumulative**	0,627	0,979	**Production (ton)**	0,539	-0,432
			Seed Yield (t/ha)	0,624	-0,154				**Seed Yield (t/ha)**	0,042	-0,840
	1961-70 Period						**1971-80 Period**				
	PC_1	**PC_2**	**Variable**	**PC_1**	**PC_2**		**PC_1**	**PC_2**	**Variable**	**PC_1**	**PC_2**
Eigenvalue	3,146	0,767	**Years**	0,514	0,392	**Eigenvalue**	3,461	0,300	**Years**	0,478	0,630
Proportion	0,786	0,192	**Acreage (ha)**	0,480	0,564	**Proportion**	0,865	0,070	**Acreage (ha)**	0,485	0,384
Cumulative	0,786	0,978	**Production (ton)**	0,641	-0,314	**Cumulative**	0,865	0,940	**Production (ton)**	0,624	-0,161
			Seed Yield (t/ha)	0,362	0,655				**Seed Yield (t/ha)**	0,611	-0,242
	1981-90 Period						**1991-00 Period**				
	PC_1	**PC_2**	**Variable**	**PC_1**	**PC_2**		**PC_1**	**PC_2**	**Variable**	**PC_1**	**PC_2**
Eigenvalue	2,804	0,920	**Years**	0,476	0,486	**Eigenvalue**	2,010	1,670	**Years**	0,483	-0,637
Proportion	0,701	0,230	**Acreage (ha)**	0,455	0,566	**Proportion**	0,503	0,425	**Acreage (ha)**	-0,315	0,474
Cumulative	0,701	0,931	**Production (ton)**	0,655	-0,280	**Cumulative**	0,503	0,928	**Production (ton)**	0,633	0,338
			Seed Yield (t/ha)	0,308	-0,647				**Seed Yield (t/ha)**	0,688	0,162
	2001-10 Period						**2011-20 Period**				
	PC_1	**PC_2**	**Variable**	**PC_1**	**PC_2**		**PC_1**	**PC_2**	**Variable**	**PC_1**	**PC_2**
Eigenvalue	2,628	1,325	**Years**	0,410	0,204	**Eigenvalue**	2,250	1,550	**Years**	-0,523	0,357
Proportion	0,657	0,331	**Acreage (ha)**	-0,574	0,308	**Proportion**	0,563	0,387	**Acreage (ha)**	0,607	0, 341
Cumulative	0,657	0,988	**Production (ton)**	-0,048	0,865	**Cumulative**	0,563	0,950	**Production (ton)**	0,219	0,672
			Seed Yield (t/ha)	0,644	0,297				**Seed Yield (t/ha)**	-0,203	0,708

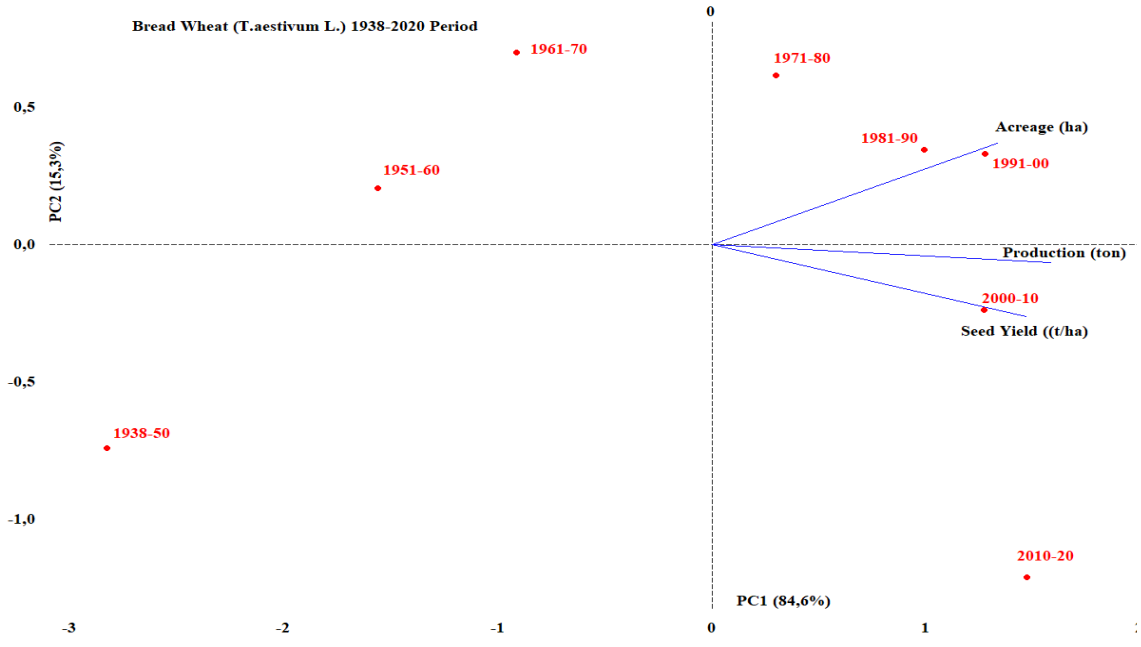
Figure 1. *Biplot Analysis, examining the changes in acreage, crop production and seed yield in wheat since 1938*



Although there is not much change in the acreage, significant variations in crop production and seed yield per unit area happened. This shows that when the change in crop production is considered holistically, it is closely related to the crop production. In the bi-plot analysis given in the same table, crop production is very closely related to the seed yield per unit area compared to the acreage, and this relationship has been realized significantly especially after the 1990's. On the other hand, Principle Component Analysis, considering the acreage, crop production and seed yield per unit area holistically from 1938 to the present were shown in Table 4. It was seen that the seed yield per unit area is more effective in crop production than the acreage. Biplot Analysis revealed that grain yield per unit area is closely related to crop production. This shows that the use of high-yielding, quality cultivars and the application of optimum agronomic techniques, causing an increase in grain yield per unit area, have been an important factor in the increase in production. If examined on the basis of years, especially after the 1970's, there has been an increase in grain yield per unit area and therefore in crop production (Table 4).

Table 4. *Path analysis made by considering the cultivation area, production and unit area seed yield since 1938*

Eigenanalysis of the Correlation Matrix			PCA Analysis		
	PC_1	PC_2	Variable	PC_1	PC_2
Eigenvalue	2,537	0,458	**Acreage (ha)**	0,526	0,805
Proportion	0,846	0,153	**Production (ton)**	0,624	-0,147
Cumulative	0,846	0,998	**Seed Yield (t/ha)**	0,678	-0,275



CONCLUSION

When wheat yield in Turkey was analyzed chronologically, it can be said that the analysis of crop production increase could be done by considering two different periods. In the first period (1938-1970), the increase in production was largely due to the increase in the acreage. After the 1970's, the increase in seed yield per unit area has been an

important factor in crop total production. In the study, where the increase in seed yield per unit area, the use of high yielding cultivars and the use of modern agronomic techniques were analyzed together, Crop production increased due to the increase in seed yield per unit area, especially since the 1980's. A released cultivar could be described as high yielding and quality, resistant to biotic and abiotic stresses, and stable in different years and locations terms of these characteristics. With the increase in the use of released cultivars, a safe increase in wheat production can be achieved. More detailed studies are needed on this subject.

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