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Determination of organic acids on the development periods in bread wheat genotypes

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Abstract

The purpose of this study is to determine changes of organic acid levels (oxalic acid, propionic acid, tartaric acid, butyric acid, malonic acid, malic acid, lactic acid, citric acid, fumaric acid, maleic acid succinic acid, gibberellic acid, salicylic acid, indol acetic acid, abscisic acid) in thirteen bread wheat genotypes (BW$_1$: Es-26, BW$_2$: Bezostaja-1, BW$_3$: Müfitbey, BW$_4$: Altay-2000, BW$_5$: Sönmez-01, BW$_6$: Soyer-02, BW$_7$: Çetinel-2000, BW$_8$: Harmankaya-99, BW$_9$: Sultan-95, BW$_{10}$: Alpu-01, BW$_{11}$: Atay-85, BW$_{12}$: Özdemir and BW$_{13}$: Gerek-79) during growth stages of wheat (tillering, flowering, maturity stages and seeds) in growing periods of 2012-2013.The highest and the lowest levels of organic acids belonged to BW$_5$ (Sönmez-01) and BW$_7$ (Çetinel-2000) in all amino acids. Bread wheat genotypes and developmental stages have significant changes in organic acids. Great different levels on organic acids in bread wheat genotypes means that they are acted in different intensity and level under genetic capacity and differences. Differences of organic acid levels in different growth stages shows that genotype x environment interaction monitors organic acid levels and metabolic processes in different development stages.

Key words: bread wheat genotypes, organic acid level, growth stages, double dendogram

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Farklı gelişme dönemlerdeki ekmeklik buğdayda organik asit miktarlarının belirlenmesi

Özet

Bu çalışmanın amacı, 13 ekmeklik buğday çeşidinde 2012-2013 yılında (BW$_1$: Es-26, BW$_2$: Bezostaja-1, BW$_3$: Müfitbey, BW$_4$: Altay-2000, BW$_5$: Sönmez-01, BW$_6$: Soyer-02, BW$_7$: Çetinel-2000, BW$_8$: Harmankaya-99, BW$_9$: Sultan-95, BW$_{10}$: Alpu-01, BW$_{11}$: Atay-85, BW$_{12}$: Özdemir ve BW$_{13}$: Gerek-79) değişik gelişme dönemlerinde (sapa kalkma, çiçeklenme, olgunluk denemleri) ve tohumda amino asit düzeylerinin (oksalik asit, propiyodik asit, tartarik asit, butirik asit, malonik asit, malik asit, laktik asit, sitrik asit, fumarik asit, maleik asit süksinik asit, giberellik asit, salisilik asit, indol asetik asit, absisik asit) değişimi incelenmiştir. Buğdayın bütün dönemlerinde ve tohumda bütün çeşitlerde organik asit seviyelerinde benzer değişim gözlenmiştir. Organik asitlerde en yüksek ve en düşük seviyeler BW5 (Sönmez-01) ve BW7'ye (Çetinel-2000) ait olmuştur. Ekmek buğday genotipleri ve gelişim aşamaları, organik asitler açısından önemli değişiklikler göstermiş olup, farklı yoğunluk ve seviyelerdeki organik asitlerin farklı genetik yapı ve kapasiteye sahip genotiplerin etkisi altında olduğu belirlenmiştir. Yine farklı büyüme dönemlerindeki organik asit farklılıklarının da organik asit faaliyetinin genotip x çevre interaksiyonunun etkisi altında olduğunu göstermektedir.

Anahtar kelimeler: ekmeklik buğday çeşitleri, organik asit seviyesi, gelişme dönemleri, double dendogram

1. Introduction

Wheat is the plant that takes the first order among the cultivated plants in terms of acreage and production for human nutrition and production in the world. Due to proper nutritional value, ease of handling, storage and handling,

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and adaptability on a very large geographical area, wheat is the basic food of about 50 countries and is basic nutrient for approximately 35% of the world's population. Cereals including bread wheat are known as valuable crops in biochemical and nutritional quality for protein, amino and organic acids, minerals, vitamins etc. (Gupta and Varshney, 2000; Wronkowska et al., 2010). As a part of important ingredients for metabolic reactions, organic acids play vital act in plants (Kamilova et al., 2006). Organic acids are produced in mitochondria and function and level of organic acids in wheat are controlled by genotype x environment interaction and wheat growth stages(Boyer, 1982; Zolman et al., 2008).. Having importance in metabolic reactions, level of organic acids increases/decreases with increasing/decreasing metabolic processes and plant growth. They differ not only in different growth stages but also in genotypes (Mahmood and Chowdhry, 2000; Iwasaki et al., 2011; Olgun et al., 2015). Assigning organic levels in growth stages in bread wheat contribute to determine characteristics of organic acids assist promising genotypes and help to increase effectiveness of breeding programs. The purpose of this study is to determine changes of organic acid levels during growth periods of bread wheat genotypes.

2. Materials and methods

Current study was carried out on greenhouse conditions and experimental station of Osmangazi University, Agricultural College Eskişehir. Thirteen genotypes of bread wheat (**BW_1:** Es-26, **BW_2:** Bezostaja-1, **BW_3:** Müfitbey, **BW_4:** Altay-2000, **BW_5:** Sönmez-01, **BW_6:** Soyer-02, **BW_7:** Çetinel-2000, **BW_8:** Harmankaya-99, **BW_9:** Sultan-95, **BW_{10}:** Alpu-01, **BW_{11}:** Atay-85, **BW_{12}:** Özdemir and **BW_{13}:** Gerek-79) were used in the current study. This study was carried out in completed randomized block design with three replications in 2012-2013. Seeds were sterilized by bleach (NaOCl 10%) and put into pots (0.75 m width, 1 m length, and 0.75 m height) having 80 kg of humus soil. Ssoil also had 28.5 % $CaCO_3$, 297.3 mmol/kg P_2O_5, 385.5 mmol/kg K_2O, and 2.36% organic matter, 6.11 pH, and 2,63 dS/m electrical conductivity. Seed planting was made in 15th of September. By dividing in two (½ at sowing period and ½ at tillering period), 60 kg N ha^{-1} and once (at sowing) 60 kg ha^{-1} P_2O_5 were applied. Normal water (EC=0.8–2.1 dS m^{-1}) was used in the study. Plants grew until tillering period (Zadoks 21) in greenhouse conditions until November then pots were put outside for overwinter, and they kept growing under ambient conditions. Pots were protected from bird damage by netting. Three times irrigation at sowing, at stem elongation (Zadoks 24), and at flowering (Zadoks 65) were Irrigations were made. Precipitations were 316.9 mm in 2012-2013 and 311.5 mm in long-term years (Table 1).

Table 1 Average, minimum and maximum temperatures, precipitations in 2012-2013 and long-term years in Eskişehir

Climatic Param.	Years	October	November	December	January	February	March	April	May	June	July	Tot./Av.
Max. Temp.	**2012-2013**	24.2	21.8	19.1	14.3	17.8	24.6	24.4	29.2	34.3	38.9	24.9
(ºC)	**Long**	33.0	25.4	21.4	20.2	20.5	28.1	31.1	33.3	36.8	40.6	29.0
Min. Temp.	**2012-2013**	-3.3	-6.7	-9.1	-7.4	-12.9	-8.1	-2.8	1.5	5.6	6.6	-2.6
(ºC)	**Long**	-6.8	-12.2	-19.2	-27.8	-22.4	-12.0	-10.4	-2.2	0.5	5.0	-10.8
Av. Temp.	**2012-13**	8.5	0.8	0.9	-3.6	-5.5	1.5	12.0	14.4	20.1	22.8	7.2
(ºC)	**Long**	11.7	5.6	1.7	-0.2	0.9	4.9	9.6	14.9	19.1	22.1	9.0
Total Ra.	**2012-2013**	5.8	0.0	46.1	58.0	42.1	56.4	22.1	80.9	0.0	5.5	316.9
(mm)	**Long**	32.8	34.0	40.5	30.6	26.1	27.6	43.1	40.0	23.7	13.1	311.5

* Meteorology office, Eskisehir, **Long years-1970-2013

Samples were taken for determining level of organic acids (oxalic acid, propionic acid, tartaric acid, butyric acid, malonic acid, malic acid, lactic acid, citric acid, fumaric acid, maleic acid succinic acid, gibberellic acid, salicylic acid, indol acetic acid, abscisic acid) at tillering period, flowering period, maturity period and seed, respectively. For determination of organic acids, 10 mL of deionized water was added to mg plant samples, which were homogenized using an IKA Ultra Turrax D125 Basic homogenizer. After centrifugation at 1200 rpm for 50 minutes, the supernatants were filtered through a 0.22 μm pore Millex Millipore filter and collected in vials. The supernatants were subjected to HPLC analysis using a Zorbax Eclipse-AAA 4.6 × 250 mm, 5 μm column (Agilent 1200 HPLC), and the absorbance at 220 nm was read using a UV detector. The flow speed was 1 mL min-1, and the column temperature was 250°C. The organic acid contents of the bacterial suspensions, including oxalic and propionic acids, were determined using 25 mM potassium phosphate pH 2.5 as the mobile phase. Double dendogram analyze was made by NCSS statistic software program.

3. Results

The prominence in the nutrition of the wheat and the performance of the genotype against environmental stress is indisputable. The level of the nutrients contained in the bread wheat determines the nutritive quality of the wheat, and the nutritional quality of the increased nutrients is increased.

Table2. Distribution of organic acids in tillering stage of bread wheat genotypes

	Oxalic	Propionic	Tartaric	Butyric	Malonic	Malic	Lactic	Citric
BW1	1.18	1.85	2.60	4.10	23.65	2.60	17.87	2.65
BW2	1.25	1.97	2.78	4.37	25.22	2.78	19.06	2.82
BW3	1.14	1.79	2.52	3.96	22.86	2.52	**17.28**	2.56
BW4	1.20	1.89	2.67	4.19	24.21	2.67	18.30	2.71
BW5	**1.27**	**2.00**	**2.81**	**4.43**	**25.56**	**2.81**	**19.32**	**2.86**
BW6	1.19	1.87	2.63	4.13	23.87	2.63	18.04	2.67
BW7	**1.11**	**1.74**	**2.46**	**3.86**	**22.29**	**2.46**	16.85	**2.49**
BW8	1.18	1.86	2.62	4.11	23.76	2.62	17.96	2.66
BW9	1.14	1.79	2.52	3.96	22.86	2.52	**17.28**	2.56
BW10	1.24	1.94	2.74	4.31	24.88	2.74	18.81	2.78
BW11	1.21	1.90	2.68	4.21	24.32	2.68	18.38	2.72
BW12	1.19	1.87	2.64	4.15	23.98	2.64	18.13	2.68
BW13	**1.27**	1.99	2.80	4.41	25.45	2.80	19.23	2.85
	Oxalic	**Propionic**	**Tartaric**	**Butyric**	**Malonic**	**Malic**	**Lactic**	**Citric**
Mean	1.20	1.88	2.65	4.17	24.07	2.65	18.19	2.69
Sx	0.05	0.08	0.11	0.18	1.02	0.11	0.77	0.11
	Maleic	**Fumaric**	**Succinic**	**Gibberellic**	**Salicylic**	**IAA**	**Abscisic**	
BW1	1.59	0.88	21.68	112.67	36.58	2.58	0.17	
BW2	1.69	0.94	23.13	120.18	39.02	2.76	**0.18**	
BW3	1.53	0.85	20.96	108.91	35.36	2.50	0.16	
BW4	1.63	0.90	22.20	115.35	37.45	2.64	0.17	
BW5	**1.72**	**0.95**	**23.44**	**121.79**	**39.54**	**2.79**	**0.18**	
BW6	1.60	0.89	21.89	113.74	36.93	2.61	0.17	
BW7	**1.50**	**0.83**	**20.45**	**106.23**	**34.49**	**2.44**	**0.16**	
BW8	1.60	0.89	21.79	113.20	36.76	2.60	0.17	
BW9	1.53	0.85	20.96	108.91	35.36	2.50	0.16	
BW10	1.67	0.93	22.82	118.57	38.50	2.72	**0.18**	
BW11	1.63	0.91	22.30	115.88	37.63	2.66	0.17	
BW12	1.61	0.89	21.99	114.27	37.10	2.62	0.17	
BW13	1.71	**0.95**	23.34	121.25	39.37	2.78	0.18	
	Maleic	**Fumaric**	**Succinic**	**Gibberellic**	**Salicylic**	**IAA**	**Abscisic**	**Maleic**
Mean	1.62	0.90	22.07	114.69	37.24	2.63	0.17	1.62
Sx	0.07	0.04	0.94	4.88	1.59	0.11	0.01	0.07

BW$_1$: Es-26, **BW$_2$:** Bezostaja-1, **BW$_3$:** Müfitbey, **BW$_4$:** Altay-2000, **BW$_5$:** Sönmez-01, **BW$_6$:** Soyer-02, **BW$_7$:** Çetinel-2000, **BW$_8$:** Harmankaya-99, **BW$_9$:** Sultan-95, **BW$_{10}$:** Alpu-01,**BW$_{11}$:** Atay-85,**BW$_{12}$: Özdemir,BW$_{13}$:** Gerek-79

Therefore, the increase/decrease in the organic acid level is an important factor in determining the nutritive qualities of wheat and its performance against stress conditions (Bucio et al., 2000). Differences in anabolic and catabolic events during different developmental periods in bread wheat are indicative of the formation of organic acid levels at different levels (Salisbury and Ross, 1997). Distribution of organic acids in tillering stage of bread wheat genotypes were given in Table 2. While **BW$_5$** (Sönmez-01) had the highest levels in lactic, propionic, tartaric, butyric, malonic, malic, citric, maleic, fumaric, succinic, gibberellic, salicylic and indol acetic acids, **BW$_7$** (Çetinel-2000) had the lowest levels. In abscisic acids, the highest level belonged to **BW$_5$** (Sönmez-01), **BW$_3$** (Müfitbey) and **BW$_9$** (Sultan-95) had the lowest levels. Besides, d~~D~~istribution of organic acids in flowering stage of bread wheat genotypes were given in Table 3. All organic acid levels are highest in **BW$_5$** (Sönmez-01), lowest in **BW$_7$** (Çetinel-2000). Table 4 denoted organic acids levels in maturity stage of bread wheat genotypes. **BW$_5$** (Sönmez-01) had the highest **BW$_7$** (Çetinel-2000) had the lowest levels in all organic acids but lactic acid, in which the highest level belonged to **BW$_5$** (Sönmez-01), **BW$_3$** (Müfitbey), **BW$_7$** (Çetinel-2000) and **BW$_9$** (Sultan-95) had the lowest levels. Similar trends occurred in Table 5, which assigned organic acids levels in seed of bread wheat genotypes. In seed, the highest levels belonged to **BW$_2$ (**Bezostaja-1), **BW$_5$** (Sönmez-01), **BW$_{10}$** (Alpu-01) and **BW$_{13}$: (**Gerek-79), the lowest ones belonged to **BW$_7$** (Çetinel-2000) and **BW$_9$** (Sultan-95).

Organic acids, which are an important part of metabolism, are of vital importance for metabolic reactions such as adaptation to stress conditions (Hoffland et al., 1992; Salisbury and Ross, 1997). Furthermore, organic acids behave as a product in the nitric acid carbon metabolism (Bucio et al., 2000). Ca oxalate, playing an important role in providing this ionic balance, serves as a signal for plants to withstand stress conditions. When oxalic acid is produced in plants, it plays an important role in increasing the resistance to drought, especially in stabilizing the minerals in the cell, preventing their loss from the cell membrane (Webb et al., 1995). Propionic acid, being a defensible acid, acts as a signal in stress conditions and plays a role in the synthesis of some defense-related amino acids. In addition, propionic acid is used as defense amino acid against microbial attack in some plants (Walker et al., 2003). Tartaric acid is the basis for the production of vitamin C as well as making a significant contribution to fruit accumulation and fruit flavoring during maturation. It is found in the leaves and in the fruit in abundance. In addition, increased tartaric acid in arid conditions increases maturation, promotes an increase in the rate of potassium, and helps to the osmotic balance of the plant (Rivas-Ubach et al., 2012). Butyric acid forms plant activities such as growth, development, cell division, activity, growth, tissue formation, leaf growth, apical dominance, phototropism, root growth and development in plants.

Table 3. Distribution of organic acids in flowering stage of bread wheat genotypes

	Oxalic	**Propionic**	**Tartaric**	**Butyric**	**Malonic**	**Malic**	**Lactic**	**Citric**
BW1	1.34	2.11	2.97	4.67	26.96	2.97	20.37	3.02
BW2	1.43	2.25	3.17	4.98	28.75	3.17	21.73	3.22
BW3	1.30	2.04	2.87	4.51	26.06	2.87	19.69	2.92
BW4	1.37	2.16	3.04	4.78	27.60	3.04	20.86	3.09
BW5	**1.45**	**2.28**	**3.21**	**5.05**	**29.14**	**3.21**	**22.02**	**3.26**
BW6	1.35	2.13	3.00	4.71	27.21	3.00	20.57	3.05
BW7	**1.26**	**1.99**	**2.80**	**4.40**	**25.42**	**2.80**	**19.21**	**2.84**
BW8	1.35	2.12	2.98	4.69	27.08	2.98	20.47	3.03
BW9	1.30	2.04	2.87	4.51	26.06	2.87	19.69	2.92
BW10	1.41	2.22	3.12	4.91	28.37	3.12	21.44	3.17
BW11	1.38	2.17	3.05	4.80	27.73	3.05	20.96	3.10
BW12	1.36	2.14	3.01	4.73	27.34	3.01	20.66	3.06
BW13	1.44	2.27	3.19	5.02	29.01	3.19	21.93	3.25
	Oxalic	**Propionic**	**Tartaric**	**Butyric**	**Malonic**	**Malic**	**Lactic**	**Citric**
Mean	1.36	2.14	3.02	4.75	27.44	3.02	20.74	3.07
Sx	0.06	0.09	0.13	0.20	1.17	0.13	0.88	0.13

	Maleic	**Fumaric**	**Succinic**	**Gibberellic**	**Salicylic**	**IAA**	**Abscisic**	
BW1	1.81	1.01	24.72	92.53	41.70	2.75	0.22	
BW2	1.93	1.07	26.37	98.70	44.48	2.94	0.23	
BW3	1.75	0.97	23.90	89.44	40.31	2.66	0.21	
BW4	1.85	1.03	25.31	94.73	42.70	2.82	0.22	
BW5	**1.96**	**1.09**	**26.72**	**100.02**	**45.08**	**2.98**	**0.23**	
BW6	1.83	1.02	24.96	93.41	42.10	2.78	0.22	
BW7	**1.71**	**0.95**	**23.31**	**87.24**	**39.32**	**2.60**	**0.20**	
BW8	1.82	1.01	24.84	92.97	41.90	2.77	0.22	
BW9	1.75	0.97	23.90	89.44	40.31	2.66	0.21	
BW10	1.90	1.06	26.02	97.37	43.89	2.90	0.23	
BW11	1.86	1.03	25.43	95.17	42.90	2.83	0.22	
BW12	1.84	1.02	25.07	93.85	42.30	2.79	0.22	
BW13	1.95	1.08	26.60	99.58	44.88	2.96	0.23	
	Maleic	**Fumaric**	**Succinic**	**Gibberellic**	**Salicylic**	**IAA**	**Abscisic**	**Maleic**
Mean	1.84	1.02	25.16	94.19	42.45	2.80	0.22	1.84
Sx	0.08	0.04	1.07	4.01	1.81	0.12	0.01	0.08

BW1: Es-26, **BW2:** Bezostaja-1, **BW3:** Müfitbey, **BW4:** Altay-2000, **BW5:** Sönmez-01, **BW6:** Soyer-02, **BW7:** Çetinel-2000, **BW8:** Harmankaya-99, **BW9:** Sultan-95, **BW10:** Alpu-01,**BW11:** Atay-85, **BW12:** **Özdemir, BW13:** Gerek-79

Butyric acid, breaks the root apical dormancy, caused by cytokinins and indirectly increases root productivity, increases root development for tolerance. In addition, butyric acid increases proline synthesis and promotes tolerance of the plant to the drought (Zolman et al., 2008). Malonic acid is an important organic acid for metabolic activity, which is formed mainly by acetyl coenzyme A carboxylase in plant roots, and its level varies depending on the amount of nitrogen in the body and nitrogen uptake. Malonics play an important role in lipid synthesis in plants. Malonic acid also increases the amount of stress accumulated as it increases its resistance to arid conditions by adjusting its osmotic potential in plants (Greene et al., 1993).

Table 4. Distribution of organic acids in maturity stage of bread wheat genotypes

	Oxalic	Propionic	Tartaric	Butyric	Malonic	Malic	Lactic	Citric
BW1	1.13	1.77	2.49	3.92	22.64	2.49	17.11	2.53
BW2	1.20	1.89	2.66	4.18	24.15	2.66	18.25	2.70
BW3	1.09	1.71	2.41	3.79	21.89	2.41	16.54	2.45
BW4	1.15	1.81	2.55	4.01	23.18	2.55	17.52	2.59
BW5	**1.22**	**1.91**	**2.70**	**4.24**	**24.48**	**2.70**	**18.50**	**2.74**
BW6	1.14	1.79	2.52	3.96	22.86	2.52	17.28	2.56
BW7	**1.06**	**1.67**	**2.35**	**3.70**	**21.35**	**2.35**	**16.14**	**2.39**
BW8	1.13	1.78	2.51	3.94	22.75	2.51	17.19	2.55
BW9	1.09	1.71	2.41	3.79	21.89	2.41	16.54	2.45
BW10	1.19	1.86	2.62	4.13	23.83	2.62	18.01	2.67
BW11	1.16	1.82	2.56	4.03	23.29	2.56	17.60	2.61
BW12	1.14	1.79	2.53	3.98	22.97	2.53	17.36	2.57
BW13	1.21	1.90	2.68	4.22	24.37	2.68	18.42	2.73
	Oxalic	**Propionic**	**Tartaric**	**Butyric**	**Malonic**	**Malic**	**Lactic**	**Citric**
Mean	1.15	1.80	2.54	3.99	23.05	2.54	17.42	2.58
Sx	0.05	0.08	0.11	0.17	0.98	0.11	0.74	0.11

	Maleic	Fumaric	Succinic	Gibberellic	Salicylic	IAA	Abscisic
BW1	1.52	0.84	20.77	65.66	35.03	2.05	0.24
BW2	1.62	0.90	22.15	70.04	37.37	2.19	0.26
BW3	1.47	0.82	20.07	63.47	33.86	1.98	**0.23**
BW4	1.56	0.86	21.26	67.22	35.86	2.10	0.25
BW5	**1.64**	**0.91**	**22.45**	**70.97**	**37.87**	**2.22**	**0.26**
BW6	1.53	0.85	20.96	66.28	35.36	2.07	0.24
BW7	**1.43**	**0.80**	**19.58**	**61.91**	**33.03**	**1.93**	**0.23**
BW8	1.53	0.85	20.86	65.97	35.20	2.06	0.24
BW9	1.47	0.82	20.07	63.47	33.86	1.98	**0.23**
BW10	1.60	0.89	21.85	69.10	36.87	2.16	0.25
BW11	1.56	0.87	21.36	67.53	36.03	2.11	0.25
BW12	1.54	0.86	21.06	66.60	35.53	2.08	0.24
BW13	1.64	**0.91**	22.35	70.66	37.70	2.21	0.26

	Maleic	Fumaric	Succinic	Gibberellic	Salicylic	IAA	Abscisic	Maleic
Mean	1.55	0.86	21.14	66.84	35.66	2.09	0.25	1.55
Sx	0.07	0.04	0.90	2.85	1.52	0.09	0.01	0.07

BW$_1$: Es-26, **BW$_2$:** Bezostaja-1, **BW$_3$:** Müfitbey, **BW$_4$:** Altay-2000, **BW$_5$:** Sönmez-01, **BW$_6$:** Soyer-02, **BW$_7$:** Çetinel-2000, **BW$_8$:** Harmankaya-99, **BW$_9$:** Sultan-95, **BW$_{10}$:** Alpu-01,**BW$_{11}$:** Atay-85, **BW$_{12}$: Özdemir, BW$_{13}$:** Gerek-79

Malic acid is a type of fruit acid found in plants and is an organic compound naturally found in fruits and vegetables. Malic acid is located in an important step of the Krebs cycle, the energy cycle in the mitochondria of living cells. Malic acid is metabolized by malic enzyme in mitochondria, and the formed malate acts as an important anion for K and Ca in the coarse state. This association act a significant osmotic regulation in the plant. The amount of this organic acid in plant increases with increasing drought stress (Egle et al., 2003). Lactic acid acts as a plant growth regulator in the low concentration in chlorophyll accumulation, root growth.

Again, lactic acid plays a role in inhibiting development at high concentrations. Lactic acid, which increases in abundance with drought, reduces growth, stimulates plant-regulating cycles against stress, osmotic conditioning, adjusts the volume for energy production, and increases the amount of stress in the environment (Iwasaki et al., 2011; Gupta et al., 2016). Citric acid is an organic acid that affects plant growth at low doses. Citric acid is the major component of the Krebs cycle from catabolic events that constitute three basic reactions, such as glycolysis, Krebs cycle and electron transport. Under stress conditions, plant growth and CO2 assimilation rate decrease due to increased citric acid level. In case of increase in citric acid level, due to an increase in antioxidant level, plant defense mechanism increases (Iwasaki et al., 2011). Maleic acid is an organic acid that regulates plant growth, particularly plant growth, mitigating biosynthetic activity, delaying cell growth, and preventing it. Depending on the osmotic stress, maleic acid, increased in the roots, can be released in the rhizosphere and can adjust the soil enzyme activity (Kravchenko et al., 2002; Cawthray, 2003). Fumaric acid is an important component of tricarboxylic acid and is obtained by fumarase enzyme activation from malate synthesis. By increasing water-soluble metabolites in stress conditions, it helps to prevent water loss and increase the resistance of the plant by providing osmotic balance of the plant, especially in the roots. In addition, since fumaric acid is a good antimicrobial, the level of fumaric acid is increased against increasing pathogenic attack (Song et al., 2012). Succinic acid is an organic acid that is important for plant growth and increases with developing plant (Kuiper et al., 2002).

Table 5. Distribution of organic acids in seed of bread wheat genotypes

	Oxalic	Propionic	Tartaric	Butyric	Malonic	Malic	Lactic	Citric
BW1	1.04	1.63	2.29	3.61	20.83	2.29	15.74	2.33
BW2	1.11	1.74	2.45	3.85	22.22	2.45	16.79	2.49
BW3	1.00	1.57	2.22	3.49	20.14	2.22	15.22	2.25
BW4	1.06	1.67	2.35	3.69	21.33	2.35	16.12	2.39
BW5	**1.12**	**1.76**	**2.48**	**3.90**	**22.52**	**2.48**	**17.02**	**2.52**
BW6	1.05	1.64	2.32	3.64	21.03	2.32	15.89	2.35
BW7	**0.98**	**1.54**	**2.16**	**3.40**	**19.64**	**2.16**	**14.84**	**2.20**
BW8	1.04	1.64	2.31	3.62	20.93	2.31	15.82	2.34
BW9	1.00	1.57	2.22	3.49	20.14	2.22	15.22	2.25
BW10	1.09	1.71	2.41	3.80	21.92	2.41	16.57	2.45
BW11	1.07	1.67	2.36	3.71	21.43	2.36	16.19	2.40
BW12	1.05	1.65	2.33	3.66	21.13	2.33	15.97	2.36
BW13	1.11	1.75	2.47	3.88	22.42	2.47	16.94	2.51
	Oxalic	**Propionic**	**Tartaric**	**Butyric**	**Malonic**	**Malic**	**Lactic**	**Citric**
Mean	1.05	1.66	2.34	3.67	21.21	2.34	16.03	2.37
Sx	0.04	0.07	0.10	0.16	0.90	0.10	0.68	0.10

	Maleic	Fumaric	Succinic	Gibberellic	Salicylic	IAA	Abscisic
BW1	1.40	0.78	19.10	71.51	32.23	2.13	0.17
BW2	1.49	0.83	20.38	76.27	34.38	2.27	**0.18**
BW3	1.35	0.75	18.47	69.12	31.15	2.06	0.16
BW4	1.43	0.80	19.56	73.21	33.00	2.18	0.17
BW5	**1.51**	**0.84**	**20.65**	**77.29**	**34.84**	**2.30**	**0.18**
BW6	1.41	0.78	19.29	72.19	32.54	2.15	0.17
BW7	**1.32**	**0.73**	**18.01**	**67.42**	**30.39**	**2.01**	**0.16**
BW8	1.41	0.78	19.19	71.85	32.38	2.14	0.17
BW9	1.35	0.75	18.47	69.12	31.15	2.06	**0.16**
BW10	1.47	0.82	20.10	75.25	33.92	2.24	**0.18**
BW11	1.44	0.80	19.65	73.55	33.15	2.19	0.17
BW12	1.42	0.79	19.38	72.53	32.69	2.16	0.17
BW13	**1.51**	0.84	20.56	76.95	34.68	2.29	**0.18**

	Maleic	Fumaric	Succinic	Gibberellic	Salicylic	IAA	Abscisic	Maleic
Mean	1.42	0.79	19.45	72.79	32.81	2.17	0.17	1.42
Sx	0.06	0.03	0.83	3.10	1.40	0.09	0.01	0.06

BW_1: Es-26, **BW_2:** Bezostaja-1, **BW_3:** Müfitbey, **BW_4:** Altay-2000, **BW_5:** Sönmez-01, **BW_6:** Soyer-02, **BW_7:** Çetinel-2000, **BW_8:** Harmankaya-99, **BW_9:** Sultan-95, **BW_{10}:** Alpu-01,**BW_{11}:** Atay-85, **BW_{12}: Özdemir, BW_{13}:** Gerek-79

Gibberellins are plant growth regulators which has a lot of activity related to growth such as breakdown of dormancy, cell division, acceleration of germination, elongation, growth, flower formation, fruit formation. Gibberellic acid are active in dividing and growing cells. Therefore, gibberellic acid, which is active in the development period of the plant in the condition of positive development, gives the signal of the next period in the plants under negative stress conditions, reducing the amount of the plant along with the decrease of the metabolic activities (Sponsel, 1995). In plants, salicylic acid has importance in the prolongation of the flowering period, inhibition of ethylene biosynthesis, seed germination, blockage of the response to injury, reversal of the abscisic acid effect. This acid also participates in the phenylpropanoid cycle and gives resistance of the plant to biotic and abiotic stresses (Rivas-San Vicente and Plasencia, 2011). Indole acetic acid plays a vital role in plant growth. Expressed on leaves, it is effective in cell growth and division, tissue differentiation, response to light, ethylene synthesis, fruit formation, flowering (Grunewald et al., 2009).

Absisic acid is synthesized in leaves and terminal buds and transplanted into other organs through the plant in the plant. Abscisic acid is highly effective on leaf shedding, slowing of plant growth, suspension of plant primer and secondary growth by inhibiting plant growth during winter season, protection of the plant from sickness, ensuring movement of the plant's defense systems against abiotic stresses. It is also effective in reduction of activity of photosynthesis related systems in plants, closure of stomata, transporting photosynthetic assimilates to seed and increasing the rate of synthesis of store proteins in seed. In the case of drought conditions, when plant roots succumb to water stress, the plant's defense system enters the system with the sign for ABA synthesis, which is routed through the roots to the leaves through xylem (Raven et al., 1992). Organic acids in bread wheat is formed significantly by genotype x environment interaction that make organic acids and therefore metabolic phenomena including photosynthetic activity, dry matter production in different level and efficiency during different developmental periods. Figure 1 shows changes of organic acids during different developmental periods.

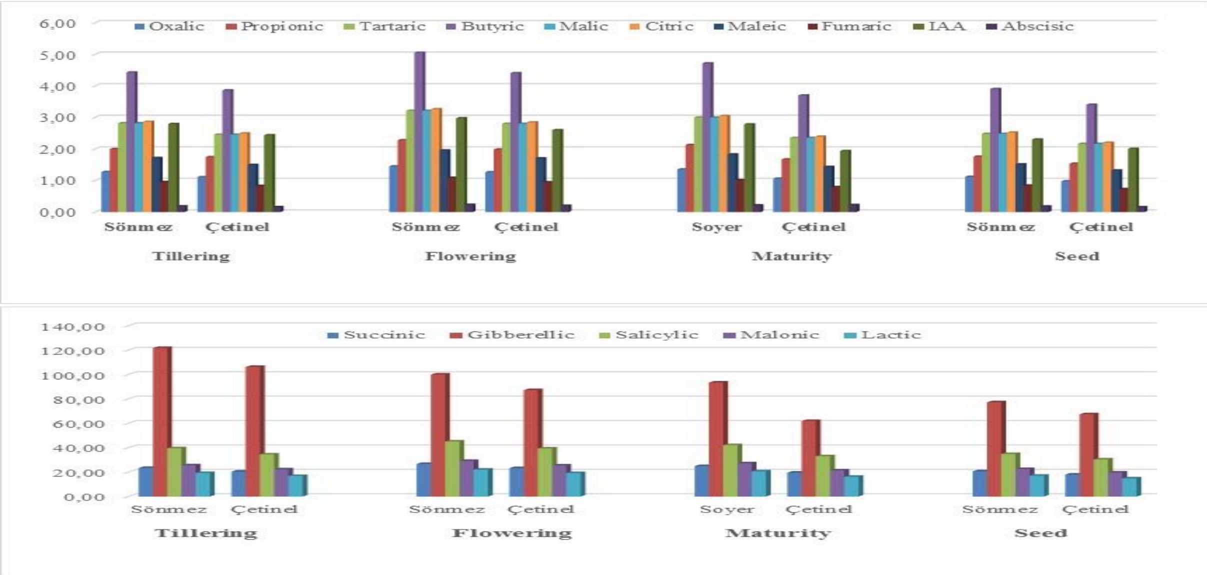

Figure 1. Changes of organic acids during different developmental periods in bread wheat genotypes

Level of organic acids start to increase from tillering to flowering then they go into a decreasing tendency and decreases in maturity and seed. Besides, double dendogram showing similarity groups of organic acids and development periods was given in Figure 2. Tillering and flowering stages constituted of separate groups, maturity stage and seed carved out one group. Organic acids formed three groups. Gibberellic acid had individual group, while salicylic acid, lactic acid, succinic acid and malonic acid joined same group. The other third group had oxalic acid, propionic acid, tartaric acid, butyric acid, malic acid, citric acid, fumaric acid, maleic acid indol acetic acid and abscisic acid.

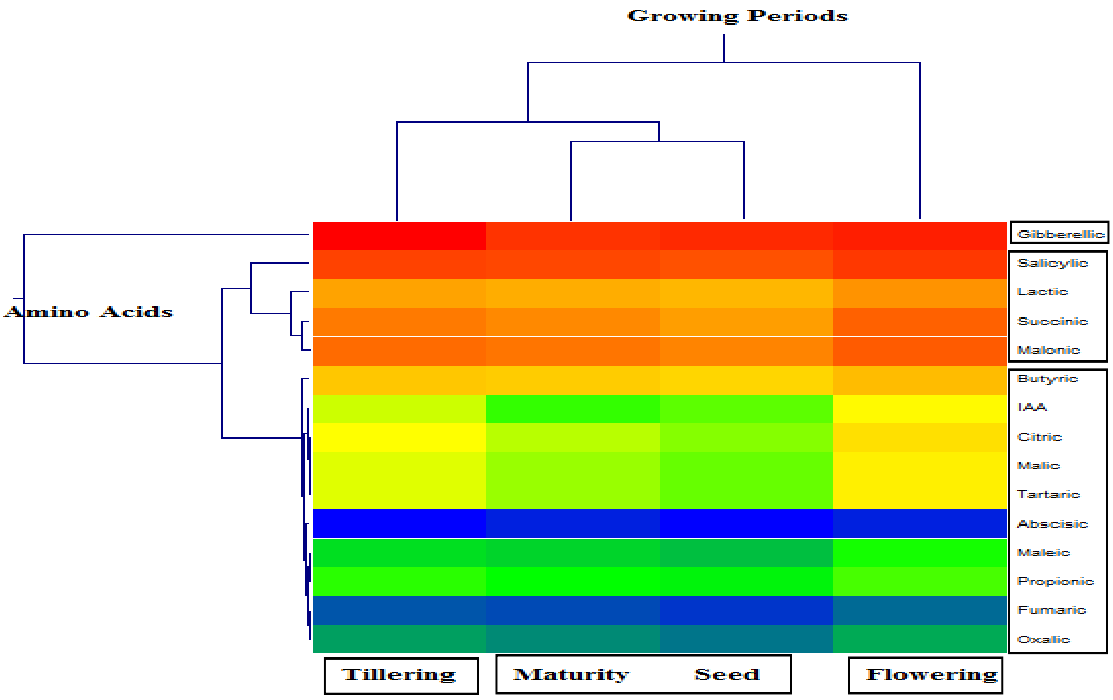

Figure 2. Double dendogram of organic acids and development periods

4. Conclusions and discussion

Results of study revealed that bread wheat genotypes and developmental stages have significant changes in organic acids. Great different levels in organic acids bread wheat genotypes means that they are acted in different intensity and level under genetic capacity and differences. Differences of organic acid levels in different growth stages shows that genotype x environment interaction monitors organic acid levels and metabolic processes in different development stages.

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