International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 9 No. 2 Sep. 2014, pp. 228-236

http://www.ijisr.issr-journals.org/

Effect of integrated use of organic and mineral fertilizer on some quality parameters of maize (*Zea mays* L.)

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ABSTRACT: Afield experiment was conducted to study the effect of integrated use of organic and inorganic fertilizers on some quality parameters of two maize cultivars in arid land in west Saudi Arabia during two seasons 2012/2013 and 2013/2014. The experiment was laid out in split split plot arranged in a randomized complete block design with three replications. The experiment consisted of two maize cultivars, three levels of chemical fertilizers NPK (20:20:20) applied at 100, 500 and 1000kg/ha and eight treatments of alfalfa green manure, chicken manure, cow manure and their combinations. The quality parameters studied were protein, oil and minerals content. The results indicated that protein content of maize grains was increased significantly with the increasing of chemical fertilizer for the two seasons, whereas the application of organic fertilizers increased the protein content significantly only in the second season. All measured quality parameters under organic treatments were recorded the highest and significant values in the second season. Among the organics, the combination of alfalfa, chicken and cow manures was superior to other treatments in term of protein content and minerals, where the highest protein content recorded in the second season was 11.14% comparing to the lowest value recorded by the control which was 9.63%, the mineral content in the second season for the same treatment for potassium, calcium, iron and zinc was 17.99, 2.09, 0.69 and 0.18 g/kg whereas for the control was 16.65, 1.29, 0.473 and 0.074 g/kg for K, Ca, Fe and Zn respectively. The oil content was affected by organic manures only in the second season. Alfalfa green manure recorded the highest oil content in the second season with a percentage of 5.6% whereas the lowest content was recorded by the control which was 5.11%.

KEYWORDS: Zea mays, organic manure, protein content, oil content, minerals content, NPK.

INTRODUCTION

Organic inputs such as green manure and animal manures has great potential for improving soil properties and crop yield as well as nutrients availability, however, sole application of organic sources of plant nutrients do not produce remarkable increase in crop yields due to their low nutrient status. Therefore, to maintain soil productivity on a sustainable basis, combination of organic and chemical sources of nutrient needs to be adopted. Continuous use of plant and animal organic nutrient sources help to build up soil organic matter, encourage microbial activity, and improve physical properties of the soil. Whereas, the sole use of chemical nutrient sources provide mainly one or more essential plant nutrient which the soil cannot supply in adequate quantities. Generally, arid land soils are of low essential fertility and therefore require external inputs to be improved. On the other hand the disposal of organic wastes is representing a serious environmental problem and therefore, the decomposing of these wastes into organic fertilizers for crop production will help in sustaining soil productivity and decreasing agricultural inputs (Bruce et al., 2007).Application of available sources of organic plant nutrients for enhancing soil fertility and sustaining crop productivity should be used in an integrated manner (FAO, 1993). Recently, there is a growing interest in the tropical world in using organic sources of plant nutrients for improving soil productivity in order to reduce the use of inorganic fertilizers [Ayeni and Adetunji, 2010]. Moreover, there is abundance of organic sources such as farm residues, green manure and animal manures, in addition, the effect of integrated use of organic and mineral fertilizers on improving the quality of crops didn't receive much research attention. These reasons demanded the need to

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study the possible use of available organic sources and mineral fertilizer to improve the yield and quality of such crops. It is within this context that this study was carried out in arid land in west of Saudi Arabia to quantify the effects of organic and mineral fertilizers and their combinations on protein, oil and minerals content of grain of two maize cultivars.

MATERIALS AND METHODS

Field Experiments

The field experiment was conducted on loamy sand soil at the Agricultural Research Station of faculty of meteorology, environment and arid land agriculture, King Abdulaziz University, Saudi Arabia. The experiment was laid out in split split plot arranged in a randomized complete-block design with four replications. The treatments included two maize cultivars, Single Hybrid 13 Bashair (white grain) and Trihybrid 352 (yellow grain) , these two cultivars represented the main plots and they named later CV1 and CV2 respectively. NPK (20:20:20) was applied in the subplots at three levels (100, 500 and 1000 kg ha -1) , while organic fertilizer comprised of eight treatments including alfalfa green manure, chicken , cow manures and their combination were applied in the sub sub plots of the experiments at 20 t/ha. NPK fertilizer was split into four doses, the first dose was applied 15 days after sowing and then 15 days interval for the other three doses, while the organic fertilizer was incorporated into soil one month before sowing. After harvesting, three representative samples of grain powder of each treatment were taken for determining protein oil and mineral content.

Table 1. The treatments of organic nutrients sources and their combinations

Treatment No	Organic amendment
1	Control (No amendment)
2	Alfalfa manure
3	Cattle manure
4	Chicken manure
5	Alfalfa + Cattle manure
6	Alfalfa + Chicken manure
7	Cattle manure + Chicken manure
8	Alfalfa + Cattle +Chicken manure

Determination of grain protein content (%)

Triplicate representative grains samples from each treatment were taken at maturity stage from each treatment for the determination of nitrogen content. The samples were oven dried at 70 °C to a constant weight. The content of nitrogen was determined by digestion methods using Micro-Kjeldahl's apparatus as described by American Association of Cereal Chemists (AACC, 2000). The percentage of protein in the grain was calculated by multiplying the grain N content with a constant factor of 6.25 and results were expressed on dry weight basis.

Determination of oil content

Oil contents were determined by Soxhlet Fat Extraction method described by Low, 1990 .

Deamination of mineral content

potassium (K) was determined by Flame Spectrophotometry, while Calcium Ca), Iron (Fe) , and , Zinc were determined by Atomic Absorption Spectrophotometry.

Statistical Analysis

All data were analyzed by analysis of variance (ANOVA) procedures using SAS program (2006). After analysis of variance, the treatment means were separated by revised LSD test according to El-Nakhlawy (2010).

RESULTS AND DISCUSSION

Protein content

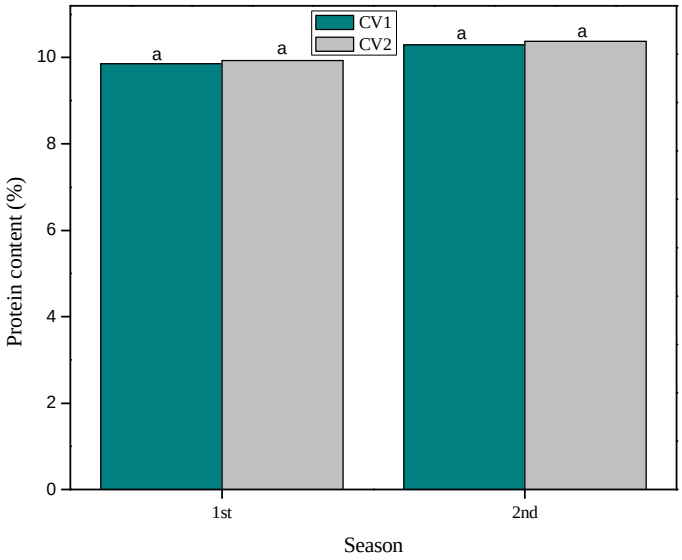

Figure 1. Effect of two maize cultivars on protein content

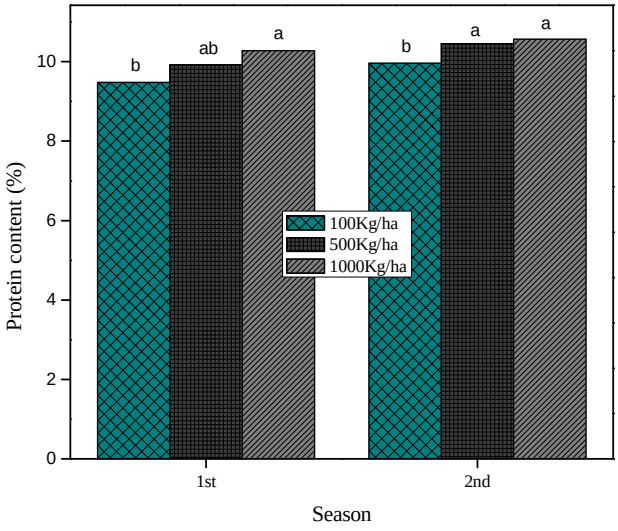

Figure 2. Effect of different levels of NPK fertilizer on protein content

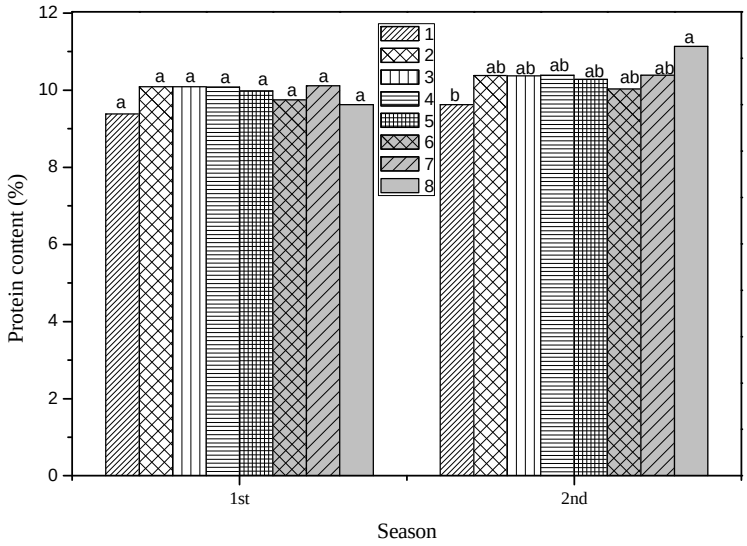

Figure 3. Effect of different sources of organic fertilizers and their combinations on protein content

Combined application of organic and inorganic source of nutrients on protein content of maize graininidicated that protein content increased significantly among various treatments. In the first and second season, the two cultivars did not show any significant differences. The average protein content for CV1 was 9.93% and 10.37%, while for CV2 was9.85% and 10.29% for the first and second season respectively (Figure 1).

Application of NPK fertilizers at different levels affected the protein content of maize grain significantly. In the first season, the protein content increased steadily with the increase of NPK fertilizer. In the second season the protein content was also increased according increasing level, however there was no significant difference in protein content of NPK dose of 500 and 1000kg/ha. The protein concentration values in respective for the first season were 100, 500 and 1000kg were 9.48, 9. 92 and 10. 27 while for the second season were 9.96, 10.45 and 10.57% respectively (Figure 2).

Application of organic sources and their combinations increased the protein content over the control in the first season, however, there was no significant differences among all the treatments, the highest value was 10.11%, which wasrecorded by the combination of alfalfa, cow and chicken manures, while the lowest value was 9.75% which was recorded by the control. In the second season, all the treatments of organic sources increased the protein content of maize grain significantly over the control, the highest value was recorded by the combination of alfalfa, cow and chicken manures, which was 10.39%, while the value of the control was 10.03% (Figure 3).The increase of protein content of maize grain could be attributed mainly to nitrogen added from either organic or inorganic sources. Nitrogen is the most important constituent of plant proteins and is required throughout the crop growth stages to enhance the formation of amino acids. The result of this study proved that the content of protein increased significantly with increasing dose of NPK application, similar result was observed by Weiser and Seilmeier (1998) who found that protein content was strongly influenced by nitrogen. Triboi et al. (2000) also reported that nitrogen is the main factor that affect the protein content of maize grain. Recently, Karasu (2012)reported similar result when he observed that protein content increased with increasing of nitrogen rate. This increase in overall protein content was due to consistent increase in different fractions of proteins. The protein is formed by different amino-acids which are constituted in higher amount due to availability of nitrogen in split doses during the all growth stages of the crop . Secondly, the slow release of nitrogen from organic sources was directly contributed to the grain protein formation and different fractions. Application of nitrogen at the optimum level was improved the protein content of maize (Amanullah et al., 2009), whereas the application of the nitrogen higher or lower than the optimum dose has adverse effects on the quality of maize (Stone et al., 1998). Therefore, the availability of nitrogen during grain filling stage is necessary to improve the protein content. Integration of organic and inorganic nitrogen sources is important for maize cop to have easy access to nitrogen whenever is needed throughout all growth stages. Increase in grain protein content of maize as a result of application of slow release source of nitrogen was reported by Amany et al. (2006).

Oil content

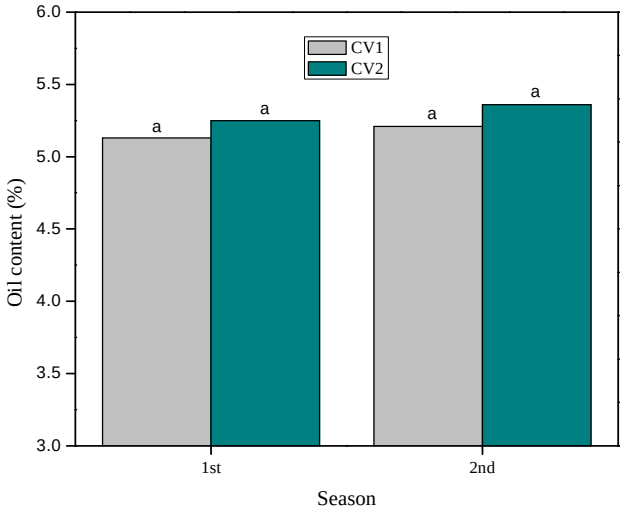

Figure 4. Effect of two maize cultivars on oil content

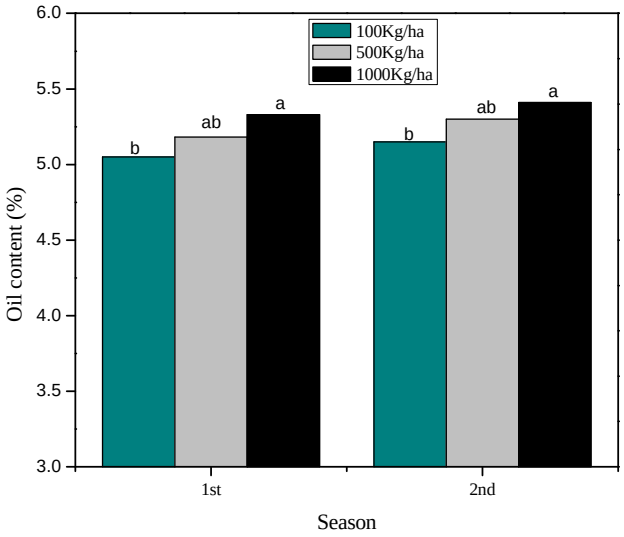

Figure 5. Effect of different levels of NPK fertilizer on oil content

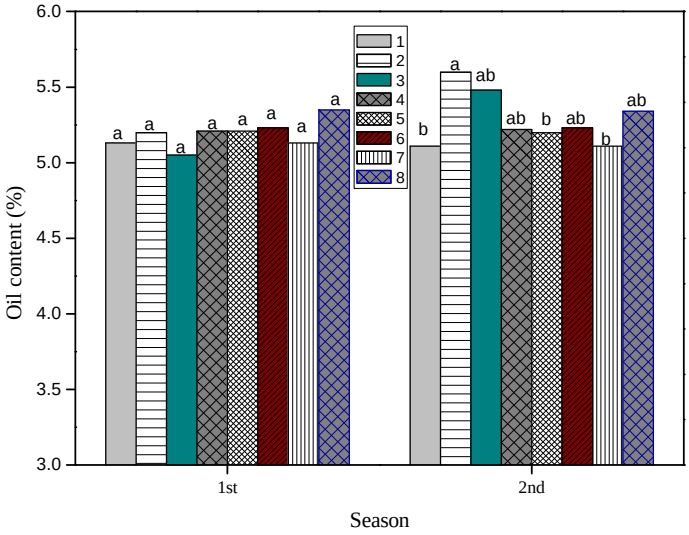

Figure 6. Effect of different sources of organic fertilizers and their combinations on oil content

Combined application of organic and inorganic source of nutrients on oil content of maize grain indicated that oil content increased significantly among various treatments. In the first and second season, the CV2 recorded higher oil content than CV1, however, the difference statistically was not significant. The average of oil content for the first season was 5.13% and 5.25%, while for the second season was 5.21% and 5.36% for CV1 and CV2 respectively (Figure 4).

Application of NPK fertilizers at different levels affected the oil content of maize grain significantly. In both seasons, the oil content increased steadily with the increase of NPK fertilizer. The oilcontent values for the three levels of NPK 100, 500 and 1000kg/ha in respective for the first season were 5.05%, 5.18% and 5.33% , while for the second season were 5.15%, 5.30 and 5.41% respectively (Figure 5). Application of organic sources and their combinations increased the oil content of some treatments over the control in the first season, however, there was no significant differences among all the treatments, the highest value was 5.35%, which was recorded by the combination of alfalfa, cow and chicken manures, while the oil content of the control was 5.2. In the second season, all the treatments of organic sources increased the oil content of maize grain significantly over the control, the highest oil content was recorded by the treatment of alfalfa green manure, the recorded value was 5.6 %, while the lowest value was recorded by the control, which was 5.11% (Figure 6). There was no significant difference among the treatments under the organic manures treatments in the first season, whereas in the second the season all the treatments increased the oil content of maize grain, the main reason was attributed to accumulation sulfur released by organic sources in the soil. Promoting effect of sulfur in grain oil content may be due to reason that sulfur is needed for the formation of disulfide bond between polypeptide chains. It has been found that oil contents of grains increases due to the disulphide bond formation between polypeptide chains which increases as sulfur concentrations increases. Sulfur is responsible for oil content increment as it is required in synthesis of co-enzyme A which involved in oxidation and synthesis of fatty acids. These results are in conformity with findings of (Azhar et al., 2011), (Rasheed *et al.*, 2004) and (Vilela*et al.*, 1995) [9] who found that sulfur induced higher oil contents in maize grains.

Minerals content

Table 2. Means for minerals content (K, Ca, Fe and Zn)

Treatments	Minerals content (g/Kg)							
	K		Ca		Fe		Zn	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Maize cultivars								
CV 1	16.82 a	17.27 a	1.097 b	1.415 b	0.420 b	0.467 b	0.075 b	0.116 b
CV2	16.42 b	16.97 a	1.510 a	2.206 a	0.541 a	0.673 a	0.106 a	0.178 a
LSD (0.05)	0.233	0.362	0.101	0.166	0.083	0.1123	0.028	0.026
NPK rates Kg/ha								
100	16.13 c	16.86 b	1.320a	1.762a	0.501a	0.567a	0.081a	0.129b
500	16.71 b	17.16 ab	1.329a	1.892a	0.458a	0.562a	0.094a	0.166a
1000	17.0243a	17.34 a	1.261a	1.777a	0.483a	0.581a	0.097a	0.145ab
LSD (0.05)	0.285	0.444	0.124	0.203	0.101	0.138	0.034	0.032
Organic fertilizers								
1	16.44 bc	16.65 c	0.869 c	1.296 d	0.427 bc	0.473 a	0.069 b	0.074 b
2	16.54 bc	16.93 bc	1.456 a	1.835 abc	0.459 bc	0.515 a	0.087 ab	0.148 a
3	16.52 bc	17.24 bc	1.219 b	1.895 abc	0.427 bc	0.535 a	0.082 ab	0.146a
4	16.44 bc	17.61 ab	1.489 a	2.082 a	0.559 ab	0.650 a	0.098 ab	0.157 a
5	16.09 c	16.74 c	1.187 b	1.691 bc	0.386 c	0.601 a	0.135 a	0.175 a
6	16.73 ab	16.69 c	1.379 ab	1.628 c	0.523 abc	0.489 a	0.856 ab	0.150 a
7	16.58 ab	17.11 bc	1.367 ab	1.966 ab	0.440 bc	0.609 a	0.082 ab	0.143 a
8	17.05 a	17.99 a	1.462 a	2.089 a	0.624 a	0.688 a	0.086 ab	0.181 a
LSD (0.05)	0.466	0.726	0.203	0.331	0.165	0.225	0.056	0.052

Means with same letter (s) in each column, are not statistically different at P ≤0.05

Organic nutrients sources affected the content of minerals in maize grain significantly. K is highly important for the seeds for sowing as low concentrations of K in seeds in general can negatively affect the rapidity of germination and development of seedlings (Hejcman et al. 2012, Nadeem et al. 2012), all the treatments were affected the content of potassium in maize grain. For both seasons the potassium content increased significantly with increasing rate of NPK fertilizer. Organic fertilizers treatments influenced the content of potassium, the highest values for the two seasons were recorded by the combination of alfalfa, chicken and cow manure which was 17.0 and 17.9 g/kg for the first and second season respectively. Calcium content was not affected by NPK fertilizers at all applications rates, whereas the organic treatment were increased the calcium content significantly over the control for the two seasons. The highest values for the two seasons were recorded by the combinations of alfalfa, chicken and cow manures which were 1.462 and 2.089 g/kg whereas the lowest values were recorded by the control which were 0.869 and 1.296 mg/kg for the first and second seasons respectively. The chemical fertilizer didn't affect the content of iron in maize grain, whereas some organic fertilizer treatments recorded higher values over the control. The combination of alfalfa, chicken and cow manure treatment recorded the highest iron content which were 0.624 and 0.688g/kg whereas the control values for the two seasons were 0.427 and 0.473 g/kg for the first and second season respectively. In the first season zinc was not affected by NPK application, while in the second season, NPK at 500 kg/ha increased the content of zinc significantly. All organic manure treatments increased zinc content significantly over the control for the second seasons. The maximum values for the two seasons were noticed with the treatment of the combination of alfalfa and cow manures, which were 0.135 g/kg and 0.175 g/kg for the first and second season respectively, whereas the lowest values were noticed with the control for the both seasons which were 0.069 g/kg and 0.074 g/kg respectively (Table 2). The integration of organic and inorganic fertilizers promoted significantly ($P < 0.05$) the minerals content in maize grain. This might be attributed to the micronutrient content in the organic manure and also the effect of organic acids produced during decomposition of soil minerals. Effect of mineral and organic manures on maize grain mineral content was observed by many studies. Prasad (1981) opined that organic manures increased the Zn and Fe content of maize from deficiency to sufficiency level, which caused the improvement in maize yield of calcareous soil. Kher and Minhas (1991) reported that the combined application of recommended dose of NPK and farm yard manure to maize-wheat rotation significantly increased the uptake of Zn, Mn and Fe in both crops. Ghosh *et al.* (2001) reported that application of farm yard

manure along with recommended dose of NPK fertilizer considerably increased the uptake of Zn, Mn, Cu and Fe by wheat over absolute control and recommended dose of fertilizer treatment.

CONCLUSION

The results presented herein prove that the application of organic and chemical sources improved the measured quality parameters of maize grain. The combination of alfalfa, chicken and cow manures with 500 kg/ha NPK (20:20:20) was the best among all studied treatments. Organic fertilizers containing micronutrients increase the content of minerals which are prerequisite for nutrition. Availability of soil nutrients should be checked on a regular basis to ensure easy accessibility and crop quality.

ACKNOWLEDGEMENTS

The authors are grateful and greatly indebted to King Abdulaziz City for Science and Technology (KACST) for full financial support of this project No (22- 12- ط -ت). Field and laboratory assistance by laboratory and research farm station staff is highly acknowledged.

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