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DIFFERENT LAND USE INFLUENCES ON AMINO ACID, ORGANIC ACID, HORMONE AND MINERAL NUTRIENT CONTENTS OF DRY BEANS

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ABSTRACT

Dry bean (Phaseolus vulgaris L.) is a widely grown and important food legume which is a major source of mineral nutrition. The present study digs in determining differences in nutrients, organic-amino acid and hormone concentrations of Ispir bean genotypes under different land use conditions. The study sites (32 locations) were identified according to the stratified sampling method in the Ispir district, Erzurum, Turkey, under consideration of bean-cultivated lands and the number of villages. The seed weights were higher for genotype no. 4 (137.5 g) than for genotype no. 14 (131.5 g) and following by all other genotypes. Moreover, values for crude protein content were significantly higher for genotype no. 14 (263.1 g/kg) in comparison to genotype no. 4 (256.9 g/kg) and other genotypes. Therefore, it is concluded that land use impacts seed weight, nutrient, crude protein, amino acid, organic acid and hormone contents of Ispir dry bean. Land use can result economic improvements in crop yields and yield components. Dry bean seed weights were impacted by other crop yield components such as amino acid, organic acid and hormone contents of dry bean.

KEYWORDS:
Dry bean, amino acid, organic acid, hormone, nutrient element

INTRODUCTION

Crop proteins are the primary source of food proteins for humans and animals. Over 66% of these food proteins come from cereal and legume seeds. In addition to proteins, legume seeds provide a high proportion of carbohydrates, starch and fibers [1]. All essential amino acid compositions, amino acid imbalance, digestibility, biological availability of amino acids and anti-nutritional activity of certain seed components influence protein quality [2]. The predominant protein fraction in legume seeds consists of globulins (60-90%). Globulins are storage proteins rich in arginine, glutamic acid, aspartic acid and their amides. In general, legume seeds are rich in lysine, leucine and isoleucine but deficient in sulfur-containing amino acids such as methionine and cysteine [3]. However, tryptophan could become the next limiting amino acid in legume seeds with a small increase in one of these two amino acids. Methionine and cysteine deficiency might also be overcome, in part, by mixing legume seeds with cereal proteins [4]. Furthermore, legume seeds are also an important source of dietary minerals with the potential to provide all 15 essential minerals required by humans [5].

Preparation of legume seeds for human consumption invariably involves some rehydration and heating except for peanuts. Hydration results in softening and swelling while heating results in denaturation of proteins. Dry legume seeds are processed primarily to develop aroma and soften seeds. However, inactivation of anti-nutritional factors such as trypsin inhibitor and lectins present in raw seeds are more important reasons.

Dry bean (*Phaseolus vulgaris* L.) is the most widely grown and important food legume in the world for human nutrition and a major source of protein, potassium, calcium, iron, and phosphorus. It serves as a staple food for humans and can account for a significant proportion of daily caloric and nutrient intake. Therefore, it plays an important role in enhancing nourishment levels in several developing countries [6]. Dry bean has the third place in importance after soybean and peanut but actually the earliest in direct human consumption [7].

Dry bean is also one of the most important pulse crops in Turkey. It is currently grown on a scale of 94,625 ha land and its production amount to 200,673 tons [8]. Northeast Anatolia is one of the main contributors of common bean production in

Turkey. Dry bean is the most important crop grown in İspir, a district of the city of Erzurum, located in the Eastern Anatolia Region. Bean population varies in the district with white seeded types high in demand on the market. However, there is no information in the literature on the nutrient element contents, organic and amino acid compositions of Ispir dry bean genotypes. Thus, the aim of this work was to determine the differences in nutrient, organic acid and hormone contents and amino acid compositions in Ispir bean genotypes.

MATERIALS AND METHODS

Study sites. Study locations for the material collection were identified according to technical staff records of Ispir Provincial Directorate of Agriculture. Collection sites were selected according to the stratified sampling method considering the parts of the district where beans are cultivated and the number of villages in them. Seed materials were collected from 32 locations (Table 1). The altitudes of the region at which the samples were taken were determined by using a GPS instrument during the collection period. Therefore, 32 Ispir common bean genotypes were used for nutrient element, hormone, amino and organic acid analysis.

Amino acid analysis. One-gram fresh sample with addition of 0.1 N HCl, was homogenized with ultraturraks and incubated at 40 ^{0}C for 12 hours. Samples were then vortexed, centrifuged at 1200 rpm for 50 minutes and the supernatants were filtered through 0.22 µm filters (Millex Millipore). Then supernatants were transferred to glass vials and sent for HPLC analysis. Amino acids were extracted from the samples and analyzed [9-10].

The amino acid derivatives were analyzed with HPLC on a Zorbax Eclipse-AAA 4.6 x150 mm, 3.5 µm columns (Agilent 1200 HPLC). The samples were analyzed by measuring the absorbance at 254 nm and the amino acids were identified by comparing with standards. O-phthaldialdehyde (OPA), fluorenylmethyl-chloroformate (FMOC) and 0.4 N Borate were used for derivation processes in an auto sampler. The following were used as the mobile phase in the chromatography system: mobile phase A: 40 mM NaH2PO4 (pH 7.8) and mobile phase B: Acetonitrile/Methanol/Water (45/45/10. v/v/v) solutions. The flow rate of the mobile phase was 2 mL min^{-1} and the column temperature was 40^{0}C. Aspartate, glutamate, asparagine, serine, glutamine, histidine, glycine, threonine, arginine, alanine, tyrosine, cysteine, valine, methyl-nine, tryptophan, phenylalanine, isoleucine, leucine, lysine, hydroxyproline, sarcosine, proline quantities from PGPR samples were determined as pmol µl^{-1} after the 26-minute derivation process in HPLC.

TABLE 1
List of common bean genotypes collected from Ispir district of Erzurum

Number	Sample Code	Coordinate		
1	GM1	40^0 38’37.26’’K	41^0 09’34.78’’ D	Camlıkaya section
2	GM2	40^0 25’32.12’’K	41^0 09’25.45’’ D	Kuzullu section
3	GM3	40^0 28’03.52’’K	41^0 02’29.24’’ D	Halil Pasa Village
4	GM4	40^0 38’37.41’’K	41^0 09’34.70’’ D	Camlıkaya section
5	GM5	41^0 01’53.00’’K	41^0 25’51.09’’ D	Bıcakcı section
6	GM6	40^0 38’37.11’’K	41^0 09’38.24’’ D	Camlıkaya section
7	GM7	40^0 38’35.56’’K	41^0 09’33.90’’ D	Camlıkaya section
8	GM8	40^0 29’19.57’’K	41^0 00’29.59’’ D	Ispir MYO
9	GM9	40^0 38’28.43’’K	41^0 09’48.42’’ D	Muti section
10	GM10	40^0 56’23.75’’K	40^0 30’51.65’’ D	Elmali section
11	GM11	40^0 38’34.55’’K	41^0 09’32.99’’ D	Camlıkaya section
12	GM12	40^0 25’49.94’’K	40^0 58’16.83’’ D	Koprukoy
13	GM13	40^0 25’48.67’’K	40^0 58’15.84’’ D	Koprukoy
14	GM14	40^0 32’15.76’’K	41^0 08’35.65’’ D	Ispir
15	GM15	40^0 31’16.93’’K	41^0 03’17.85’’ D	Oztoprak
16	GM16	40^0 28’41.80’’K	40^0 59’52.41’’ D	Camlica section
17	GM17	40^0 24’54.60’’K	40^0 46’25.46’’ D	Pazaryolu
18	GM18	40^0 31’21.24’’K	41^0 11’12.10’’ D	Cicekli section
19	GM19	40^0 36’20.03’’K	40^0 59’12.73’’ D	Baskoy
20	GM20	40^0 32’18.40’’K	41^0 09’24.11’’ D	İspir
21	GM21	40^0 33’08.10’’K	41^0 04’17.20’’ D	Halil Pasa village
22	GM22	40^0 32’51.80’’K	41^0 11’21.22’’ D	Numanpasa
23	GM23	40^0 31’19.10’’K	41^0 03’15.40’’ D	Oztoprak
24	GM24	40^0 30’12.40’’K	41^0 07’42.10’’ D	İspir
25	GM25	40^0 31’27.40’’K	41^0 11’18.13’’ D	Cicekli section
26	GM26	40^0 28’24.40’’K	40^0 59’36.10’’ D	Camlıca section
27	GM27	40^0 31’20.12’’K	41^0 11’14.10’’ D	Cicekli section
28	GM28	40^0 38’25.40’’K	41^0 09’31.13’’ D	Asagı section
29	GM29	40^0 28’35.27’’K	40^0 59’58.10’’ D	Camlıca section
30	GM30	40^0 31’14.12’’K	41^0 03’10.40’’ D	Oztoprak
31	GM31	40^0 31’12.01’’K	41^0 03’12.21’’ D	Oztoprak
32	GM32	40^0 29’25.41’’K	4 0^0 58’47.13’’ D	Kusluca

Organic acid analysis. Deionized water (10 ml) was added to one gram of fresh bean and homogenized with an ultra-turraks. Supernatants were filtered through 0.22 µm filters (Millex Millipore) after the solution was centrifuged at 1200 rpm for 50 minutes. The supernatants then were transferred to glass vial and sent for HPLC analysis. The organic acids were analyzed by HPLC on Zorbax Eclipse-AAA 4.6 x 250 mm 5 µm columns (Agilent 1200 HPLC) and absorbance of 220 nm in UV detector. Flow rate was 1 ml/min and column temperature were 25 ^{0}C. Oxalic, propionic, tartaric, butyric, malonic, malic, lactic, citric, maleic, fumaric and succinic acids were determined by using 25 mM potassium phosphate (pH 2.5) as the mobile phase.

Hormone analysis. Extraction and purification processes were conducted [11-12]. The methanol (%80) was cooled to -40 ^{0}C and added to fresh samples. After the mixture was homogenized for 10 minutes with ultraturraks it was incubated for 24 hours in the dark. The samples were filtered with (Whatman No: 1) and then supernatants were filtered through 0.45 µm filters [13]. Supernatants were evaporated to dryness at 35^{0}C by evaporator pumps. Dried supernatants were solved using 0.1 M KH_2PO_4 (pH 8.0). Extracts were centrifuged at 5000 rpm for 1 hour at 40 ^{0}C to separate fatty acids [14]. One gram of polvinilpolipirilidon (PVPP) was prepared and added to supernatants to separate phenolic and colored matters [15-16-17-18]. A Sep-Pak C-18 (Waters) cartridge was used for further specific separation. Hormones adsorbed by the cartridge were transferred to vials using 80% methanol and analyzed by HPLC on a Zorbax Eclipse-AAA C-18 column (Agilent 1200 HPLC). The absorbance was measured at 265 nm in a UV detector. Flow rate was set to 1.2 ml/min and column temperature was set to 25 ^{0}C. Gibberallic acid, salicylic acid, indol-3-acetic acid (IAA), abscisic acid (ABA) were determined with 13% acetonitrile (pH 4.98) as the mobile phase.

Element Analysis. The Kjeldahl method and a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Ko-nigswinter, Germany) were used to determine the total N [19] and Ca, Mg, Na, K, P, S, Fe, Cu, Mn, Zn, Pb, Ni and Cd contents of dry bean. After wet digestion of dried and ground sub-samples with a HNO_3-H_2O_2 acid mixture (2:3 v/v) at three steps;

(i) first step: 145 ºC, 75% RF, 5 min,
(ii) second step: 180 ºC, 90% RF, 10 min and
(iii) third step: 100 ºC, 40% RF, 10 min)

in a microwave oven (Bergof Speedwave Microwave Digestion Equipment MWS-2) [20]. Ca, Mg, Na, K, P, S, Fe, Cu, Mn, Zn, Pb, Ni and Cd were determined using an Inductively Couple Plasma spectrometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT 06484-4794, USA) [21].

TABLE 2
Nutrient element contents of common bean genotypes collected from Ispir district of Erzurum (n=10)

Loc	N	P	K	Ca	Mg	Na	Zn	Cu	Mn	Fe	B	S	Cp	Ash	GW
							g/kg								
1	32.4	4.22	16.8	22.4	11.3	0.22	30.2	10.6	12.4	55.1	30.1	26.9	203	394	80.7
2	34.0	4.24	15.5	21.3	12.1	0.20	29.9	11.3	13.4	55.0	32.1	25.6	213	413	48.0
3	31.5	4.41	15.9	20.2	12.4	0.19	32.8	10.3	12.3	56.1	33.5	24.2	197	383	73.0
4	41.1	5.33	19.4	25.7	17.1	0.23	38.5	13.4	15.8	61.6	36.9	33.4	257	500	138
5	32.8	4.30	15.7	21.3	13.1	0.20	33.1	10.2	13.4	58.0	30.2	25.6	205	399	62.3
6	34.5	4.38	16.4	21.5	12.9	0.21	31.9	10.5	13.9	54.2	29.9	25.7	216	420	73.2
7	30.9	4.39	16.8	22.0	14.1	0.19	31.0	11.4	13.1	55.9	29.5	28.6	193	376	42.6
8	34.4	4.37	16.8	20.9	14.0	0.18	33.8	11.0	12.3	56.7	29.1	25.1	215	418	74.0
9	35.2	4.41	15.5	20.1	13.9	0.17	32.2	13.1	11.1	50.4	29.9	24.2	220	428	34.1
10	34.8	4.46	15.1	19.9	13.1	0.19	34.7	12.1	11.9	48.8	32.8	23.8	218	423	50.5
11	32.8	4.42	16.7	19.0	14.5	0.17	30.1	12.9	13.4	46.3	28.8	22.8	205	399	72.9
12	33.6	4.50	16.8	19.5	15.4	0.18	33.5	11.4	13.0	49.8	28.1	23.3	210	409	70.1
13	34.9	4.41	14.6	20.2	14.9	0.18	32.1	11.8	78.0	45.1	26.6	26.2	218	424	83.3
14	42.1	5.58	20.2	26.1	17.5	0.20	41.7	13.9	17.8	60.9	29.4	31.3	263	512	131
15	35.7	4.47	15.4	21.5	19.1	0.19	35.9	11.9	20.1	43.8	22.3	25.7	223	434	95.0
16	36.2	4.51	17.7	21.0	14.3	0.19	33.1	10.1	16.5	44.5	20.1	25.2	226	440	74.0
17	34.0	4.31	16.3	21.3	15.3	0.19	28.3	10.5	17.7	44.1	24.6	25.6	213	413	75.7
18	33.6	4.45	16.6	20.7	14.1	0.18	29.1	10.5	19.4	45.5	27.5	24.8	210	409	79.5
19	34.6	4.40	15.7	20.0	14.3	0.18	30.4	11.0	12.4	43.1	25.5	24.0	216	421	56.2
20	35.2	4.45	16.6	19.8	13.9	0.19	30.8	10.4	13.4	42.4	25.1	23.8	220	428	61.9
21	33.0	4.40	15.4	20.4	15.3	0.18	34.5	13.4	12.1	49.9	23.1	24.5	206	401	69.3
22	34.1	4.48	16.7	21.4	15.3	0.19	38.8	14.0	14.4	51.1	28.1	25.7	213	415	72.7
23	34.9	4.31	15.6	22.0	16.1	0.17	36.5	12.5	13.8	50.4	26.8	26.4	218	424	75.1
24	35.2	4.49	19.8	19.8	15.8	0.15	35.4	12.1	12.3	49.8	22.4	23.8	220	428	70.9
25	34.1	4.56	16.5	19.2	14.5	0.18	36.3	12.8	14.2	48.7	24.6	23.0	213	415	48.3
26	34.9	4.52	17.2	20.4	16.3	0.15	32.2	12.2	13.9	49.1	24.9	24.5	218	424	57.9
27	35.2	4.60	16.6	21.7	15.4	0.20	34.6	19.8	16.3	48.3	26.3	26.0	220	428	69.1
28	36.1	4.48	15.8	21.4	17.5	0.19	35.1	14.4	15.4	49.2	25.4	25.7	226	439	86.8
29	35.3	4.61	16.4	20.2	18.1	0.21	36.4	13.2	14.0	45.8	29.3	24.2	221	429	74.2
30	35.8	4.46	17.4	21.3	17.7	0.21	31.0	15.3	16.6	44.3	29.8	25.6	224	435	76.1
31	40.3	4.67	17.0	22.1	20.2	0.19	37.4	15.1	16.7	44.4	28.7	26.5	252	490	84.8
32	39.7	4.86	18.3	21.8	19.6	0.20	36.3	14.0	15.0	48.2	26.8	28.4	248	483	91.3

Loc: Locations, Cp: Crude protein, GW: 100 Grain Weight, N: Nitrogen, P: Phosphorus, K: Potassium, Ca: Calcium, Mg: Magnesium, Na:Sodium, Zn: Zinc, Cu: Cupper, Mn: Manganese, Fe: Iron, B: Boron, S: Sulfur

Statistical Analysis. A statistical analysis was set to determine land use influences on selected properties by using the Duncan method in analysis of variance with SPSS package [22]. The level of significant differences was established to be at $P<0.05$.

RESULTS AND DISCUSSION

Seed weight of dry bean. The seed weight of the bean genotypes was tabulated in Table 2. The seed weight of the genotypes varied within the wide range from 34.07 to 137.47 g. The seed weight was highest in genotype no. 4 (137.47 g) followed by genotype no. 14 (131.51 g) with differences observed in terms of seed weight among other genotypes. These study results showed that seed weight/crop significantly varied depending on different land uses. These results are supported by different studies under different land use conditions Mokhtar [23-24-25].

Macro and micro nutrient contents of dry bean. Crude protein and mineral concentrations of the bean genotypes are presented on Table 2. Crude protein content of the genotypes varied within the wide range from 193.1 g/kg to 263.1 g/kg. The crude protein content was the highest in genotype no. 14 (263.1 g kg^{-1}) followed by genotype no. 4 (256.9 g kg^{-1}) and genotype no. 31 (251.9 g kg^{-1}). Differences were observed among genotypes in the mineral concentrations. Similar findings were also reported by different experiments [26-27-28]. These researchers found significant correlations between genotype and seed mineral nutrient contents. The amount of nutrient per seed is an important measure of macro and micro nutrients supply in grain [29]. Concentration of macro and micro nutrients in seed depends on soil type, nutrient availability, genotypes, season and cultivars [30]. The variations among cultivars in the mineral composition can be attributed to varying genetic constitutions [31-32].

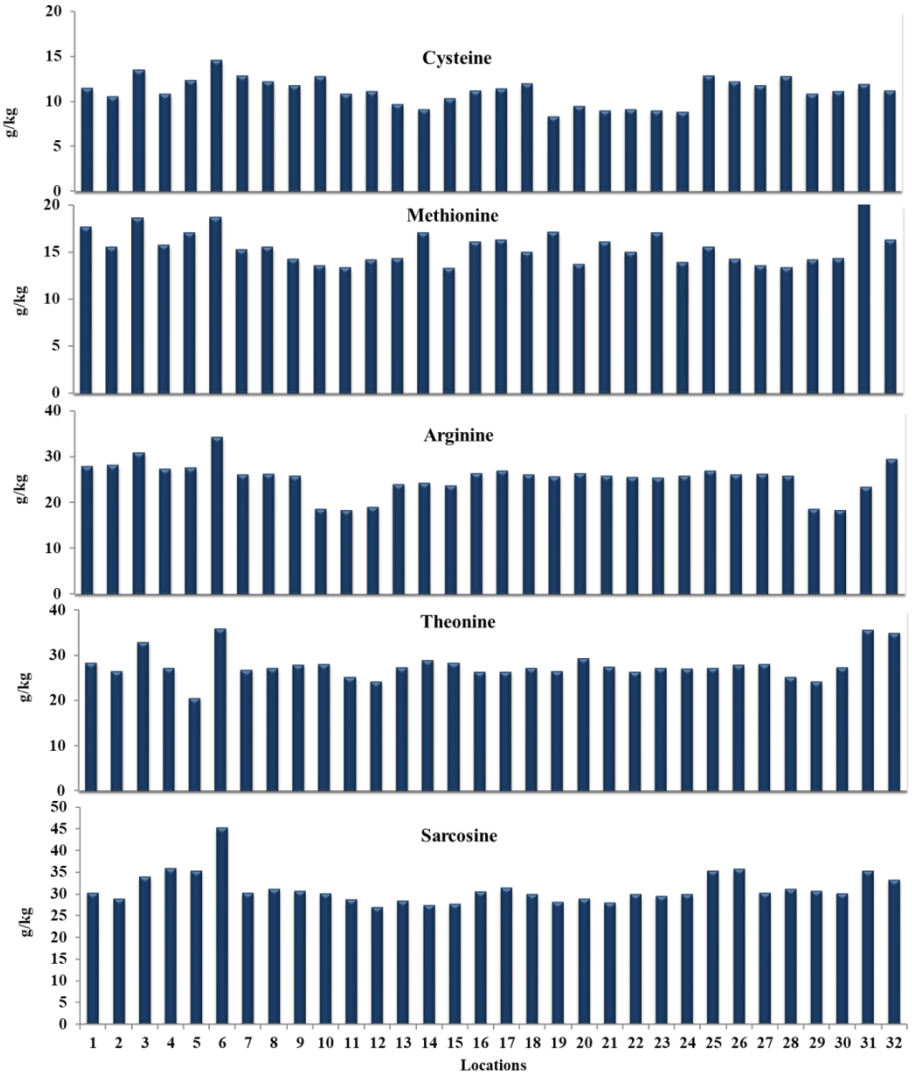

FIGURE 1A
Some amino acid contents of common bean genotypes collected from İspir district of Erzurum (n=10).

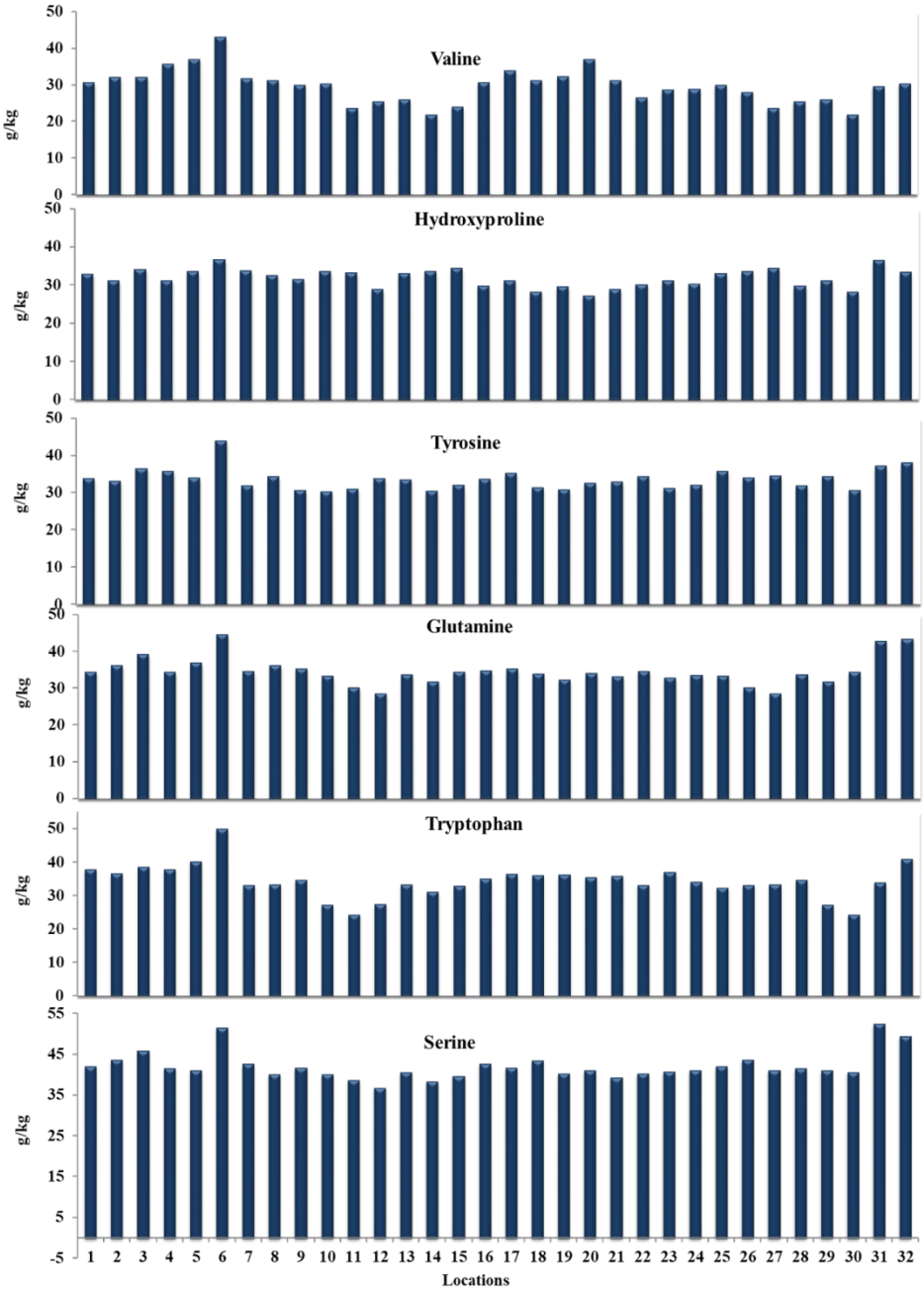

FIGURE 1B
Some amino acid contents of common bean genotypes collected from İspir district of Erzurum (n=10).

Amino acids contents of dry bean. Considerable differences were observed among bean genotypes in terms of amino acid compositions. Overall aspartate, glutamate, isoleucine, leucine and lysine were the most abundant amino acids whereas all genotypes were deficient in methionine and cysteine. In general, the highest amino acid concentrations were detected in genotype no. 6. On the other hand, most of the amino acids were also high in genotype no. 3, genotype no. 31 and genotype no. 32. Methionine and cysteine which are deficient amino acids in legume seeds, changed among genotypes. The range of methionine and cysteine contents of bean genotypes were from 13.18 to 20.88 g kg^{-1} and 8.79 to 14.50 g kg^{-1}, respectively (Figure 1.a). Methionine content was the highest in genotype no. 31 (20.88 g kg^{-1}), followed by genotype no. 6 (18.59 g kg^{-1}) and genotype no. 3 (18.51 g kg^{-1}). Similarly, the cysteine content was higher in genotype no. 6 (14.50 g kg^{-1}), followed by genotype no. 3 (13.42 g kg^{-1}).

Amino acids presence in the medium may promote shoot production through the differentiation of dividing cells. Exogenous amino acids can modulate membrane permeability and ion uptake, and this may be the major component by which amino acids help mitigating drought or salt stress effects [33].

This study shows that growing dry bean under different cultivation conditions leads to high level of

amino acid contents. Therefore, amino acid production in the dry bean can be said to benefit plant growth. Similar findings were reported in previous studies showing that these amino acids may contribute to yield, growth and nutrient element uptake from soil in different plant species under stress plant growth conditions for different crops. Proline, alanine, serine, and asparagine also delayed wilting of maize under stress conditions. Proline, glycine, alanine, leucine, threonine, lysine, arginine, tryptophan and phenylalanine inhibited stomatal opening while histidine, methionine, aspartic acid, glutamic acid, asparagine and glutamine promoted stomatal opening of Viciafaba. Histidine, proline, glutamine, methionine and glycine promoted calcium uptake in Pharsalus seedlings (Figures 1.b, 1.c, and 1.d). Proline relieved salt toxicity in barley plant lets by changing salt transport from root to shoot. Increasing proline content increased K^+ content and alleviated salt stress effects on growth of Vigna radiate cultures [34-35-36-37].

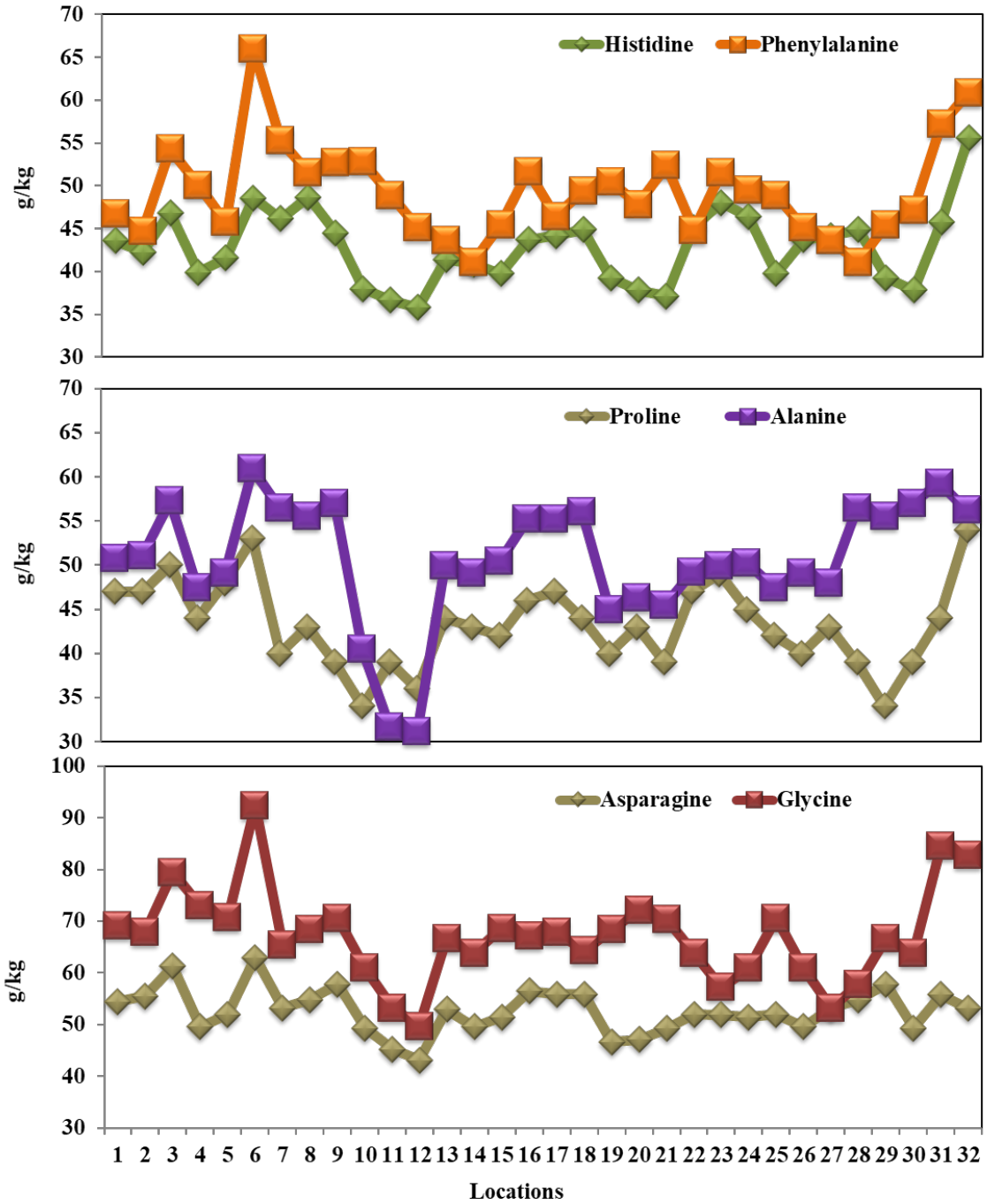

FIGURE 1C
Some amino acid contents of common bean genotypes collected from İspir district of Erzurum (n=10).

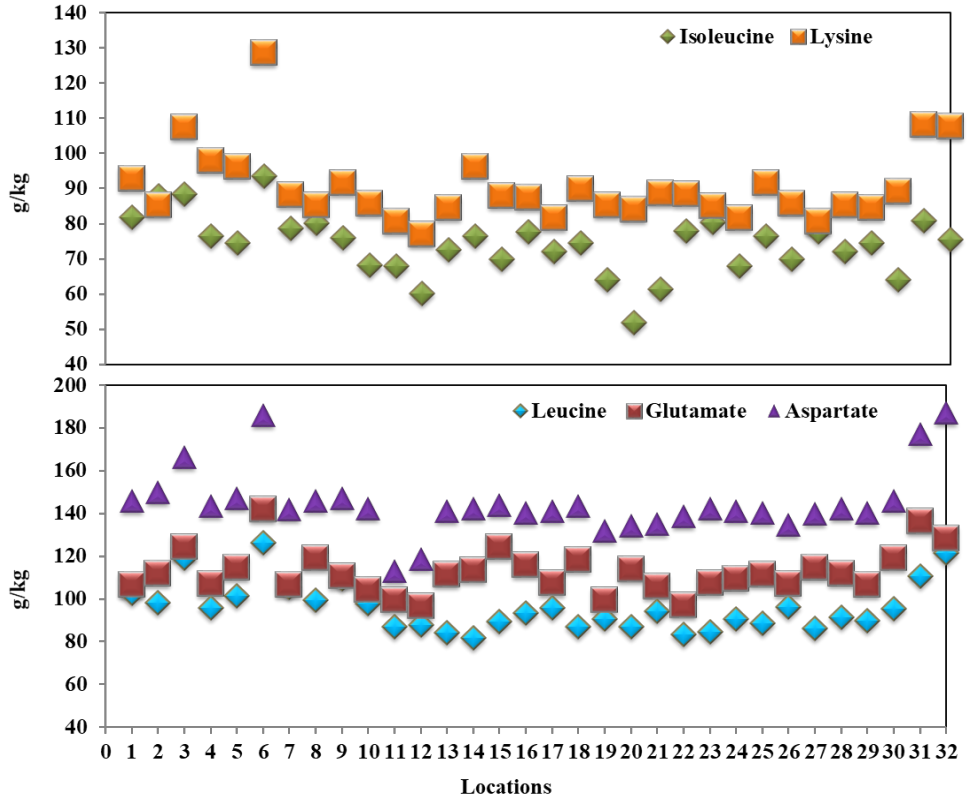

FIGURE 1D
Some amino acid contents of common bean genotypes collected from İspir district of Erzurum (n=10).

TABLE 3
Organic acid contents of common bean genotypes collected from Ispir district of Erzurum (n=10).

	Oxalic	Propionic	Tartaric	Butyric	Malonic	Malic	Lactic	Citric	Maleic	Fu-maric	Succinic
	----------	----------	----------	----------	----------	*Ng/µl*	----------	----------	----------	----------	----------
1	6.89	6.60	1.84	2.48	4.92	5.21	6.91	4.35	0.29	1.74	8.90
2	6.20	5.94	1.80	2.44	4.82	5.79	7.06	4.57	0.25	1.98	9.12
3	6.78	5.51	1.79	2.49	5.01	5.70	6.64	4.26	0.28	1.80	9.69
4	6.48	6.12	1.85	2.09	4.33	5.31	5.59	3.56	0.41	1.52	7.60
5	6.61	6.35	2.03	2.17	4.65	5.41	6.27	3.68	0.31	1.56	8.25
6	6.77	6.31	1.81	1.98	4.47	5.09	5.94	3.22	0.44	1.40	8.62
7	7.35	7.07	3.08	2.63	5.29	4.74	7.53	3.70	0.28	1.78	9.91
8	6.66	6.23	3.25	2.54	5.54	4.89	7.04	3.93	0.23	2.02	10.57
9	7.05	6.82	3.01	2.68	6.03	5.10	8.06	3.96	0.28	2.52	12.51
10	7.52	6.94	2.91	2.63	6.22	5.79	7.72	4.26	0.22	2.50	11.80
11	7.61	6.71	2.38	2.47	6.16	5.96	7.46	4.20	0.65	2.19	14.18
12	8.19	7.79	2.21	2.42	6.48	5.87	8.27	3.89	0.71	2.13	13.57
13	7.27	7.15	3.15	2.87	5.52	5.56	6.57	5.11	0.22	1.97	10.57
14	6.57	6.31	3.33	2.78	5.68	5.81	6.09	5.43	0.17	2.20	11.22
15	5.74	6.54	3.16	2.60	5.38	5.64	7.83	5.55	0.20	2.31	11.02
16	5.95	5.46	2.32	2.38	4.31	5.11	6.39	3.78	0.32	1.51	10.09
17	6.59	5.80	3.18	2.52	4.41	5.32	6.73	3.85	0.33	1.64	13.10
18	6.82	5.64	2.94	2.19	4.45	4.95	7.20	3.44	0.35	1.70	10.24
19	7.08	6.68	2.25	2.52	5.42	5.14	7.08	4.17	0.39	2.10	13.11
20	6.39	5.84	2.42	2.43	5.67	5.29	6.59	4.39	0.31	2.33	14.19
21	7.02	6.99	2.38	2.31	5.48	5.81	7.38	3.84	0.41	2.50	14.79
22	7.37	7.54	2.72	1.99	5.05	7.14	8.30	4.96	0.54	2.12	14.84
23	7.79	6.82	2.53	2.19	5.05	6.36	8.51	5.12	0.47	1.95	15.58
24	7.59	7.32	2.62	2.41	5.19	6.60	7.75	5.23	0.57	2.12	15.43
25	7.83	6.82	2.38	2.54	4.65	5.79	6.57	4.89	0.32	2.02	13.31
26	7.35	6.94	2.21	2.68	4.47	5.96	6.09	5.02	0.33	2.52	10.45
27	7.24	6.71	3.15	2.63	5.29	5.87	7.83	5.11	0.35	2.50	11.34
28	7.05	7.79	3.33	2.47	5.54	5.56	6.39	5.43	0.39	2.19	11.84
29	7.52	7.15	3.16	2.42	6.03	5.81	6.73	4.90	0.31	2.13	13.62
30	7.61	6.31	2.32	2.87	6.22	5.64	7.20	4.13	0.41	1.97	12.35
31	7.43	6.54	3.18	2.78	6.16	5.11	7.08	4.45	0.54	2.20	12.51
32	7.27	5.46	2.94	2.60	6.48	5.32	6.59	4.02	0.47	2.31	11.80

Organic acid contents of dry bean. As seen on the Table 3, succinic, oxalic, lactic and propionic acids were the most abundant whereas maleic and fumaric acids were the scarcest. Organic acid content of the genotypes varied within a wide range. Most of the organic acids were high in genotype no. 10, 11, 12, 21, 22, 23, 24, 29 and 31, and low in genotype no. 1, 2, 3, 4, 5, 6, 16 and 18. However, in some genotype, certain organic acids were high while some others were low. For example, genotype no. 14 had the highest tartaric acid but the lowest maleic acid. Similarly, genotype no. 15 had the highest citric acid but the lowest oxalic acid. Similar results were also observed in genotype no. 13, 17, 22, 23, 26 and 32.

Organic acids have a potential role as metabolically active solutes for the osmotic adjustment and the balance of cation excess in the plant. Organic acids also participate as key components in the mechanisms, by which some plants use to cope with nutrient deficiencies, metal tolerance and plant-microbe interactions operating at the root-soil interface. Because of its high affinity for di- and tri-valent cations, citrate and other organic acids can displace P from insoluble complexes making it more soluble and thus available for plant uptake and stimulating nitrate uptake of plant [38-39].

Acetic acid, glycolic, malonic, oxalic, formic, and acidic acid each plays a crucial role in nutrient acquisition (P, Fe and Mn) by plants growing in low nutrient soils, and their release in response to nutrient starvation differs between plant species [40-41]. Similarly, these acids can desorb P from sesquioxide surfaces with anion exchange [42-43] and also maintain sulfate mobility in rhizosphere soil through competitive displacement from adsorption sites [44]. The concentrations of fumaric, malic and citric acids can also chelate Fe and Mn in iron and manganese oxides (i.e. Fe_2O_3 and MnO_2) thus making them available for uptake by the plant [45].

Hormone contents of dry bean (*Phaseolus vulgaris* L.). Significantly differences were observed among bean genotypes in terms of hormone content (Table 4). Gibberellic acid content of the genotypes ranged from 239.2 ng μl^{-1} to 331.2 ng μl^{-1}. The highest gibberellic acid contents were determined in genotype no. 11, 12, 16, 17, 18, 22, 23 and 24 whereas genotype no. 3, 20, 21 and 25 had the lowest gibberellic acid contents. The amount of salicylic acid, which was the second abundant hormone following gibberellic acid, significantly varied among bean genotypes. Genotype number 26, 27 and 28 had higher salicylic acid content than those of the other genotypes. The indole acetic acid content of the genotypes also varied within the wide range from 11.01 ng μl^{-1} to 16.27 ng μl^{-1}. The amount of indole acetic acid was high in genotype no. 9, 13, 15, 25,

TABLE 4
Hormone contents of common bean genotypes collected from Ispir district of Erzurum (n=10). Ng/µl

	Gibberellic Acid	Salicylic Acid	Absisic Acid	Indole acetic Acid
		----------*Ng/µl*----------		
1	264	81.6	0.12	12.9
2	254	84.2	0.14	12.3
3	239	87.2	0.12	13.4
4	274	92.8	0.12	13.5
5	288	89.6	0.12	12.7
6	296	88.5	0.14	11.8
7	294	91.1	0.09	14.6
8	297	82.4	0.11	13.8
9	286	98.7	0.07	16.3
10	289	93.4	0.09	14.7
11	303	88.8	0.16	14.3
12	331	96.7	0.15	12.6
13	290	92.7	0.11	15.0
14	274	95.5	0.1	13.8
15	266	90.5	0.1	15.3
16	319	114.0	0.11	13.8
17	323	122.1	0.16	14.6
18	311	134.5	0.12	11.0
19	264	130.1	0.11	11.9
20	243	120.7	0.09	13.5
21	239	117.2	0.1	13.6
22	304	116.5	0.13	14.2
23	318	122.5	0.16	12.3
24	329	114.8	0.14	14.4
25	239	116.7	0.16	15.0
26	274	153.1	0.15	13.8
27	288	156.3	0.11	15.3
28	296	168.8	0.1	13.8
29	294	109.7	0.1	14.6
30	297	108.7	0.11	11.0
31	286	107.1	0.16	11.9
32	289	115.4	0.12	13.5

and 27 and low in genotype no. 18, 30, 6, 19 and 31. Absisic acid content of the genotypes ranged between 0.07 ng/μl (genotype no. 9) to 0.16 ng μl^{-1} (genotype no. 11, 17, 23, 25 and 31).

Indol-3-acetic acid, a main auxin in plants, is known to control many important physiological processes of plants such as cell enlargement, cell division, root initiation, growth rate, phototropism, geotropisms and apical dominance etc. [46]. In plant cells, IAA is formed by de novo synthesis from tryptophan that undergoes either oxidative deamination or decarboxylation with indole-3-acetic aldehyde as an intermediate. Indole-3-acetic acid (IAA) controls a wide variety of processes in plant development, also control many important physiological processes of plants such as cell enlargement, cell division, root initiation, growth rate, phototropism, geotropisms and apical dominance, etc. and plays a key role in shaping plant root architecture as the regulation of lateral root initiation, root vascular tissue differentiation, polar root hair positioning, root meristem maintenance and root gravitrophism [46-47-48].

Cytokines stimulate plant cell division, control root meristem differentiation, inhibit primary root elongation and lateral root formation but can promote root hair development [49]. Gibberellins enhance the development of plant tissues, particularly stem tissue and promote root elongation and lateral root extension [50]. Similar studies have shown that under different stress conditions, plant nutrient content, amino acid, organic acid, and hormone amount change [51-52-53].

This study show that cultivars affect seed weight, nutrient, crude protein, amino acid, organic acid and hormone contents of dry bean in İspir, Erzurum, Turkey. Cultivar selection can improve the economic yield and directly influence yield components.

Different cultivar conditions were caused by variations in seed weight, crude protein and nutrient contents. Seed weight of dry bean was affected by other components of yield parameters. However, probability in the variations of seed weight and yield parameters were affected by amino acid, organic acid and hormone contents of dry bean.

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