

Influence of Nitrogen Fertilizer on Ash, Organic Carbon, Phosphorus, Potassium, and Fiber of Forage Corn Intercropped by Three Cultivars of Berseem Clover as Cover Crops in Semi Arid Region of Iran

Ali Soleymani¹ & Mohamad Hesam Shahrajabian¹

¹ Department of Agronomy and Plant Breeding, Khorasgan (Esfahan) Branch, Islamic Azad University, Esfahan, Iran

Correspondence: Ali Soleymani, Department of Agronomy and Plant Breeding, Khorasgan (Esfahan) Branch, Islamic Azad University, Esfahan, PO box 81595-158, Iran. E-mail: a_Soleymani@khuisf.ac.ir

Received: March 1, 2012 Accepted: March 28, 2012 Online Published: June 12, 2012

doi:10.5539/ijb.v4n3p38

URL: <http://dx.doi.org/10.5539/ijb.v4n3p38>

Abstract

Supplementation of animal feeds with high quality needs new agriculture management, like intercropping system. In order to determine qualitative characteristics of forage corn intercropped by berseem clover cultivars in different levels of nitrogen fertilizer, an experiment was conducted in 2010 at Research Farm, Faculty of Agriculture, Islamic Azad University, Khorasgan Branch, Esfahan. A factorial layout within randomized complete block design with 3 replications was used. Cultivars were Karaj, Sacromont and Multicut, and nitrogen levels were included 0, 40 and 60 kg/ha. The nitrogen fertilizer was provided from urea source (46% pure N). Cultivar had significant effect on ash percentage, P, organic carbon of soil and soil nitrogen percentage. Nitrogen had significant influence on ash, K, organic carbon of soil, soil nitrogen percentage, light transmission, solar radiation absorption and extinction coefficient. Organic carbon of soil and soil nitrogen percentage just significantly influenced by cultivar and nitrogen interaction. In this experiment the highest ash percentage, organic carbon of plant, ENDF was obtained in forage corn intercropped by Multicut. The maximum organic carbon of soil and soil nitrogen percentage also related to forage corn and Multicut intercropping. The highest ash percentage, organic carbon, ENDF, organic carbon of soil, soil nitrogen percentage and solar radiation absorption was obtained in forage corn and Multicut intercropping.

Keywords: ash, organic carbon, nitrogen, forage corn, berseem clover

1. Introduction

Plants growth may be limited either because of lack of sufficient light, water, and nutrients in the environment or because of competition for these resources from other plants (Friday & Fownes, 2000). Supplementation of animal feeds needs new agricultural management (Friday & Fownes, 2000). Two or more crops planted together were known as intercropping system in order to maximize beneficial interactions (Ghanbari et al., 2010). The increase in agricultural productivity during the 20th century was obtained through the use of high levels of external inputs, and agricultural intensification produced environmental pollution by agrochemicals and excessive utilization of fertilizers (Unlu et al., 2010). Corn (*Zea mays L.*) is one the most important cereal crop grown in Iran (Seyed Sharifi et al., 2009) and the world (Kamara et al., 2006; Bekavac et al., 2007; Doka & Pepo, 2009; Carpici et al., 2010). Maize is important crop in industrial and livestock production (Olaniyan & Lucas, 2004; Oktem, 2008; Kusaksiz, 2010). The yield of maize in Iran is very low as compared to other maize producing countries (Seyed Sharifi & Taghizadeh, 2009). Maize intercropped with a legume is the appropriate management to have surplus cash income (Shisanya, 2005). Forage maize has become a major constituent of ruminant rations in recent years (Javanmard et al., 2009). One of the most important effective factors is non application of optimal amounts of nitrogen fertilizer per hectare (Limon-Ortega, 2009; Seyed Sharifi & Taghizadeh, 2009; Cabrera-Bosquet et al., 2011). The rates of inputs especially nitrogen is important if the aim is to maximize, or make consistent, levels of nutrients in plants (Odunze et al., 2004; Russo, 2006). Basbag et al. (2009) reported that crude ash, ADF and NDF in alfalfa was 8.0-18.6%, 16.8-33.3% and 63.0-75.8%, respectively. The amount of minerals in forages and their bioavailability need to be considered (Evitayani Warly et al., 2006). Warly et al. (2006) concluded that deficiency or imbalance of certain minerals of the forages is not suitable to feeding animals. Pieretii (2005) also demonstrated that nutritive value of forages is important for

several reasons. Ash concentration of maize-cowpea was higher than that of sole maize, but sole cowpea had higher ash concentration compared to sole maize and intercrops (Dahmardeh et al., 2009). There were differences amongst various sole crops and intercropping mixtures in terms of organic matter (Yolcu et al., 2009). Intercropping is one sustainable idea that can greatly increase the use of solar radiation. The additional solar energy used by the intercrop canopy leads to improved crop production, and thus greater economic yield (Awal et al., 2006). The canopy's extinction coefficient, the most critical element of Beer's law, defined as the average projection of leaves onto a horizontal surface, is a function of the area and form of the leaf, the leaf inclination, the zenith angle of the sun, and the leaf's azimuth (Awal et al., 2006). Organic carbon in arable lands has a favorable effect on soil fertility, crop production, soil sustainability and soil biological productivity (Batjes, 1996; Marton, 2008). Lavado et al. (2001) illustrated that potassium and phosphorus content was varied between 11.2 to 11.0 g kg⁻¹ and 1.2 to 1.6 g kg⁻¹, respectively. Fassio et al. (2009) concluded that the maximum and minimum ash percentage of grain corn was 1.3% and 3.8%, respectively. Kruse et al. (2008) reported that a maximum difference of 58.1 g NDF in silage maize. Different cultivars showed different reactions and responses to various agricultural managements (Soleymani et al., 2010). Pepo (2011) reported that the productivity of a specific field ecosystem is greatly influenced by the degree and length of the impact by the factors disturbing the equilibrium. There are no reported studies on Influence of nitrogen fertilizer on ash, organic matter, phosphorus, potassium, cellulose and fiber of forage corn intercropped by three cultivars of berseem clover. Therefore, the present study was aimed to evaluate those parameters in semi arid climatic condition of Iran.

2. Materials and Methods

The aim of this experiment was to determine ash, organic carbon, P, K, ENDF, organic carbon of soil, soil nitrogen percentage, light transmission, solar radiation absorption and extinction coefficient of forage corn intercropped by three berseem clover cultivars in different nitrogen levels in 2010. This research was done at Research Farm, Faculty of Agriculture, Islamic Azad University, Khorasgan Branch (Esfahan) (latitude 32°40' N, longitude 51°58' E, and 1570 m elevation). A factorial layout within randomized complete block design with 3 replications was used. Cultivars were Karaj, Sacromont and Multicut, and nitrogen levels were included 0, 40 and 60 kg/ha. The nitrogen fertilizer was provided from urea source (46% pure N). The soil preparation consisted of mouldboard ploughing followed by discing and smoothing with a land leveler. Ditches were prepared separately for each replication. Ditches were prepared separately for each replication. The distance between rows of forage corn was 100 cm and clover cultivars were planted on the basis of 20 kg seed per ha. Clover cultivars seed were planted at distance between forage corn rows. Plantation was done 15 June by skillful workers. The first irrigation was done after plantation, the second irrigation for better seedling establishment was done four years after first irrigation. Other irrigation interval was 8 years. Weeds were controlled by hand weeding. Clover cultivars were harvested at 15% of flowering stage. The second cut was used as green manure. Ash content determined by incinerating the samples in a muffle furnace at 550 °C for 4 h. Phosphorus estimated by colorimetric method (Badrzadeh et al., 2008). A flame photometer used for determination of K (Badrzadeh et al., 2008). Neutral detergent fiber evaluated by the method of Van Soest and Wine (1968) with enzyme addition. Soil organic carbon samples determined by the Tyurin method (Marton, 2008). For determining light transmission (T), solar radiation absorption (A) and extinction coefficient (K), equation number 1, 2 and 3 were used respectively. I and I₀ mean the solar radiation under plant canopy and solar radiation absorption above of plant canopy.

$$T = \frac{I}{I_0} \times 100 \quad (1)$$

$$A = 100 - T \quad (2)$$

$$\frac{\ln I}{I_0} = -K(LAI) \quad \longrightarrow \quad T = -\ln(I/I_0) / LAI \quad (3)$$

Data were subjected to analysis of variance (ANOVA) using statistical analysis system, followed by Duncan's multiple range test and differences were considered significant at P<0.05 by MSTAT-C software.

3. Results and Discussion

The effect of cultivar on ash percentage was significant, but organic matter was not influenced by cultivar significantly (Table 1). Among the three cultivars, intercropping of forage corn by Multicut performed better ash percentage, but there was no significant difference between Karaj and Sacromont. The maximum organic carbon was obtained in forage corn and Multicut intercropping, but there was no significant difference found between

these three cultivars (Table 2). Fassio et al. (2009) noted that organic matter digestibility of corn varied between 77.6% and 92.1%. Phosphorus content was significantly influenced by cultivar, but K content and ENDF was not significantly influenced by cultivar treatments (Table 1). ADF and NDF have been regarded as good indicators of forage quality because of their negative relation to digestibility for livestock animals (Bao et al., 2007). Sacromont had obtained the highest P content. There was also significant difference in P content between cultivation of Karaj and Multicut. The differences in K content and ENDF between berseem clover cultivars were not significant (Table 2). The highest organic carbon of soil and soil nitrogen percentage was related to forage corn and Multicut intercropping. Forage crop production and quality is very important for successful animal production (Yolcu et al., 2009). Cultivar treatments did not influenced light transmission, solar radiation absorption and extinction coefficient to the level of significant (Table 1). The maximum light transmission and solar radiation absorption was related to intercropping of forage corn with Sacromont and Multicut, respectively. There was no significant difference in extinction coefficient between these three cultivars (Table 2). Ash percentage and K content was significantly influenced by nitrogen fertilizer (Table 1). Ash percentage in application of 60 kg N/ha was more than others. Application of 40 kg N/ha produced maximum K percentage (789.5 ppm) (Table 2). Sing et al. (2009) indicated that the highest ash content in popcorn, white corn, sweet corn and dent corn was 2.7%, 1.2%, 1.8% and 1.2%, respectively. Nitrogen application had non significant effect on organic carbon, P content and ENDF, while cultivar had significant influence on organic carbon of soil (Table 1). Maximum and minimum organic carbon of soil were noted in application of 60 kg N/ha (1.26%) and control treatment (0 kg N/ha) (1.10%), respectively. Marton (2008) concluded that N fertilization resulted in a significant decline (16.6%) in SOC in comparison to the control plots in the 1st 20-year interval, while in the 2nd 20-year period a significant rise (up to 31.9%) was registered. ENDF was increased from application of 0 to 60 kg N/ha, but it was not significant (Table 2). Reduction in fiber content of forage cause significantly increase in digestibility of the forage (Javanmard et al., 2009). Soil nitrogen percentage and light transmission was significantly influenced by nitrogen (Table 1). The maximum soil nitrogen percentage and light transmission was obtained in application of 60 kg N/ha and 0 kg N/ha, respectively (Table 2). Among these three nitrogen fertilizer treatments, application of 0 and 40 kg N/ha produced the same soil nitrogen percentage (0.11%) (Table 2). Data showed that nitrogen has a significant effect on solar radiation absorption and extinction coefficient (Table 1). Soleymani et al. (2011) concluded that nitrogen had significant effect on solar radiation absorption, but light transmission was not significantly influenced by nitrogen fertilizer. Regarding nitrogen treatments, maximum solar radiation absorption was noted in application of 60 kg N/ha, but the difference between 40 and 60 kg N/ha was not significant. Extinction coefficient in no application of nitrogen fertilizer (0 kg N/ha) was more than other nitrogen treatments (Table 2). Wang et al. (2007) illustrated that significant differences content was found in barley cultivars, they also concluded that the plant quality was also sensitive to the growing conditions, especially nitrogen level. Soleymani et al. (2011) noted that phosphorus significantly influenced by cultivar and nitrogen, but the effect of cultivar and nitrogen on potassium content was not significant. In that experiment the maximum phosphorus and potassium content was found in application of 40 kg N/ha and 60 kg N/ha, respectively. Cultivar and nitrogen interaction had significant influence on organic carbon of soil and soil nitrogen percentage (Table 1). The maximum organic carbon of soil was obtained in forage corn and Multicut intercropping with application of 40 kg N/ha. Forage corn and Multicut interaction with application of 40 kg N/ha had obtained the highest soil nitrogen percentage (0.14%) (Table 2).

Table 1. Analysis of variance for experimental characteristics

S.O.V	d.f	Ash	Organic carbon	P	K	END F	Organic carbon of soil	soil nitrogen percentage	Light transmissi	Solar radiation absorption	Extinction coefficient
Replication	2	1.14 ^{ns}	14.11 ^{ns}	2777.32 ^{ns}	2678.04 ^{ns}	4.98 ^{ns}	0.0001	0.0001**	0.032	0.033	0.002 ^{ns}
Cultivar	2	4.59**	19.20 ^{ns}	10897.37*	4892.52 ^{ns}	3.14 ^{ns}	0.123**	24.66**	4.105 ^{ns}	4.206 ^{ns}	0.002 ^{ns}
Nitrogen	2	2.92*	11.96 ^{ns}	7303.73 ^{ns}	13221.49*	1.02	0.063**	12.66**	52.59**	51.623**	0.036**
Cultivar × Nitrogen	4	0.14	6.77 ^{ns}	2626.29 ^{ns}	5241.92 ^{ns}	2.59 ^{ns}	0.113**	45.33**	4.861	4.854 ^{ns}	0.002 ^{ns}
Error	16	0.56	14.08 ^{ns}	2622.10	2147.79	1.90	0.0001	0.0002**	2.942	2.843	0.001

* significant at 0.05 significance in F-tests

** significant at 0.001 significance in F-tests

^{ns} non significant.

Table 2. Mean comparison for ash (%), organic carbon (%), P (ppm), K (ppm) and ENDF (%), organic carbon of soil (%), soil nitrogen percentage (%) after corn harvesting, light transmission (%), solar radiation absorption (%) and extinction coefficient

Treatment	Ash	Organic carbon	P	K	ENDF	Organic carbon of soil	Soil nitrogen percentage	Light transmission	Solar radiation absorption	Extinction coefficient
Cultivar (C)										
Karaj(C1)	9.66b	1.16a	720.7b	723.1a	25.18a	1.16b	0.11b	9.73a	90.25a	0.3378a
Sacromont(C2)	9.44b	1.06a	775.0a	769.6a	25.86a	1.06c	0.10c	10.33a	89.66a	0.3612a
Multicut(C3)	10.78a	1.30a	710.1c	743.9a	26.36a	1.30a	0.13a	8.98a	91.00a	0.3328a
Nitrogen (N) (kg/ha)										
0	9.33b	1.10a	705.7a	727.3b	25.43a	1.10c	0.11b	12.45a	87.54b	0.4150a
40	10.11ab	1.16a	762.6a	789.5a	25.86a	1.16b	0.11b	8.66b	91.33a	0.3234b
60	10.44a	1.26a	737.5a	719.7b	26.10a	1.26a	0.12a	7.94b	92.04a	0.2933b
Cultivar×Nitrogen (C×N)										
C1N1	9.00b	1.00e	663.9i	668.3c	25.90abc	1.00e	0.10e	13.98a	86.01d	0.4367a
C1N2	10.00b	1.30b	781.4b	770.4ab	25.17bc	1.30b	0.13b	8.34cd	91.65ab	0.3137cd
C1N3	10.00b	1.20c	716.9f	730.4b	24.47c	1.20c	0.12c	6.89d	93.10a	0.2630d
C2N1	9.00b	1.10d	764.3d	756.5ab	25.17bc	1.10d	0.11d	12.83ab	87.16cd	0.4243a
C2N2	9.33b	0.80f	771.0c	792.1ab	25.83abc	0.80f	0.08f	8.93cd	91.05ab	0.3303bc
C2N3	10.00b	1.30b	789.6a	760.2ab	26.57ab	1.30b	0.13b	9.23cd	90.76ab	0.3290bc
C3N1	10.00b	1.20c	689.0h	757.1ab	25.23bc	1.20c	0.12c	10.52bc	89.47bc	0.3840ab
C3N2	11.00a	1.40a	735.3e	806.1a	26.57ab	1.40a	0.14c	8.72cd	91.27ab	0.3263bc
C3N3	11.33a	1.30a	706.0g	668.4c	27.27a	1.30a	0.13b	7.71cd	92.27ab	0.2880cd

Common letters within each column do not differ significantly.

4. Conclusions

Sustainability of the farming system can be improved by corn cropping with cover crops (Sainju et al., 2006). In this experiment the highest ash percentage, organic carbon of plant, ENDF was obtained in forage corn intercropped by Multicut. The maximum organic carbon of soil and soil nitrogen percentage also related to forage corn and Multicut intercropping. There was no difference between cultivars in solar radiation absorption, but forage corn and Multicut intercropping had obtained the highest one. The efficient use of solar radiation is one of the major criteria for obtaining a yield advantage through intercropping (Awal et al., 2006). Intercropping management and low input farming also can be applied to control soil erosion and reduce N leaching in the regions where cover crops can be grown and costs for energy requirement for N fertilization is a major concern. The response to N application depends upon the requirement of variety (Limon-Ortega et al., 2008). The highest ash percentage, organic carbon, ENDF, organic carbon of soil, soil nitrogen percentage and solar radiation absorption was obtained in forage corn and Multicut intercropping. Wang et al. (2007) illustrated that quality of the plant was dependent on growing conditions, especially N level in soil. A continuous measurement of the components of the radiation balance for different types of vegetation has become an almost standard procedure giving us information about the transformation of incoming solar radiation by vegetation (Svirezhev and Steinborn, 2001). Light transmission and extinction coefficient in no application of nitrogen fertilizer was higher than 40 and 60 kg N/ha.

References

Awal, M. A., Koshi, H., & Ikeda, T. (2006). Radiation interception and use by maize/peanut intercrop canopy.

- Agricultural and Forest Meteorology*, 139, 74-83. <http://dx.doi.org/10.1016/j.agrformet.2006.06.001>
- Badrzadeh, M., Zaragarzadeh, F., & Esmailpour, B. (2008). Chemical composition of some forage Vicia spp. in Iran. *Journal of Food Agriculture and Environment*, 6(2), 178-180.
- Bao, J. S., Jin, L., Shen, Y., & Xie, J. K. (2007). Genetic mapping of quantitative trait loci associated with fiber and lignin content in rice. *Cereal Research communications*, 35(1), 23-30. <http://dx.doi.org/10.1556/CRC.35.2007.1.4>
- Basbag, M., Demirel, R., & Avci, M. (2009). Determination of some agronomical and quality properties of wild alfalfa (*Medicago sativa* L.) clones in Turkey. *Journal of Food Agriculture and Environment*, 7(2), 357-359.
- Batjes, N. H. (1996). Total carbon and nitrogen in the soils of the world. *European Journal of Soil Science*, 47, 151-163. <http://dx.doi.org/10.1111/j.1365-2389.1996.tb01386.x>
- Bekavac, G., Purap, B., Stojakovic, M., Jockovic, D. J., Ivanovic, M., & Nastasic, A. (2007). Genetic analysis of stay-green trait in broad-based maize populations. *Cereal Research Communications*, 35(1), 31-41. <http://dx.doi.org/10.1556/CRC.35.2007.1.5>
- Cabrera-Bosquet, L., Molero, G., Stellacci, A. M., Bort, J., Nogues, S., & Araus, J. L. (2011). NDVI as a potential tool for predicting biomass, plant nitrogen content and growth in wheat genotypes subjected to different water and nitrogen conditions. *Cereal Research Communications*, 39(1), 147-159. <http://dx.doi.org/10.1556/CRC.39.2011.1.15>
- Carpici, E. B., Celik, N., & Bayram, G. (2010). Yield and quality of forage maize as influenced by plant density and nitrogen rate. *Turkish Journal of Field Crops*, 15(2), 128-132.
- Dahmardeh, M., Ghanbari, A., Syasar, B., & Ramrodi, M. (2009). Intercropping maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.) as a whole-crop forage: Effects of planting ratio and harvest time on forage yield and quality. *Journal of Food Agriculture and Environment*, 7(2), 505-509.
- Doka, L. F., & Pepo, P. (2009). Yield and water balance of maize grown in rotation on chernozem soil. *Cereal Research Communications*, 37(4), 611-621. <http://dx.doi.org/10.1556/CRC.37.2009.4.16>
- Evitayani, Warly, L., Fariani, A., Ichinohe, T., Hayashida, M., Abdul, Razak S.A., & Fujihara, T. (2006). Macro mineral distribution of forages in South Sumatra during rainy and dry seasons. *Journal of Food Agriculture and Environment*, 4(2), 155-160.
- Fassio, A., Fernandez, E. G., Restaino, E. A., La Manna, A., & Cozzolino, D. (2009). Predicting the nutritive value of high moisture grain corn by near infrared reflectance spectroscopy. *Computers and Electronics in Agriculture*, 67, 59-63. <http://dx.doi.org/10.1016/j.compag.2009.03.001>
- Friday, J. B., & Fownes, J. H. (2001). A simulation model for hedgerow light interception and growth. *Agricultural and Forest Meteorology*, 108, 29-43. [http://dx.doi.org/10.1016/S0168-1923\(01\)00220-9](http://dx.doi.org/10.1016/S0168-1923(01)00220-9)
- Ghanbari, A., Dahmardeh, M., Siashsar, B. A., & Ramroudi, M. (2010). Effect of maize (*Zea mays* L.)- cowpea (*Vigna unguiculata* L.) intercropping on light distribution, soil temperature and soil moisture in arid environment. *Journal of Food Agriculture and Environment*, 8(1), 102-108.
- Javanmard, A., Dabbagh Mohammadi Nasab, A., Javanshir, A., Moghaddam, M., & Janmohammadi H. (2009). Forage yield and quality in intercropping of maize with different legumes as double-cropped. *Journal of Food Agriculture and Environment*, 7(1), 163-166.
- Kamara, A. Y., Kureh, I., Menkir, A., Kartung, P., Tarfa, B., & Amaza, P. (2006). Participatory on-farm evaluation of the performance of drought-tolerance maize varieties in the Guinea savannas of Nigeria. *Journal of Food Agriculture and Environment*, 4(1), 192-196.
- Kruse, S., Herrmann, A., Kornher, A., & Taube, F. (2008). Evaluation of genotype and environmental variation in fibre content of silage maize using a model-assisted approach. *European Journal of Agronomy*, 28, 210-223. <http://dx.doi.org/10.1016/j.eja.2007.07.007>
- Kusaksiz, T. (2010). Adaptability of some new maize (*Zea mays* L.) cultivars for silage production as main crop in Mediterranean environment. *Turkish Journal of Field Crops*, 15(2), 193-197.
- Lavado, R. S., Porcelli, C. A., & Alvarez, R. (2001). Nutrient and heavy metal concentration and distribution in corn, soybean and wheat as affected by different tillage systems, in the Argentine Pampas. *Soil and Tillage research*, 62, 55-60. [http://dx.doi.org/10.1016/S0167-1987\(01\)00216-1](http://dx.doi.org/10.1016/S0167-1987(01)00216-1)
- Limon-Ortega, A. (2009). Wheat grain yield response to N application evaluated through canopy reflectance. *Cereal Research Communications*, 37(4), 595-601. <http://dx.doi.org/10.1556/CRC.37.2009.4.14>
- Limon-Ortega, A., Villasenor-Mir, E., & Espitia-Rangel, E. (2008). Nitrogen management and wheat genotype

- performance in a planting system on narrow raised beds. *Cereal Research Communications*, 36(2), 343-352. <http://dx.doi.org/10.1556/CRC.36.2008.2.14>
- Marton, L. (2008). Effect of precipitation and fertilization on the changes in soil organic carbon (SOC). *Cereal Research Communications*, 36(4), 611-622. <http://dx.doi.org/10.1556/CRC.36.2008.4.10>
- Odunze, A. C., Tarawali, S. A., de Haan, N. C., Akouegun, E., Amadji, A. F., Schultze-Kraft, R., & Bawa, G. S. (2004). Forage legumes for soil productivity enhancement and quality fodder production. *Journal of Food Agriculture and Environment*, 2(2), 201-209.
- Oktem, A. (2008). Determination of selection criterions for sweet corn using path coefficient analyses. *Cereal Research Communications*, 36(4), 561-570. <http://dx.doi.org/10.1556/CRC.36.2008.4.5>
- Olanayan, A. B., & Lucas, E. O. (2004). Maize hybrids cultivation in Nigeria- A review. *Journal of Food, Agriculture and Environment*, 2(3&4), 177-81.
- Peiretti, P. G. (2005). Prediction of the gross energy value of Mediterranean forages. *Journal of Food Agriculture and Environment*, 3(3&4), 102-104.
- Pepo, P. (2011). Role of genotypes and agrotechnical elements in cereal crop models. *Cereal Research Communications*, 39(1), 160-167. <http://dx.doi.org/10.1556/CRC.39.2011.1.16>
- Russo, V. M. (2006). Mineral nutrient and protein contents in tissues, and yield of navy bean, in response to nitrogen fertilization and row spacing. *Journal of Food Agriculture and Environment*, 4(2), 168-171.
- Sainju, U. M., Whitehead, W. F., Singh, B. P., & Wang, S. (2006). Tillage, cover crops, and nitrogen fertilization effects on soil nitrogen and cotton and sorghum yields. *European Journal of Agronomy*, 25, 372-382. <http://dx.doi.org/10.1016/j.eja.2006.07.005>
- Seyed Sharifi, R., & Taghizadeh, R. (2009). Response of maize (*Zea mays* L.) cultivars to different levels of nitrogen fertilizer. *Journal of Food Agriculture and Environment*, 7(3&4), 518-521.
- Shisanya, C. A. (2005). Economic analysis of maize-tepary bean production using a soil fertility replenishment product (PREP-PAC) in semi arid Eastern Kenya. *Journal of Food Agriculture and Environment*, 3(2), 208-212.
- Singh, N., Bedi, R., Garg, R., Garg, M., & Singh, J. (2009). Physico-chemical, thermal and pasting properties of fractions obtained during three successive reduction milling of different corn types. *Food Chemistry*, 113, 71-77. <http://dx.doi.org/10.1016/j.foodchem.2008.07.023>
- Soleymani, A., Shahrajabian, M. H., & Naranjani, L. (2011). The responses of qualitative characteristics and solar radiation absorption of berseem clover cultivars to various nitrogen fertilizer levels. *Journal of Food Agriculture and Environment*, 9(2), 319-321.
- Soleymani, A., Shahri, M. M., Shahrajabian, M. H., & Naranjani, L. (2010). Responses of cultivars of canola to sulfur fertilizer and plant densities under climatic condition of Gorgan region, Iran. *Journal of Food Agriculture and Environment*, 8(3&4), 298-304.
- Svirezhev, Y. M., & Steinborn, W. H. (2001). Exergy of solar radiation: information approach. *Ecological Modelling*, 145, 101-110. [http://dx.doi.org/10.1016/S0304-3800\(01\)00409-4](http://dx.doi.org/10.1016/S0304-3800(01)00409-4)
- Unlu, H., Sari, N., & Solmaz, I. (2010). Intercropping effect of different vegetables on yield and some agronomic properties. *Journal of Food Agriculture and Environment*, 8(3&4), 723-727.
- Van Soest, P. J., & Wine, R. H. (1968). Determination of lignin and cellulose in acid-detergent fiber with permanganate. *J. Assoc off Anal Chem*, 51, 780-785.
- Wang, J. M., Chen, J. X., Dai, F., Wu, F. B., Yang, J. M., & Zhang, G. P. (2007). Protein fractions in barley grains as affected by some agronomic factors and their relationships to malt quality. *Cereal Research Communications*, 35(1), 129-140. <http://dx.doi.org/10.1556/CRC.35.2007.1.15>
- Warly, L., Fariani, A., Evitayani, Hayashida, M., & Fujihara, T. (2006). Mineral status of forages and grazing goats in West Sumatra, Indonesia: 1. Macro minerals. *Journal of Food Agriculture and Environment*, 4(2), 234-236.
- Yolcu, H., Polat, M., & Aksakal, V. (2009). Morphological, yield and quality parameters of some annual forages as sole crops and intercropping mixtures in dry conditions for livestock. *Journal of Food Agriculture and Environment*, 7(3&4), 594-599.