

Evaluation of Annual Legumes and Barley as Sole Crops and Intercrop in Spring Frost Conditions for Animal Feeding II. Mineral Composition

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Abstract: Sole grass pea (*Lathyrus sativus* L), sole common vetch (*Vicia sativa* L.), sole barley (*Hordeum vulgare* L.), common vetch + barley intercrop, common vetch (I) and barley (I) in terms of mineral contents were assessed in the present study for animal feeding. Common vetch + barley intercrops were separated as common vetch (called as common vetch I) and barley (called as barley I). The experiment was designed in a factorial arrangement of a randomized complete block design with 3 replications and carried out at the research station at Kelkit Aydin Dogan Vocational Training School, Gumushane University, in 2006 and 2007. All the plants had important potential in terms macro and micro mineral contents in animal feeding. There were significant differences between years in Mg, Ca, P, Mn, Fe and Cu contents. According to the results, sole grass pea, sole common vetch and common vetch (I) in Mg, sole grass pea, common vetch (I) and sole common vetch in Ca, common vetch (I), sole grass pea and sole common vetch in Mn and sole barley and sole grass pea in Cu were rich for animal feeding. If farmers want rich forage in terms of Mg, Ca and Mn, they should select sole grass pea and sole common vetch cultivation. If farmers want rich forage in terms of Cu, they should choose sole grass pea and sole barley cultivation.

Key words: Common vetch, grass pea, barley, intercrop, mineral content, sole crops

INTRODUCTION

Forage crops production is very important for successful animal production, but there are some problems in meeting required feed for livestock in some regions of the world. As a result of incitement decision made by the Ministry of Agriculture and Rural Affairs, production areas of forage crops have importantly increased in Turkey (Yolcu and Tan, 2008). Farmers have begun to cultivate annual forage crops except Lucerne since these crops stay shorter than perennial forage crops on fields. This increase in forage crops cultivation has been achieved with the support given by the government, because changing former habits on their own was difficult for farmers. They preferred sole common vetch and common vetch + barley intercrop for the most part and sole grass pea and sole cereals for the less.

Common vetch (*Vicia sativa* L.) is an important legume cultivated for feed grain and forage in the

Mediterranean and Central Asia regions (Samarah and Ereifej, 2009). Common vetch take an important part as roughage and concentrated feed to animal feeding and its intercrop with cereals supply increasing of milk yield in dairy cows especially, (Bulur and Celik, 1996). Grass pea is a low production cost legume adapted to harsh and low rainfall environments having considerable potential as a good quality, cheap protein source (Tadelle *et al.*, 2003). Cereals have important potential in terms of yield, quality and mineral content in animal feeding as roughage. (Yolcu, 2008).

Macro and micro mineral contents of forages are very important for animal feeding. Mineral elements exist in the cells and tissues of the animal body in a variety of functional, chemical combinations and characteristic concentrations, which vary with the element and tissue (Underwood and Suttle, 1999). Minerals are non-nutrient constituents of feed and food and play an important role in nutrient utilization, growth and production

(Tripathi and Karim, 2008). The elements known to be essential and which are sometimes deficient in farm livestock are N, P, S, K, Ca, Mg, Na, Cl, Fe, Mn, Zn, Cu, Co, I, Mo and Se (Whitehead, 2000). Deficiency of macro and micro elements in feed may seriously cause growth and healthy problem in animals. Therefore, it is important that rich forages in terms of mineral content are used in animal feeding (Yolcu *et al.*, 2009)

Mineral contents of forages have been an important research topic in many studies made by Yolcu (2008) in cereals, by Yolcu and Turan (2008) and Yolcu and Serin (2009) in lucerne and smooth brome grass intercropping system, by Yolcu *et al.* (2009) in red clover genotypes. The objective of the study was to evaluate performances of sole common vetch, sole grass pea, sole barley, intercrop (common vetch + barley), common vetch (I), barley (I) in terms of macro and micro minerals in spring frost and organic manure conditions.

MATERIALS AND METHODS

The experiment was carried out at Kelkit Aydin Dogan Vocational Training School of Gumushane University in the North East part of Turkey in 2006 and 2007 growing season. Intercrops (common vetch + barley), sole grass pea, sole common vetch and sole barley were sown in April of 2006 and 2007. The plants were sown 90 kg ha⁻¹ + 50 kg ha⁻¹ doses common vetch + barley (Serin and Tan, 2001), 500-600 plants in m² for sole barley (Kun, 1996), 100 kg ha⁻¹ sole grass pea (Acikgoz, 2001) and 100 kg ha⁻¹ sole common vetch (Acikgoz, 2001) with 24 cm row spacing in each year. Common vetch + barley intercrops were sown in cross seeding pattern. Individual plots were 1.68×3 = 5.04 m² in size. The study was designed in a factorial arrangement of a randomized complete block design with 3 replications organic farmyard manure.

The plots were fertilized with 20 ton ha⁻¹ in the spring of the 1st and 2nd year before seeding. Some properties of organic farmyard manure used in research showed in Table 1. The soils of the experiment area were clay-loam character and mean pH level was 7.64. Mean organic matter of the soils was 1.50 and mean P, K and lime levels were 37.5 kg ha⁻¹, 438.5 kg K₂O ha⁻¹ and 26.74%, respectively. According to the results, the soils

of experiment area had alkaline at a slight level, organic matter at a poor-middle level; available P at a middle level and K at a rich level. The research was carried out in other part of the same field which had similar soil properties in the 2nd year.

The research location in Kelkit has low humidity, dry summers and cold and snowy winters. Mean air temperature were 9.9 and 10.0°C in 2006 and 2007, respectively. These temperatures were few higher than a long term average temperatures (9.4°C). Total precipitations were 586.8 and 493.9 mm in 2006 and 2007, respectively. Also, mean relative humidity were 69.4 and 66.8% in experiment years, respectively. The numbers of spring frost days were 2 days at April of 2006 and 7 days at April of 2007. Late spring frosts caused damage to vetches especially and sole grass pea in 2007.

Intercrops (Serin and Tan, 2001) and sole crops barley (Tan and Serin, 1997) were harvested in milk stage of barley. Grass pea in all flowering stage (Serin and Tan, 2001) and sole common vetch in stuffed stage of the few pods near the soil (Acikgoz, 2001) were harvested. All the plants collected by harvesting 1 m² areas from each plot. Common vetch + barley intercrops were separated as common vetch (called as common vetch I) and barley (called as barley I). Samples were oven-dried at 68°C for 48 h and they ground to pass 1 mm.

Phosphorus content of all the plants in both years was determined after wet digestion using a HNO₃-HClO₄ acid mixture (4:1 v v⁻¹). Phosphorus content in the extraction solution was measured spectrophotometrically using the indophenol-blue and ascorbic acid method and a UV/VIS Aquamat Spectrophotometer (Thermo Electron Spectroscopy LTD, Cambridge, UK). Mg, Ca, K, Na, Mn, Zn, Fe and Cu contents of each samples were determined after wet digestion using a HNO₃-HClO₄ acid Mixture (4:1 v v⁻¹) and a Perkin-Elmer 360 Atomic Absorption Spectrophotometer (Perkin-Elmer, Waltham, Massachusetts, USA) (AOAC, 2005). Mg, Ca, K, Na, Mn, Zn, Fe and Cu contents of intercrop were calculated as weighted mean squares by taking botanical composition into consideration.

Statistical analysis: The statistical procedures of JMP (SAS Institute, 2002) were used data analyses. All means were compared with LSD test.

Table 1: Some properties of farmyard manure used in research (2006-2007)

Farmyard manure	pH	Moisture (%)	Dry matter (%)	Org. matter (%)	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	Fe (ppm)	Zn (ppm)
2006	7.74	80.3	19.7	20.00	2500	2100	1200	3200	976	675	436	586
2007	7.45	81.5	18.5	21.60	2700	1800	1200	3200	982	670	432	580

RESULTS AND DISCUSSION

Macro minerals contents of all the plants treatments:

Late spring frosts may cause damaging effects in forage crop production at some periods in Kelkit. The year effects were important ($p < 0.01$) in Mg, Ca and P. These differences between years can be attributed to serious frost damage and low total precipitation in 2007. Significant differences were determined in Mg ($p < 0.05$) amongst all the plants (sole grass pea, sole common vetch, sole barley, intercrops, common vetch (I) and barley (I)) in the first year (Fig. 1). The highest Mg content was found in sole grass pea plants (2357 mg kg^{-1}) in the 1st year. Mg content of sole common vetch, common vetch (I), intercrops, sole barley and barley (I) was found as 2275, 2217, 2183, 2135 and 2088 mg kg^{-1} in the 1st year, respectively. There also were important differences ($p < 0.01$) in terms of Mg in the 2nd year. The highest Mg contents were found sole common vetch, sole grass pea and common vetch (I) in the 2nd year. These values were 2215, 2193 and $2192 \text{ Mg mg kg}^{-1}$ in the 2nd year, respectively. These plants were followed by sole barley ($1972 \text{ Mg mg kg}^{-1}$), intercrops ($1672 \text{ Mg mg kg}^{-1}$) and barley (I) ($1622 \text{ Mg mg kg}^{-1}$).

Similar Mg variation between species has been reported by Stockdale (1999) amongst white clover, ryegrass and paspallum and by Durr *et al.* (2005) amongst Kentucky blue grass and timothy. Mg content of all the plants was over Mg requirements of growing and finishing cattle (0.10%) and gestating cows (0.12%) issued by National Research Council (2000). But, Mg content of barley (I), intercrops and sole barley in 2007 was under Mg requirements of cows in early lactation (0.20%) issued by NRC (2000). Mg content of sole barley was higher than those of barley (I) in 2007, but it was similar in 2006. Mg content of sole common vetch was also similar with common vetch (I) in 2007, but it was slightly higher than common vetch (I) in 2006. Mg contents of legumes were generally higher than those of both barley (sole barley and barley in intercrops) in 2006 and 2007 (Fig. 1). Similarly, Whitehead (2000) stated that Mg content of legumes was 20% greater than grasses under same conditions. Differences were also determined in Mg amongst all the plants in the mean of 2 years. The highest Mg content was found in sole grass pea ($2275 \text{ Mg mg kg}^{-1}$). This plant was followed by sole common vetch ($2245 \text{ Mg mg kg}^{-1}$), common vetch (I) ($2204 \text{ Mg mg kg}^{-1}$), sole barley ($2053 \text{ Mg mg kg}^{-1}$), intercrops ($1927 \text{ Mg mg kg}^{-1}$) and barley (I) ($1855 \text{ Mg mg kg}^{-1}$), respectively.

Sole grass pea, sole common vetch, sole barley, intercrop, common vetch (I) and barley (I) in terms of Ca content ($p < 0.01$) showed significant differences in the 1st

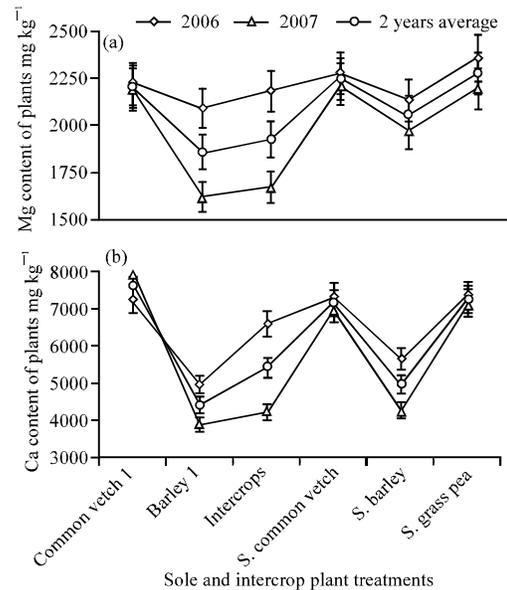


Fig. 1: Magnesium and calcium contents of common vetch (I), barley (I), intercrop, sole common vetch, sole barley

year and 2nd year (Fig. 1). The highest Ca content was gained from sole grass pea, sole common vetch and common vetch (I) in the 1st year. These values were 7333, 7300 and $7200 \text{ Ca mg kg}^{-1}$, respectively. These plants were followed by intercrops, sole barley and barley (I) (Fig. 1). In the 2nd year, the highest Ca content was gained only common vetch (I) ($7967 \text{ Ca mg kg}^{-1}$). Ca content of sole grass pea, sole common vetch, sole barley, intercrops and barley (I) were 7133, 6967, 4267, 4222 and $3867 \text{ Ca mg kg}^{-1}$, respectively. Similar Ca variations were determined by Stockdale (1999) between white clover, ryegrass and paspallum and by Durr *et al.* (2005) amongst Kentucky blue grass and timothy. All of the plants except barley (I) and sole barley in 2006 and barley (I), intercrops and sole barley in 2007 had higher Ca content than recommended Ca quantity for early stages (0.60%) of dry cow period and late stages (0.60%) of milk cows issued by Hutjens (2003). Ca content of sole grass pea, sole common vetch and common vetch (I) in 2006 and common vetch (I) and sole grass pea in 2007 were over those of recommended Ca quantity for close-up (0.70%) stages of dry cow period and middle (0.70%) of milk cows issued by Hutjens (2003). But all the plants have lower Ca content than those of recommended Ca quantity for fresh stage (1%) and early stage (0.90%) of milk cows according to Hutjens (2003). Ca contents of legumes were higher than those of both barley (sole barley and barley in intercrops). Also, Whitehead (2000) stated that Ca contents of legumes were 2 or 3 times higher than in grasses in similar

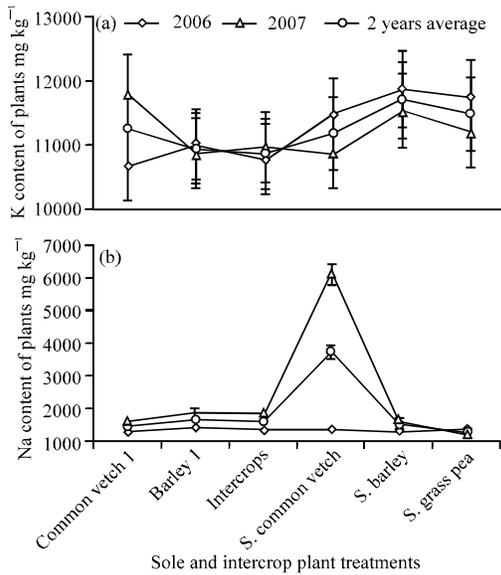


Fig. 2: Potassium and sodium contents of common vetch (I), barley (I), intercrop, sole common vetch, sole barley

conditions. Also, in the mean of the 2 year, the highest Ca content was gained in common vetch (I) (7583 Ca mg kg⁻¹), sole grass pea (7233 Ca mg kg⁻¹) and sole common vetch (7133 Ca mg kg⁻¹).

All the plants were similar in terms of K, Na and P in the 1st year, 2nd year and mean of 2 years (Fig. 2 and 3). The similar results were stated by Whitehead (2000) in K in similar conditions and by Yolcu (2008) in K and P between barley and wheat used as roughage. All the plants in 2006 and 2007 had higher K and Na contents than requirement for cow in gestating (0.60% K, 0.06-0.08% Na) and early lactation (0.70% K, 0.10% Na) stage and growing and finishing cattle (0.60% K, 0.06-0.08% Na) issued in NRC (2000). P contents of all the plants in 2006 and 2007 years except common vetch (I) in 2006 and sole grass pea in 2007 were sufficient in terms of required P content for dry cow in early stage (0.26%) issued by Hutjens (2003). Barley (I), intercrops, sole barley and sole common vetch in 2007 had near or over values of required P content for dry cow in close-up (0.30%) stages and milk cows in late stages (0.32%) according to Hutjens (2003).

Micro minerals contents of all the plants treatments: The year effects were important in ($p < 0.05$) Mn and ($p < 0.01$) Cu. While Mn content in the first year was higher than those of the 2nd year, Cu content in the 2nd year was higher than those of the 1st year. Significant differences were not found in terms of Mn content amongst all the

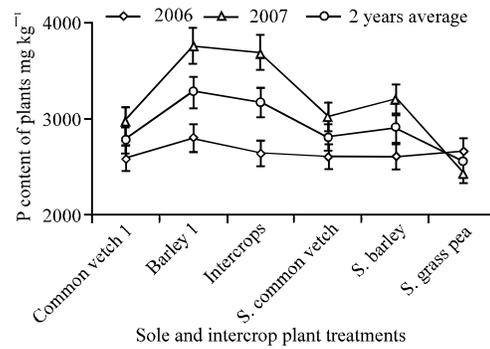


Fig. 3: Phosphorus contents of common vetch (I), barley (I), intercrop, sole common vetch, sole barley

plants in the 1st year (Fig. 4). But differences ($p < 0.05$) were determined in Mn content in the 2nd year. The highest Mn values were gained from common vetch (I) (132 Mn mg kg⁻¹). This plant was followed by sole grass pea (120 Mn mg kg⁻¹), sole common vetch (98 Mn mg kg⁻¹), sole barley (90 Mn mg kg⁻¹), intercrops (76 Mn mg kg⁻¹) and barley (I) (71 Mn mg kg⁻¹). Mn contents of legumes were generally higher than those of both barleys. Cu contents showed significant differences amongst all the plants in the 1st and 2nd year (Fig. 4). The highest Cu content (125 Cu mg kg⁻¹) was found in sole barley in the 1st study year. Sole grass pea, sole common vetch, barley (I), intercrop and common vetch (I) had 117, 104, 100, 91 and 88 Cu mg kg⁻¹, respectively. Sole barley had the highest Cu content in the 2nd year (200 Cu mg kg⁻¹). This plant was followed by sole grass pea (180 Cu mg kg⁻¹), common vetch (I) (150 Cu mg kg⁻¹), sole common vetch (125 Cu mg kg⁻¹), intercrop (120 Cu mg kg⁻¹) and barley (I) (117.00 Cu mg kg⁻¹), respectively. Similar variation between plant species has been reported by Khan *et al.* (2007) in Cu and Mn amongst Bermuda grass, Bahia grass, Star grass and Guinea grass, by Durr *et al.* (2005) in Mn and Cu amongst Kentucky blue grass and timothy and by Ahmad *et al.* (2008) in Mn amongst dominant species in forage plants. Mn and Cu contents of all the plants was over Mn and Cu requirements of growing and finishing cattle (20 mg kg⁻¹ Mn, 10 mg kg⁻¹ Cu) and cows (40 mg kg⁻¹ Mn, 10 mg kg⁻¹ Cu) in gestating and early lactation stage issued by NRC (2000). Significant differences were found in Mn ($p < 0.05$) and Cu ($p < 0.01$) amongst all the plants in the mean of 2 years (Fig. 4). The highest Mn values were determined in the sole grass pea (166 Mn mg kg⁻¹) and sole common vetch (151 Mn mg kg⁻¹). The highest Cu content was determined in sole barley (163 Cu mg kg⁻¹) and sole grass pea (148 Cu mg kg⁻¹).

Differences were not found in terms of Zn and Fe amongst all the plants in the 1st year, 2nd year and mean

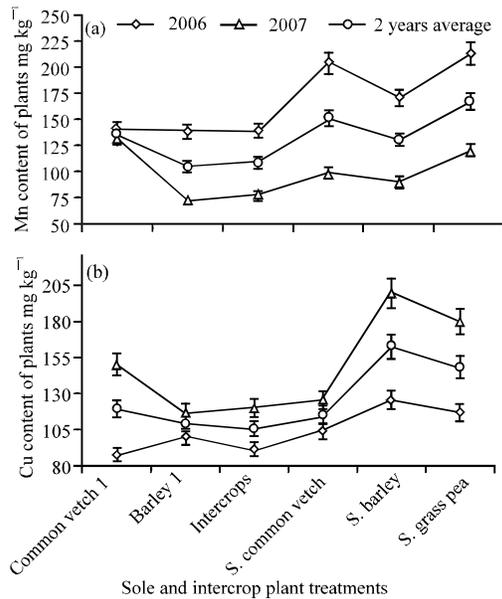


Fig. 4: Manganese and copper contents of common vetch (I), barley (I), intercrop, sole common vetch, sole barley

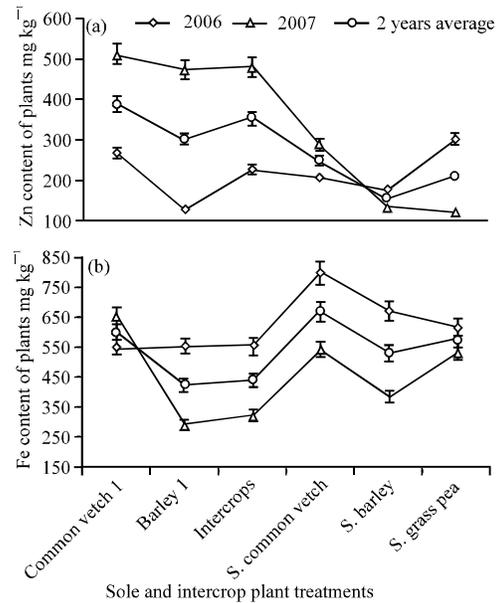


Fig. 5: Zinc and iron contents of common vetch (I), barley (I), intercrop, sole common vetch, sole barley

of these years (Fig. 5). Zn and Fe contents of all the plants was over Zn and Fe requirements of growing and finishing cattle (30 mg kg⁻¹ Zn and 50 mg kg⁻¹ Fe) and cows (30 mg kg⁻¹ Zn and 50 mg kg⁻¹ Fe) in gestating and early lactation stage issued by NRC (2000).

Mg, K, Mn, Zn and Fe contents of all the plants were under value of maximum tolerable concentration issued by NRC (2000). Only Cu contents were slightly over maximum tolerable concentration issued by NRC (2000) (100 mg kg⁻¹ Cu).

Over all, there were important differences in terms of Mg, Ca, Mn and Cu amongst intercrops (common vetch + barley), sole grass pea, sole common vetch and sole barley, common vetch (I) and barley (I). According to the results, sole grass pea, sole common vetch and common vetch (I) in Mg, sole grass pea, common vetch (I) and sole common vetch in Ca, common vetch (I), sole grass pea and sole common vetch in Mn and sole barley and sole grass pea in Cu had higher mineral content than the others for animal feeding. Legumes in terms of Mg, Ca and Mn were generally higher than barley but legumes in terms of Cu were similar or low.

The study revealed that researched plants had important potential in terms of macro and micro mineral contents in animal feeding. If farmers want rich forage in terms of Mg, Ca and Mn content, they should select sole grass pea and sole common vetch production. If farmers want rich forage in terms of Cu content, they should

select sole barley and sole grass pea production in organic manure conditions. This research will be general information in terms of macro and micro minerals for farmers preparing ration unmade forage analyses and cultivating this plant species in organic farmyard manure condition.

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