*Asian Journal of Chemistry* Vol. 20, No. 7 (2008), 5601-5613

# Effects of Sowing Dates and Cultivars on Protein and Mineral Contents of Bean (*Phaseolus vulgaris* L.)

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Six bean cultivars were grown at four different sowing dates for two years to study the effects of sowing date, genotypic and growing seasons on protein and mineral contents. The protein and mineral contents of bean are influenced by growing seasons, sowing date and genetic factors. This study investigated differences in protein and mineral contents in grains of six bean (*Phaseolus vulgaris* L.) cultivars. Protein content ranged 21.40-27.29 %, phosphorus 570.00-796.59 mg/100 g, potassium 1856.40-2159.24 mg/100 g, magnesium 174.56-197.95 mg/100 g, calcium 120.06-182.65 mg/100 g, sodium 45.57-51.89 mg/100 g, iron 6.50-8.41 mg/100 g and zinc 1.69-2.27 mg/100 g, respectively with significant differences among bean cultivars. The effects of years, sowing date, cultivars, year × cultivars interaction, year × sowing date interaction, cultivars × sowing date interaction and year × cultivars × sowing date interaction were highly significant, but the variation was mainly attributed to the environment and sowing date. In general, protein, phosphorus, potassium, calcium, sodium and iron content increased with delayed sowing. Unlike, the zinc content decreased with delayed sowing.

**Key Words: Sowing, Bean, Protein and Mineral contents.**

## INTRODUCTION

Bean (*Phaseolus vulgaris* L.) is grown extensively in most regions of the world and is an important source of dietary protein, vitamins, nutrients and fiber[1]. Worldwide increases in bean production have been insufficient to counter the continued rise in world population[1]. Today, more people from under-developed countries are relying on beans to satisfy their basic nutritional needs, while more people from developed countries are increasing their intake of beans to increase the quality of their diets[2]. Its high protein content is particularly important for prevention of protein malnutrition

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resulting from the cereal-based diets of people living in the under develop and developing country. The availability of protein to people living in these country could be enhanced by increasing supplies of food legumes (such as bean) rather than by organizing costly feeding programmes based on protein-rich animal foods.

Mineral element composition of legume seeds is distinctive when compared to other food of plant origin[3]. The contents of nickel and iron in legume seeds are higher while contents of manganese are somewhat lower than those in cereal grains. Amounts of phosphorus, zinc and copper are comparable in both groups[3]. Nowadays, dietary minerals are receiving attention for their usefulness in prevention of several diseases. These major minerals (such as Ca, P, Mg, S, K, Cl and Na) which are structural components of tissues and function in cellular and basal metabolism and water and acid-base balance[4] trace (minor) minerals (such as Zn, Mn, Cu, Fe and I) which are very important for vitamin, hormone and enzyme activity.

Concentration is a more important measure of micronutrient supply in grain destined for human food than micronutrient content[5]. As seed develops on the parent plant, concentration of nutrients in seed is dependent on soil type, nutrient availability, crops species and to a lesser extent, season and cultivars[6]. Environmental conditions, genetic variations and soil type exert significant influences on the chemical composition of legume seeds have been reported[7-9]. Most of the published studies were conducted on the effects of genotypes on mineral content in bean[9,10]. But there are only a few studies on effects of sowing date on mineral content of bean. This work attempts to contribute to this lack of knowledge about the effects of sowing date on the mineral composition of bean.

## EXPERIMENTAL

The study was conducted at Cumra Research Farm of the Agricultural College in the Central Anatolia (Turkey) in 2000 and 2001 growing seasons were used in all laboratory experiments. The experiment was arranged in split plot design four main plots (sowing dates) each was split for three sub-plots (genotypes), with three replications for the 2000 and 2001. Sehirali-90, Karacasehir, Akman-98, Göynük-98, Önceler-98, Yunus-90 cultivars were used as genetic materials. Genotypes were supplied by the Anatolia Agriculture Research Institute. They were sown at following four dates starting from 24 April (first), 2 May (second), 9 May (third) and 16 May (last) in 2000 and 26 April, 3 May, 17 May and 22 May in 2001. Time of sowing was arranged by the climatically conditions of each season.

**Sample preparation:** After harvest, bean genotypes samples were prepared for each plot. The seeds were cleaned manually to remove all foreign matter such as dust, stones and chaff as well as immature, broken

seeds. Before analysis, initial moisture content of bean genotypes were determined by using a dry air heated oven at 105 ± 1 ºC for 24 h on a 50 g bean sample[11].

**Determination of protein and mineral contents**

**Protein content:** Protein content was determined according to Kjeldahl method[12] using *ca.* 1.0 g of ground seeds. Kjeldahl nitrogen values were multiplied by 6.25 to obtained crude protein values.

**Mineral content:** About 0.5 g dried and ground sample was put into a burning cup and 15 mL pure $HNO_3$ was added. The sample was incinerated in a MARS 5 Microwave Oven at 200 ºC temperature and a solution diluted to certain volume with distilled water. Mineral concentrations were determined by ICP-AES[13] (Varian-Vista Model). These values were expressed as mg/100 g dry matter.

## RESULTS AND DISCUSSION

Protein and mineral contents of bean cultivars obtained from four sowing date in two years showed a wide range for most parameters. This is probably as a result of the diversity of bean cultivars, distinct differences in terms of climatic conditions in the growing seasons and sowing date.

The results of statistical analysis showed highly significant difference between years ($p < 0.01$). Protein content was 23.35 and 24.02 % during 2000 and 2001, respectively. The differences between sowing dates ($p < 0.01$) were also significant. The highest protein content (23.82 %) was obtained when sown on May 04. Protein contents ranged from 23.37 to 23.82 % in the sowing dates (Table-1). The differences between sowing dates × year interactions ($p < 0.01$) were also significant. The highest protein content (23.82 %) was obtained when sown on May 04. Protein composition is subjected to fluctuations, depending on various factors like cultivar and maturity stage, environment (mostly weather conditions), agrotechnics and others[14]. In general, early sowing did not the highest protein content, all cultivars except for Karacasehir performed better with delayed sowing. Ceyhan and Önder[9] demonstrated that the protein content of pea decreases as seed yields increased, in general. In this study, seed yield decreased significantly with delayed sowing (data not shown). These results are in agreement with Ceyhan and Önder[9]. There was significant sowing date × cultivar interaction ($p < 0.01$) for protein content. The highest protein content (28.90 %) was obtained from the Karacasehir with first sowing date (Table-1).

Analysis of variance for protein content showed differences at the $p < 0.01$ probability level among cultivars. Protein content is a varietal characteristic that can be strongly influenced by genotypes, sowing date, soil composition

TABLE-1
PROTEIN CONTENT (%) OF BEAN CULTIVARS WHEN GROWN IN TWO CONSECUTIVE YEARS WITH FOUR SOWING DATE

| Year | Cultivars | Sowing dates | | | | |
|---|---|---|---|---|---|---|
| | | April 28 | May 04 | May 09 | May 16 | Mean |
| 2000 | Sehirali 90 | 21.56 s-u | 22.07 p-s | 22.45 o-q | 22.21 o-r | 22.07 h |
| | Karacasehir | 28.98 a | 28.49 a | 26.75 c | 26.39 c | 27.65 a |
| | Akman 98 | 22.63 o | 23.21 n | 23.67 j-n | 24.08 h-k | 23.40 e |
| | Göynük 98 | 20.19 w | 21.26 uv | 24.17 h-j | 22.32 o-q | 21.98 h |
| | Öncüler 98 | 20.82 v | 21.30 uv | 21.69 r-u | 21.58 s-u | 21.35 i |
| | Yunus 90 | 21.41 tu | 23.79 j-m | 23.28 mn | 21.94 q-t | 22.61 g |
| | Mean | 22.60 e | 23.35 c | 23.67 b | 23.09 d | 23.35 |
| 2001 | Sehirali 90 | 23.68 j-n | 23.56 k-n | 25.31 de | 25.18 d-f | 24.43 c |
| | Karacasehir | 28.82 a | 27.73 b | 25.49 d | 25.65 d | 26.92 b |
| | Akman 98 | 23.57 k-n | 23.89 i-l | 24.00 h-l | 24.49 gh | 23.99 d |
| | Göynük 98 | 22.59 op | 23.57 k-n | 23.48 l-n | 22.35 o-q | 23.00 f |
| | Öncüler 98 | 21.41 tu | 21.62 s-u | 21.18 uv | 21.57 s-u | 21.44 i |
| | Yunus 90 | 24.78 fg | 23.50 l-n | 24.34 g-i | 24.77 fg | 24.35 c |
| | Mean | 24.14 a | 23.98 a | 23.97 a | 24.00 a | 24.02 |
| Mean of years | Sehirali 90 | 22.62 ij | 22.82 hi | 23.88 e | 23.69 ef | 23.25 d |
| | Karacasehir | 28.90 a | 28.11 b | 26.12 c | 26.02 c | 27.29 a |
| | Akman 98 | 23.10 gh | 23.55 ef | 23.83 e | 24.28 d | 23.69 b |
| | Göynük 98 | 21.39 kl | 22.41 j | 23.82 e | 22.33 j | 22.49 e |
| | Öncüler 98 | 21.11 l | 21.46 kl | 21.43 kl | 21.58 k | 21.40 f |
| | Yunus 90 | 23.10 gh | 23.65 ef | 23.81 e | 23.35 fg | 23.48 c |
| | Mean | 23.37 c | 23.67 ab | 23.82 a | 23.54 b | |

$LSD_{\%0.01}$[a]: C = 0.1662, C ×Y = 0.2294, S = 0.1540, S × Y = 0.2178, S × C = 0.3773, S × C × Y = 0.5336

[a]Least significant difference for comparisons between individual means: C; S; C × Y; S × Y; S × C; S × C × Y indicate cultivars main effect (C), sowing date main effect (S), interaction of year with cultivars (C × Y), interaction of year with sowing date (S × Y), interaction of sowing date with genotype (S × C), interaction of year with sowing date and cultivars (S × C × Y).

and growing seasons[15]. Protein content ranged from 21.40 % for Öncüler-98 to 27.29 % for Karacasehir (Table-1). Variations between the cultivars may result from genetic differences as reported by Ceyhan[11]. There were significant difference ($p < 0.01$) for protein content between years and cultivars. Karacasehir was the highest protein content with 27.65 % in 2000 growing seasons. Year × sowing date × cultivar interaction ($p < 0.01$) was statistically significant; the highest protein content (28.98 %) was obtained from Karacasehir with first sowing date in 2000 growing seasons (Table-1). These results agree with the results of Akcin[16], Akdag[17], Anlarsal *et al.*[18] and Ceyhan[11].

The results of statistical analysis showed highly significant difference between years ($p < 0.01$). Phosphorus content was 679.72 mg/100 g in 2000 and 691.84 mg/100 g in 2001. The main effects of sowing dates were also significant ($p < 0.01$). In general, delayed sowing did the highest phosphorus values. The highest phosphorus content of 686.24 mg/100 g was

observed in the last sowing. Cultivars × sowing date interaction ($p < 0.05$) was significant, the highest phosphorus concentration (813.95 mg/100 g) observed from the Karacasehir at first sowing date. There were significant differences ($p < 0.01$) among the cultivars. The highest phosphorus value (796.59 mg/100 g) was observed from the Karacasehir, whereas other cultivars gave from 697.84 to 570.00 mg/100 g (Table-2). It is estimated that these phosphorus content differences among cultivars could be due to genotype[11]. These phosphorus values are in agreement with Beebe *et al.*[19], Shimelis and Rakshit[20] and Ceyhan[11]. But they were greater than those reported by Mubarek[21]. There were significant difference ($p < 0.01$) for yield between years and cultivars. The Karacasehir was the highest phosphorus contenting cultivar with 802.69 mg/100 g in 2001 growing seasons. Year × sowing date × cultivar interaction ($p < 0.01$) was statistically significant; the highest phosphorus content (821.61 mg/100 g) was obtained from Karacasehir with first sowing may in 2001 growing seasons (Table-2).

TABLE-2
PHOSPHORUS CONTENT (mg/100 g) OF BEAN CULTIVARS WHEN GROWN IN TWO CONSECUTIVE YEARS WITH FOUR SOWING DATE

| Year | Cultivars | Sowing dates | | | | |
|---|---|---|---|---|---|---|
| | | April 28 | May 04 | May 09 | May 16 | Mean |
| 2000 | Sehirali 90 | 683.02 lm | 677.69 m-p | 661.02 q | 656.09 q | 669.46 f |
| | Karacasehir | 806.29 b | 793.57 cd | 785.26 de | 776.80 e | 790.48 b |
| | Akman 98 | 685.32 lm | 692.06 kl | 715.36 gh | 725.60 f | 704.58 d |
| | Göynük 98 | 559.83 u | 562.02 u | 581.43 t | 592.18 s | 573.86 h |
| | Öncüler 98 | 680.83 m-o | 641.46 r | 636.35 r | 640.93 r | 649.89 g |
| | Yunus 90 | 641.46 r | 677.19 m-p | 683.59 lm | 685.90 lm | 672.04 f |
| | Mean | 676.13 de | 674.00 e | 677.17 de | 679.58 d | 676.72 |
| 2001 | Sehirali 90 | 725.13 f | 723.58 fg | 716.66 f-h | 712.58 h? | 719.49 c |
| | Karacasehir | 821.61 a | 812.04 b | 795.04 c | 782.03 e | 802.69 a |
| | Akman 98 | 655.63 q | 671.77 op | 712.93 h | 724.04 fg | 691.09 e |
| | Göynük 98 | 547.80 v | 555.54 uv | 578.21 t | 583.01 t | 566.14 i |
| | Öncüler 98 | 714.99 gh | 703.60 ij | 695.92 jk | 684.76 lm | 699.82 d |
| | Yunus 90 | 661.29 q | 681.94 mn | 672.99 n-p | 670.98 p | 671.80 f |
| | Mean | 687.74 c | 691.41 bc | 695.30 a | 692.90 ab | 691.84 |
| Mean of years | Sehirali 90 | 704.08 g | 700.64 g | 688.84 h | 684.34 h? | 694.47 b |
| | Karacasehir | 813.95 a | 802.81 b | 790.18 c | 779.42 d | 796.59 a |
| | Akman 98 | 670.48 k | 681.91 ? | 714.15 f | 724.82 e | 697.84 b |
| | Göynük 98 | 553.81 p | 558.78 p | 579.82 o | 587.59 n | 570.00 d |
| | Öncüler 98 | 697.91 g | 672.53 jk | 666.13 kl | 662.85 l | 674.86 c |
| | Yunus 90 | 651.38 m | 679.57 i | 678.29 ij | 678.44 ij | 671.92 c |
| | Mean | 681.93 b | 682.71 b | 686.23 a | 686.24 a | |

$LSD_{\%0.01}$[a]: C = 4.218, C × Y = 5.966, S = 2.647, S × Y = 3.774, S × C = 6.484, S × C × Y = 9.170

[a]Least significant difference for comparisons between individual means: C; S; C × Y; S × Y; S × C; S × C × Y indicate cultivars main effect (C), sowing date main effect (S), interaction of year with cultivars (C × Y), interaction of year with sowing date (S × Y), interaction of sowing date with genotype (S × C), interaction of year with sowing date and cultivars (S × C × Y).

Potassium content was 2007.68 mg/100 g in 2000 and 2006.89 mg/100 g in 2001, with insignificant variations. The effect of sowing date on potassium content ($p < 0.01$) was significant. The highest potassium content (2031.44 mg/100 g) was obtained at the last sowing date. According to cultivar × sowing date interactions ($p < 0.01$), the highest potassium content (2230.98 mg/100 g) was obtained from Öncüler-98 in the last sowing date. Potassium content ($p < 0.01$) was statistically significant difference between cultivars. Öncüler-98 (2159.24 mg/100 g) gave the highest potassium content. On the other hand, the lowest potassium content was (1856.40 mg/100 g) obtained from Göynük-98 (Table-3). Variations between the cultivars may result from genetic differences as reported by Ceyhan[11]. Similar results have been reported earlier by Barampama and Simard[22], Beebe *et al.*[19], Shimelis and Rakshit[20] and Ceyhan[11]. The interaction between cultivar × year ($p < 0.01$) on number potassium content was significant. The highest potassium content (2166.11 mg/100 g) was obtained from Öncüler-98 in 2001 growing seasons. The significant ($p < 0.01$) cultivar × year × sowing

TABLE-3
POTASSIUM CONTENT (mg/100 g) OF BEAN CULTIVARS WHEN GROWN IN TWO CONSECUTIVE YEARS WITH FOUR SOWING DATE

| Year | Cultivars | Sowing dates | | | | |
|---|---|---|---|---|---|---|
| | | April 28 | May 04 | May 09 | May 16 | Mean |
| 2000 | Sehirali 90 | 1890. 05 r-t | 1910.94 q-s | 1914.55 p-r | 1965.12 k-n | 1920.17 |
| | Karacasehir | 1933. 90 o-q | 1948.85 m-o | 1955.39 l-o | 1972.25 i-m | 1952.60 |
| | Akman 98 | 2164.75 cd | 2165.37 cd | 2163.43 cd | 2167.00 c | 2165.14 |
| | Göynük 98 | 1883.39 st | 1862.85 tu | 1837.71 uv | 1845.72 uv | 1857.42 |
| | Öncüler 98 | 2127.22 ef | 2124.83 ef | 2150.96 c-e | 2206.45 b | 2152.37 |
| | Yunus 90 | 2037.12 h | 1967.62 j-n | 1990.76 i-k | 1998.19 i | 1998.42 |
| | Mean | 2006.07 cd | 1996.74 de | 2002.13 d | 2025.79 ab | 2007.68 |
| 2001 | Sehirali 90 | 1808.49 w | 1842.30 uv | 1988.92 i-k | 1994.35 ij | 1908.51 |
| | Karacasehir | 1931.36 o-q | 1974.49 i-m | 1940.80 n-p | 1982.39 i-l | 1957.26 |
| | Akman 98 | 2130.61 ef | 2165.05 cd | 2176.01 c | 2126.40 ef | 2149.52 |
| | Göynük 98 | 1885.00 st | 1820.00 vw | 1839.05 uv | 1877.47 t | 1855.38 |
| | Öncüler 98 | 2110.55 f | 2138.47 d-f | 2159.89 cd | 2255.51 a | 2166.11 |
| | Yunus 90 | 2068.49 g | 1982.38 i-l | 1981.06 i-l | 1986.40 i-k | 2004.58 |
| | Mean | 1989.08 e | 1987.12 e | 2014.29 bc | 2037.09 a | 2006.89 |
| Mean of years | Sehirali 90 | 1849.27 mn | 1876.62 kl | 1951.74 ij | 1979.73 gh | 1914.34 d |
| | Karacasehir | 1932.63 j | 1961.67 hi | 1948.09 ij | 1977.32 gh | 1954.93 c |
| | Akman 98 | 2147.68 cd | 2165.21 bc | 2169.72 b | 2146.70 cd | 2157. 33a |
| | Göynük 98 | 1884.20 k | 1841.43 n | 1838.38 n | 1861.59 lm | 1856.40 e |
| | Öncüler 98 | 2118.89 e | 2131.65 de | 2155.43 bc | 2230.98 a | 2159.24 a |
| | Yunus 90 | 2052.81 f | 1975.00 gh | 1985.91 g | 1992.29 g | 2001.50 b |
| | Mean | 1997.58 c | 1991.93 c | 2008.21 b | 2031.44 a | |

$LSD_{\%0.01}$[a]: C = 14.77, S = 8.211, S × Y = 11.61, S × C = 20.11, S × C × Y = 28.44

[a]Least significant difference for comparisons between individual means: C; S; S × Y; S × C; S × C × Y indicate cultivars main effect (C), sowing date main effect (S), interaction of year with sowing date (S × Y), interaction of sowing date with genotype (S × C), interaction of year with sowing date and cultivars (S × C × Y).

date interaction revealed that Öncüler-98 (2255.51 mg/100 g) had highest potassium content at the last sowing date 2001 growing seasons (Table-3).

Variation for magnesium content ($p < 0.05$) was significant between years. Magnesium content weight was 186.15 mg/100 g in 2000 and 183.61 mg/100 g in 2001. Sowing date ($p < 0.01$) had significant effect on the magnesium content. The highest magnesium content (185.89 mg/100 g) was obtained from the first sowing date. Considering significant ($p < 0.01$) cultivars × sowing date interaction, Akman-98 (201.05 mg/100 g) was the highest magnesium content at the last sowing date whereas the magnesium content of other cultivars were lower (Table-4). The main effect of cultivars ($p < 0.01$) was highly significant magnesium content. The magnesium content of the Akman-98 (197.95 mg/100 g) had higher magnesium content than the other cultivars (Table-4). These differences could be due to the genotype[11]. These results are in agreement with earlier reports Barampama and Simard[22], Beebe *et al.*[19], Shimelis and Rakshit[20], Mubarek[21] and Ceyhan[11]. Year × sowing date interaction were significant ($p < 0.01$) for this character. The highest magnesium content (186.77 mg/100 g) was obtained at second sowing date in 2000 growing seasons. Year × cultivars interaction was also significant ($p < 0.01$) for magnesium content. Karacasehir, Akman-98, Göynük Önceler gave the highest magnesium in 2000 growing seasons. Significant ($p < 0.01$) year × cultivars × sowing date interaction showed that Akman-98 (204.10 mg/100 g) was the highest magnesium at third sowing date in 2000 growing seasons (Table-4).

The main effects of sowing dates ($p < 0.05$) was significant for this mineral. In general, calcium content increased significantly with delayed sowing. Thus, the highest calcium content (137.42 mg/100 g) obtained at last sowing date. Significant sowing date × cultivar interaction was registered with respect to calcium content. There was ($p < 0.01$) significant difference between the cultivars. Calcium content varied conspicuously according to bean cultivars (Karacasehir, 182.65 mg/100 g; Göynük-98, 109.54 mg/100 g) (Table-5). These calcium values are in agreement with Beebe *et al.*[19], Shimelis and Rakshit[20] and Ceyhan[11]. But they were greater than those reported by Barampama and Simard[22] and Mubarek[21]. Year × sowing date interaction were significant ($p < 0.01$) for this character. The highest calcium content (139.16 mg/100 g) was obtained at last sowing date in 2000 growing seasons. Year × cultivars interaction was also significant ($p < 0.01$) for calcium content. Karacasehir (192.11 mg/100 g) gave the highest calcium in 2000 growing seasons. According to significant ($p < 0.01$) year × cultivars × sowing date interaction, Karacasehir (214.38 mg/100 g) was the highest calcium at first sowing date in 2000 growing seasons (Table-5).

TABLE-4
MAGNESIUM CONTENT (mg/100 g) OF BEAN CULTIVARS WHEN GROWN IN TWO CONSECUTIVE YEARS WITH FOUR SOWING DATE

| Year | Cultivars | Sowing dates | | | | |
|---|---|---|---|---|---|---|
| | | April 28 | May 04 | May 09 | May 16 | Mean |
| 2000 | Sehirali 90 | 187.98 g-i | 185.57 h-l | 186.19 h-k | 181.59 j-n | 185.33 d |
| | Karacasehir | 184.07 h-l | 185.48 h-l | 189.18 e-h | 185.69 h-l | 186.11 cd |
| | Akman 98 | 197.92b-d | 199.89 a-c | 204.10 a | 202.62 ab | 201.13 a |
| | Göynük 98 | 177.61 n-r | 185.54 h-l | 178.16n-q | 180.67 l-o | 180.49 e |
| | Öncüler 98 | 178.35 n-q | 177.51 n-r | 174.98 p-r | 174.26 p-r | 176.27 f |
| | Yunus 90 | 192.78 d-g | 186.62 h-j | 185.16 h-l | 185.62 h-l | 187.55 c |
| | Mean | 186.45 ab | 186.77 a | 186.29 ab | 185.07 bc | 186.15 |
| 2001 | Sehirali 90 | 189.12 e-h | 184.47 h-l | 186.23 h-k | 181.33 k-n | 185.29 d |
| | Karacasehir | 187.96 g-i | 184.00 h-l | 187.49 hi | 184.12 h-l | 185.89 cd |
| | Akman 98 | 196.95 cd | 188.57 f-i | 193.22 d-f | 200.36 a-c | 194.77 b |
| | Göynük 98 | 166.93 t | 178.63 m-p | 178.19 n-q | 175.77 o-r | 174.88 fg |
| | Öncüler 98 | 177.17 n-r | 172.38 rs | 173.18 q-s | 168.65 st | 172.85 g |
| | Yunus 90 | 193.88 de | 186.45 h-k | 187.67 g-i | 183.82 i-m | 187.96 c |
| | Mean | 185.33 a-c | 182.42 d | 184.33 c | 182.34 d | 183.61 |
| Mean of years | Sehirali 90 | 188.55 e | 185.02 e-g | 186.21 ef | 181.46 gh | 185.31 c |
| | Karacasehir | 186.02 ef | 184.74 fg | 188.34 ef | 184.91 e-g | 186.00 c |
| | Akman 98 | 197.44 bc | 194.23 cd | 198.66 ab | 201.49 a | 197.95 a |
| | Göynük 98 | 172.27 k | 182.08 g | 178.17 hi | 178.22 hi | 177.69 d |
| | Öncüler 98 | 177.76 h-j | 174.94 i-k | 174.08 jk | 171.45 k | 174.56 e |
| | Yunus 90 | 193.33 d | 186.53 ef | 186.42 ef | 184.72 fg | 187.75 b |
| | Mean | 185.89 a | 184.59 ab | 185.31 a | 183.71 b | |

$LSD_{\%0.01}$[a]: C = 1.5102, C × Y = 2.135, S = 1.512, S × Y = 1.611, S × C = 3.3703, S × C × Y = 5.236

[a]Least significant difference for comparisons between individual means: C; S; C × Y; S × Y; S × C; S × C × Y indicate cultivars main effect (C), sowing date main effect (S), interaction of year with cultivars (C × Y), interaction of year with sowing date (S × Y), interaction of sowing date with genotype (S × C), interaction of year with sowing date and cultivars (S × C × Y).

Sowing date ($p < 0.01$) had significant effect on the sodium content. The highest value was obtained from the second sowing (51.08 mg/100 g). Sowing date × cultivar interaction were significant ($p < 0.01$) for this character. The highest sodium content (56.41 mg/100 g) was obtained from Karacasehir at second sowing date. Significant effects ($p < 0.01$) were found for sodium content among cultivars. Karacasehir (51.89 mg/100 g) gave the highest sodium content (Table-6). These results are in agreement with earlier reports Barampama and Simard[22], Beebe *et al.*[19], Shimelis and Rakshit[20], Mubarek[21] and Ceyhan[11]. Year × cultivars interaction was significant ($p < 0.01$) for sodium content. Karacasehir (53.10 mg/100 g) gave the highest sodium in 2000 growing seasons. According to significant ($p < 0.01$) year × cultivars × sowing date interaction, Karacasehir (57.75 mg/100 g) was the highest sodium at second sowing date in 2000 growing seasons (Table-6).

TABLE-5
CALCIUM CONTENT (mg/100 g) OF BEAN CULTIVARS WHEN GROWN IN TWO CONSECUTIVE YEARS WITH FOUR SOWING DATE

| Year | Cultivars | Sowing dates | | | | |
|---|---|---|---|---|---|---|
| | | April 28 | May 04 | May 09 | May 16 | Mean |
| 2000 | Sehirali 90 | 121.65 q-t | 138.64 j-l | 145.64 ij | 169.08 de | 143.75 d |
| | Karacasehir | 214.38 a | 201.01 b | 177.33 c | 175.73 cd | 192.11 a |
| | Akman 98 | 108.80 w-y | 112.85 v-x | 116.61 s-v | 115.87 t-w | 113.53 h |
| | Göynük 98 | 102.86 yz | 108.83 w-y | 113.78 u-x | 117.36 s-v | 110.71 hi |
| | Öncüler 98 | 124.77 o-r | 117.31 s-v | 113.76 u-x | 114.97 t-w | 117.71 g |
| | Yunus 90 | 112.47 v-x | 125.42 o-r | 131.39 l-o | 141.93 jk | 127.80 e |
| | Mean | 130.82 d | 134.01 bc | 133.09 cd | 139.16 a | 134.27 |
| 2001 | Sehirali 90 | 150.03 hi | 151.47 g-? | 157.98 fg | 164.04 ef | 155.88 c |
| | Karacasehir | 193.81 b | 169.95 de | 172.96 cd | 157.04 f-h | 173.19 b |
| | Akman 98 | 127.39 n-r | 128.16 n-r | 123.90 p-s | 126.86 n-r | 126.58 ef |
| | Göynük 98 | 101.42 z | 107.14 x-z | 110.15 v-y | 114.77 t-w | 108.37 ? |
| | Öncüler 98 | 129.55 m-p | 128.80 n-q | 121.02 r-u | 115.00 t-w | 123.60 f |
| | Yunus 90 | 113.31 v-x | 124.83 o-r | 133.10 l-n | 136.41 k-m | 126.91 ef |
| | Mean | 135.92 bc | 135.06 bc | 136.35ab | 135.69 bc | 135.75 |
| Mean of years | Sehirali 90 | 135.84 gh | 145.06 f | 151.81 e | 166.56 d | 149.82 b |
| | Karacasehir | 204.10 a | 185.48 b | 174.65 c | 166.38 d | 182.65 a |
| | Akman 98 | 118.10 l-o | 120.51 k-n | 120.25 k-n | 121.37 k-m | 120.06 d |
| | Göynük 98 | 102.14 s | 107.99 r | 111.97 qr | 116.07 n-q | 109.54 e |
| | Öncüler 98 | 127.16 ij | 123.06 j-l | 117.39 m-p | 114.99 o-q | 120.65 d |
| | Yunus 90 | 112.89 p-r | 125.12 jk | 132.25 hi | 139.17 g | 127.36 c |
| | Mean | 133.37 b | 134.53 b | 134.72 b | 137.42 a | |

$LSD_{\%0.01}$ [a]: C = 2.868, C × Y = 4.056, S = 2.112, S × Y = 2.987, S × C = 5.174, S × C × Y = 7.318

[a]Least significant difference for comparisons between individual means: C; S; C × Y; S × Y; S × C; S × C × Y indicate cultivars main effect (C), sowing date main effect (S), interaction of year with cultivars (C × Y), interaction of year with sowing date (S × Y), interaction of sowing date with genotype (S × C), interaction of year with sowing date and cultivars (S × C × Y).

Year effect on iron content was significant ($p < 0.05$). Iron content was 7.18 in 2000 and 7.44 mg/100 g in 2001. Iron has been affected and significantly ($p < 0.01$) increased with delayed sowing. The highest value was obtained from the last sowing (7.49 mg/100 g). Sowing date × cultivars interaction were significant ($p < 0.01$) for this character. The highest iron content (8.58 mg/100 g) was obtained for Karacasehir at first and last sowing dates. Significant effects ($p < 0.01$) were found for iron content among cultivars. Concentration of iron varied 8.41 (Karacasehir) to 6.50 mg/100 g (Yunus-90) (Table-7). Iron values obtained are similar to greater than concentrations given by many researchers[19-23]. Year × cultivars interaction was significant ($p < 0.01$) for iron content. Sehirali-90, Akman-98, Göynük and Yunus gave the highest iron in 2001 growing seasons. Significant ($p < 0.01$) year × cultivars × sowing date interaction revealed that Karcasehir (8.74 mg/100 g) was the highest magnesium at first sowing date in 2001 growing seasons (Table-7).

TABLE-6
SODIUM CONTENT (mg/100 g) OF BEAN CULTIVARS WHEN GROWN IN TWO CONSECUTIVE YEARS WITH FOUR SOWING DATE

| Year | Cultivars | Sowing dates | | | | |
|---|---|---|---|---|---|---|
| | | April 28 | May 04 | May 09 | May 16 | Mean |
| 2000 | Sehirali 90 | 48.64 h-m | 49.92 d-k | 48.59 h-m | 50.06 d-k | 49.30 c-e |
| | Karacasehir | 49.64 e-l | 57.75 a | 52.31 b-g | 52.71 b-f | 53.10 a |
| | Akman 98 | 49.84 d-k | 55.15 ab | 49.60 e-l | 46.93 j-p | 50.38 bc |
| | Göynük 98 | 47.55 j-o | 49.96 d-k | 48.79 h-m | 47.64 j-o | 48.49 d-f |
| | Öncüler 98 | 45.67 m-q | 45.18 n-q | 42.52 q | 43.94 pq | 44.33 h |
| | Yunus 90 | 49.47 f-l | 46.38 l-p | 45.75 m-q | 46.71 k-p | 47.08 fg |
| | Mean | 48.47 | 50.72 | 47.93 | 48.00 | 48.78 |
| 2001 | Sehirali 90 | 46.93 j-p | 50.11 d-j | 46.88 j-p | 48.67 h-m | 48.15 e-g |
| | Karacasehir | 44.12 pq | 55.07 ab | 51.59 c-i | 51.91 b-h | 50.67 bc |
| | Akman 98 | 54.72 a-c | 53.22 b-d | 48.93 g-m | 48.00 j-o | 51.22 b |
| | Göynük 98 | 49.98 d-k | 52.90 b-e | 49.59 e-l | 47.22 j-p | 49.92 b-d |
| | Öncüler 98 | 46.96 j-p | 48.95 g-m | 46.67 k-p | 44.69 o-q | 46.82 g |
| | Yunus 90 | 47.99 j-o | 48.39 i-n | 48.58 h-m | 46.83 j-p | 47.95 e-g |
| | Mean | 48.45 | 51.44 | 48.71 | 47.89 | 49.12 |
| Mean of years | Sehirali 90 | 47.78 e-i | 50.01 c-e | 47.74 e-i | 49.36 d-f | 48.72 c |
| | Karacasehir | 46.88 g-j | 56.41 a | 51.95 bc | 52.31 bc | 51.89 a |
| | Akman 98 | 52.28 bc | 54.18 ab | 49.26 d-g | 47.46 f-i | 50.80 b |
| | Göynük 98 | 48.77 e-h | 51.43 cd | 49.19 d-g | 47.43 f-i | 49.20 c |
| | Öncüler 98 | 46.31 i-k | 47.07 f-i | 44.60 jk | 44.31 k | 45.57 e |
| | Yunus 90 | 48.73 e-h | 47.38 f-i | 47.17 f-i | 46.77 h-j | 47.51 d |
| | Mean | 48.46 b | 51.08 a | 48.32 b | 47.94 b | |

$LSD_{\%0.01}$[a]: C = 1.043, C × Y = 3.388, S = 0.9779, S × C = 2.395, S × C × Y = 3.388
[a]Least significant difference for comparisons between individual means: C; S; C × Y; S × C; S × C × Y indicate cultivars main effect (C), sowing date main effect (S), interaction of year with cultivars (C × Y), interaction of sowing date with genotype (S × C), interaction of year with sowing date and cultivars (S × C × Y).

Zinc content of the genotypes was significantly ($p < 0.01$) decreased with delayed sowing. Zinc content decreased significantly with delayed sowing. The highest zinc values of 2.01 mg/100 g for second sowing were followed by 1.98 mg/100 g for third sowing and 1.97 mg/100 g for first sowing compared with 1.88 mg/100 g for last sowing. According to the significant ($p < 0.01$) sowing date x cultivar, the highest zinc content (2.38 mg/100 g) was obtained from Yunus-90 at third sowing date. Zinc content ($p < 0.01$) was statistically significant difference between cultivars. Zinc content in six cultivars ranged from 2.27 (Yunus-90) to 1.69 mg/100 g (Akman-98) (Table-8). These values are similar to compared on dry basis reported by Barampama and Simard[22], Beebe *et al.*[19], Shimelis and Rakshit[20] and Ceyhan[11]. Year × sowing date interaction were significant ($p < 0.01$) for this character. The highest zinc content (2.01 mg/100 g) was obtained at second and third sowing date in 2000 growing seasons. Year × cultivars interaction was also significant ($p < 0.01$) for zinc content. Sehirali-90,

TABLE-7
IRON CONTENT (mg/100 g) OF BEAN CULTIVARS WHEN GROWN IN TWO CONSECUTIVE YEARS WITH FOUR SOWING DATE

| Year | Cultivars | Sowing dates | | | | |
|---|---|---|---|---|---|---|
| | | April 28 | May 04 | May 09 | May 16 | Mean |
| 2000 | Sehirali 90 | 7.29 ij | 7.58 g-i | 7.56 hi | 7.94 f-h | 7.59 c |
| | Karacasehir | 8.42 b-e | 8.10 ef | 7.99 fg | 8.53 b-d | 8.26 b |
| | Akman 98 | 6.51 k-p | 6.56 k-p | 6.86 k | 6.63 k-o | 6.64 d |
| | Göynük 98 | 7.48 i | 7.66 g-i | 7.45 i | 7.60 g-i | 7.55 c |
| | Öncüler 98 | 6.87 k | 6.84 kl | 6.32 n-q | 6.67 k-o | 6.68 d |
| | Yunus 90 | 6.18 pq | 6.08 q | 6.41 m-q | 6.68 k-o | 6.34 e |
| | Mean | 7.13 | 7.14 | 7.10 | 7.34 | 7.18 |
| 2001 | Sehirali 90 | 8.63 bc | 8.67 b | 8.22 c-f | 9.17 a | 8.67 a |
| | Karacasehir | 8.74 b | 8.67 b | 8.16 d-f | 8.64 b | 8.55 a |
| | Akman 98 | 6.81 k-m | 6.40 m-q | 6.16 pq | 6.72 k-n | 6.52 de |
| | Göynük 98 | 7.64 g-i | 7.67 g-i | 7.56 hi | 7.68 g-i | 7.64 c |
| | Öncüler 98 | 6.44 l-q | 6.66 k-o | 6.55 k-p | 6.73 k-n | 6.59 d |
| | Yunus 90 | 6.29 o-q | 6.70 k-o | 6.76 k-m | 6.90 jk | 6.66 d |
| | Mean | 7.43 | 7.46 | 7.24 | 7.64 | 7.44 |
| Mean of years | Sehirali 90 | 7.96 c | 8.13 bc | 7.89 cd | 8.56 a | 8.13 b |
| | Karacasehir | 8.58 a | 8.39 ab | 8.08 c | 8.58 a | 8.41 a |
| | Akman 98 | 6.66 f-i | 6.48 g-j | 6.51 f-j | 6.67 f-i | 6.58 de |
| | Göynük 98 | 7.56 e | 7.67 de | 7.51 e | 7.64 de | 7.59 c |
| | Öncüler 98 | 6.66 f-i | 6.75 fg | 6.44 h-j | 6.70 f-h | 6.64 d |
| | Yunus 90 | 6.24 j | 6.39 ij | 6.59 f-i | 6.79 f | 6.50 e |
| | Mean | 7.28 bc | 7.30 b | 7.17 c | 7.49 a | |

$LSD_{\%0.01}$[a]: C = 0.1350, C × Y = 0.1909, S = 0.1200, S × C = 0.2938, S × C × Y = 0.4155
[a]Least significant difference for comparisons between individual means: C; S; C × Y; S × C; S × C × Y indicate cultivars main effect (C), sowing date main effect (S), interaction of year with cultivars (C × Y), interaction of sowing date with genotype (S × C), interaction of year with sowing date and cultivars (S × C × Y).

Karacasehir, Göynük and Önceler gave the highest zinc in 2000 growing seasons. Significant ($p < 0.01$) year × cultivars × sowing date interaction showed that Yunus-9o (2.41 mg/100 g) was the highest zinc at third sowing date in 2001 growing seasons (Table-8).

## Conclusion

Results of this study showed that all protein and mineral contents of bean seeds that were largely affected by growing seasons, genotypes and sowing dates. With regard to mineral composition small differences were evident between the two experimental years, with a slight decrease in magnesium and zinc content and an increase in protein, phosphorus, potassium, calcium, sodium and iron content in 2001. The differences were stronger between the sowing dates. In general, protein, phosphorus, potassium, calcium, sodium and iron content increased with delayed sowing. Unlike, the zinc content decreased with delayed sowing in the growing seasons. Mineral contents of bean can depended directly on growing seasons,

TABLE-8
ZINC CONTENT (mg/100 g) OF BEAN CULTIVARS WHEN GROWN IN TWO CONSECUTIVE YEARS WITH FOUR SOWING DATE

| Year | Cultivars | Sowing dates | | | | |
|---|---|---|---|---|---|---|
| | | April 28 | May 04 | May 09 | May 16 | Mean |
| 2000 | Sehirali 90 | 2.35 a-c | 2.12 d-g | 2.03 f-j | 1.96 h-l | 2.11 bc |
| | Karacasehir | 2.17 de | 2.07 e-h | 1.99 g-k | 1.79 m-q | 2.00 de |
| | Akman 98 | 1.69 qr | 1.68 qr | 1.70 p-r | 1.70 p-r | 1.69 i |
| | Göynük 98 | 1.83 l-p | 1.92 j-m | 1.88 k-m | 1.69 p-r | 1.83 gh |
| | Öncüler 98 | 1.90 j-m | 2.06 e-i | 2.10 d-g | 2.23 b-d | 2.07 cd |
| | Yunus 90 | 1.91 j-m | 2.21 cd | 2.36 ab | 2.21 cd | 2.17 b |
| | Mean | 1.97 a-c | 2.01 a | 2.01 a | 1.93 c | 1.98 |
| 2001 | Sehirali 90 | 2.15 d-f | 2.07 e-h | 1.88 k-m | 1.84 l-0 | 1.98 d-f |
| | Karacasehir | 2.07 e-h | 1.92 j-m | 1.92 i-m | 1.71 o-r | 1.91 fg |
| | Akman 98 | 1.69 qr | 1.73 n-r | 1.69 p-r | 1.67 qr | 1.70 i |
| | Göynük 98 | 1.65 r | 1.88 k-m | 1.86 k-n | 1.62 r | 1.75 hi |
| | Öncüler 98 | 1.90 j-m | 1.94 h-l | 1.95 h-l | 1.89 k-m | 1.92 e-g |
| | Yunus 90 | 2.36 ab | 2.48 a | 2.41 a | 2.22 b-d | 2.37 a |
| | Mean | 1.97 a-c | 2.00 ab | 1.95 bc | 1.83 d | 1.94 |
| Mean of years | Sehirali 90 | 2.25 b | 2.10 de | 1.95 g-? | 1.90 hi | 2.05 b |
| | Karacasehir | 2.12 de | 1.99 f-h | 1.96 g-? | 1.75 j | 1.96 c |
| | Akman 98 | 1.69 j | 1.71 j | 1.70 j | 1.69 j | 1.69 e |
| | Göynük 98 | 1.74 j | 1.90 h | 1.87 i | 1.66 j | 1.79 d |
| | Öncüler 98 | 1.90 hi | 2.00 fg | 2.03 e-g | 2.06 d-f | 2.00 bc |
| | Yunus 90 | 2.13 cd | 2.35 a | 2.38 a | 2.22 bc | 2.27 a |
| | Mean | 1.97 a | 2.01 a | 1.98 a | 1.88 b | |

$LSD_{\%0.01}$[a]: C = 0.06872, C × Y = 0.09719, S = 0.03944, S × Y = 0.05578, S × C = 0.09661, S × C × Y = 0.1366

[a]Least significant difference for comparisons between individual means: C; S; C × Y; S × Y; S × C; S × C × Y indicate cultivars main effect (C), sowing date main effect (S), interaction of year with cultivars (C × Y), interaction of year with sowing date (S × Y), interaction of sowing date with genotype (S × C), interaction of year with sowing date and cultivars (S × C × Y).

genotypes and soil composition[6]. Environmental conditions, genetic variations and soil type exert significant influences on the chemical composition of legume seeds have been reported[7,8]. Therefore, for protein and mineral content, environmental factors, genetic variations and sowing date should be given due consideration. This study about bean has demonstrated protein and mineral contents differences among the cultivars. All cultivars contained good amounts of protein and mineral contents. The lower cost of the legumes the reduced incomes of the majority of Turkish people, together with the high prices of animal products, may justify these efforts. This may be of potential importance for breeding studies in selecting for improved legumes with high protein and mineral content. These results revealed that bean may provide a sufficient amount of minerals to meet the human mineral requirement.

## ACKNOWLEDGEMENT

This study was supported by Selcuk University Scientific Research Project (BAP) Konya, Turkey.

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(*Received*: 27 October 2007; *Accepted*: 15 May 2008) AJC-6583