Climate mitigation performance assessment based on agronomic and environmental indicators

ORGANIKO LIFE+ PROJECT

Revamping organic farming and its products in the context of climate change mitigation strategies

Type of deliverable: Report

Action C2, Activity 2.3

"Barley agronomic performance and potential benefits of OF"

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FINDINGS AT A GLANCE

There is no reduction of barley grain production when manure is used compared to ammonium nitrate.

Under the semi-arid conditions of Mediterranean, organic farming is not superior to conventional farming practices in terms of qualitative characteristics.

Executive Summary

Σκοπός

Στόχος της παρούσας έκθεσης είναι να παράσχει λεπτομερή στοιχεία για τα αγρονομικά χαρακτηριστικά (απόδοση και ποιοτικά χαρακτηριστικά) κριθαριού (σπόρος, σανός) και βίκου (σανός) σε πιλοτικά οργανικά συστήματα του ΙΓΕ και να τα συγκρίνει με τα αγρονομικά χαρακτηριστικά των φυτών κριθαριού και βιτών σε συμβατικό σύστημα παραγωγής. Η έκθεση αυτή εντάσσεται στο πλαίσιο της Δράσης C2 και ειδικότερα στο πλαίσιο της Δράσης C2.3.

Αντικτυπος

Οι μετρήσεις της απόδοσης κριθαριού (σπόρου και σανού) και βίκου (σανός) πραγματοποιήθηκαν σε τρεις καλλιεργητικές περιόδους σε διαφορετικά συστήματα διαχείρισης θρέψης. Υπολογίστηκαν τα ποιοτικά χαρακτηριστικά των δύο ειδών με μετρήσεις διαφόρων θρεπτικών σε σπόρους κριθαριού και χαρακτηριστικά πεπτικότητας σε σανό κριθαριού και βίκου.

Αποτελέσματα

Στην πιλοτική μονάδα, βρέθηκε ότι το γεωργικό σύστημα καθώς και η καλλιεργητική περίοδος επηρέαζουν σημαντικά τις αποδόσεις και τα ποιοτικά χαρακτηριστικά των φυτών κριθαριού και βίκου. Η παραγωγικότητα των τεμαχίων κριθαριού που εφαρμόστηκε χημικό λίπασμα ήταν υψηλότερη σε σύγκριση με τα τεμάχια που έλαβαν κομπόστ αλλά παρόμοια με εκείνα που έλαβαν κοπριά αιγοπροβάτων. Αντίθετα, η παραγωγικότητα του βίκου σε σανό ήταν παρόμοια και στα δύο συστήματα. Σε ότι αφορά τα ποιοτικά χαρακτηριστικά, αυτά ήταν παρόμοια μεταξύ των συστημάτων παραγωγής και παρουσιάστηκε μεγάλη μεταβλητότητα μεταξύ των καλλιεργητικών περιόδων και στα δύο είδη

Conclusion

Δεν υπάρχει μείωση της παραγωγής κριθαριού όταν χρησιμοποιείται κοπρία σε σύγκριση με τη χημική λίπανση. Δεν παρατηρήθηκαν διαφορές μεταξύ πρακτικών βιολογικής και συμβατικής καλλιέργειας στην παραγωγή βίκου. Τα ευρήματά μας υποδεικνύουν ότι κάτω από τις ξηρικές συνθήκες της Μεσογείου, η βιολογική γεωργία δεν είναι ανώτερη των συμβατικών γεωργικών πρακτικών όσον αφορά ποιοτικά χαρακτηριστικά των καλλιεργειών.

Executive Summary

Purpose

The aim of this report is to provide detailed data for the agronomic characteristics (yield and qualitative traits) of the barley grain and hay as well as vetch hay in pilot organic systems of ARI and compare them with the agronomic characteristics of barley and vetch plants grown under conventional farming system. This report is within the frame of Action C2 "Climate mitigation performance assessment based on agronomic and environmental indicators" and particularly within the Activity C2.3 "Barley agronomic performance and potential benefits of OF".

Outcome

Measurements of barley (grain and hay) and vetch (hay) yield were performed in three growing seasons under different nutrient management schemes. We estimated the qualitative characteristics of the two different crop species through measurements of several mineral in barley grain and digestibility traits in barley and vetch hay.

Results

In the current pilot farm we found that farming system as well as growing season significantly affected yields and qualitative characteristics of barley and vetch plants. The productivity of barley pilot plots received chemical fertilizer was higher compared to plots received compost but similar with those received goat manure. On the contrary, vetch hay productivity was similar in both systems. The qualitative traits of the crops were similar among nutrient management schemes and great variability was noticed between the growing seasons in both crop species.

Conclusion

There is no reduction of barley grain production when manure is used compared to ammonium nitrate. No differences between organic and conventional farming practices have been noticed in vetch hay. Our findings suggest that under the semi-arid conditions of Mediterranean, organic farming is not superior to conventional farming practices in terms of qualitative characteristics.

Introduction

Barley is the most important cereal in Mediterranean rim

Barley is the most important rain-fed crop not only for Cyprus but also for the Eastern Mediterranean Region. It is a main crop used for feed while it has an exceptional adaptation capacity to drought while it has no serious pest and disease problems.

The production of organic animal feed locally it is fundamental to support organic livestock products In addition, barley, it is an essential crop for the reduction of environmental deterioration. The low nutrient demands of the crop, make it a promising tool for the development and the exploitation of low fertility and degraded soils.

Low nutrient availability and weed competition reduce barley yield

The main disadvantage of the conversion from conventional organic farming in barley production is the reduction in yields, both hay and grain. The yield reduction in organic farming systems of semi-arid regions is related with the increased weed competition and the low nutrient availability of the poor soils especially during the conversion period while in semi-arid regions crop yield is affected from rainfall.

Nutritional value of organic and conventional products

Besides yield (grain and hay) the quality and the nutritional value of these products are of paramount importance for the farmers. Most of the studies found in the literature are primary focusing on yield and protein content while components like nutrient minerals are overlooked. There is an increased interest among scientists to explore differences between organic and conventional and communicate these findings to the policy makers, the public and the farmers.

Crop species and the environment affects feed digestibility

In addition, the impact of agricultural system on the digestibility of barley hay has not been examined in Cyprus. Previous studies showed that the crop species, variety as well as the environmental conditions are affecting these agronomical characteristics of barley hay. For example, research at ARI showed that under low rain fall conditions, cereal crops like Barley produce higher quantities of hay biomass than forage crops. In terms of feed chemical composition, like crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF), differences among forage legumes like chickpeas, vetch and fodder peas have been noticed.

So far, the differences among these characteristics between organic farming and conventional system was not assessed.In particular, there is a little of information on the grain and hay quality of rain-fed crops grown under different nutrient management schemes. In the current report we are presenting the agronomic characteristics (yield and qualitative traits) of the barley grain and hay as well as vetch hay grown under different nutrient management schemes within organic farming systems and compare them with the agronomic characteristics of barley and vetch plants grown under conventional farming system.

Material and Methods

Trial design

The organic managed experimental field was subjected to alternative N nutrient management strategies: i) goat composted manure (**MAN**) was applied at the rate of 1.2 tn/ha (101 kg N/ha) at the end of November each year and ii) compost (**COM**) derived from plant residues was applied at the rate of 1 tn/ha (111 kg N/ha) at the end of November each year. The conventional managed experimental field received ammonium nitrate (**FER**) at the rate of 180 kg/ha (60 kg N/ha). In vetch-seeded plots, the biomass was incorporated into the soil during flowering using rotavator. Before incorporation, the biomass produced in 1 m^2 was weight and a subsample of 300 g was used to determined N and dry biomass. Additional plots without the application of any external nitrogen input were used as negative control (**CNT**) treatments for all crops under study to determine the emission factors from each crop and each nutrient management scheme. All treatments were arranged in a randomized complete block design with three replicates on 21 m^2 plots and repeated in the same plots during three consecutive growing seasons (2016/2017, 2017/2018 and 2018/2019).

Nutrient analysis of barley grain, hay and vetch hay

Barley hay and grain and vetch hay samples were collected during the three growing seasons from each plot after harvesting and transferred to the premises of Agrobiotechnology Department of Agricultural Research Institute for the chemical analysis. Vetch was harvested for hay in spring when plants were at the pod formation stage, while barley was harvested for grain in summer when plants were at full maturity.

Samples were air-dried, grounded and passed through a 1-mm screen before analysis. Acid Detergent Fiber (ADF) and Neutral Detergent Fibers (NDF) have been determined using A.O.A.C methods. Total N was determined following the Kjeldahl method and total protein was determined using 5.7 factor. Atomic absorption spectrometry (AAS) after microwave assisted digestion was used to determine Ca, Mg, Mn, Cu and Fe in the samples.

Statistical analysis

General Linear Modeling was implemented to examine the impact of different trials (organic and conventional) on the multiple agronomic characteristics examined. All the statistical analysis and graphs have been performed using glm() function in R software and ggpubr package respectively. Mean differences between the various treatments were evaluated using emmeans package and Tukey HSD (a=0.05).

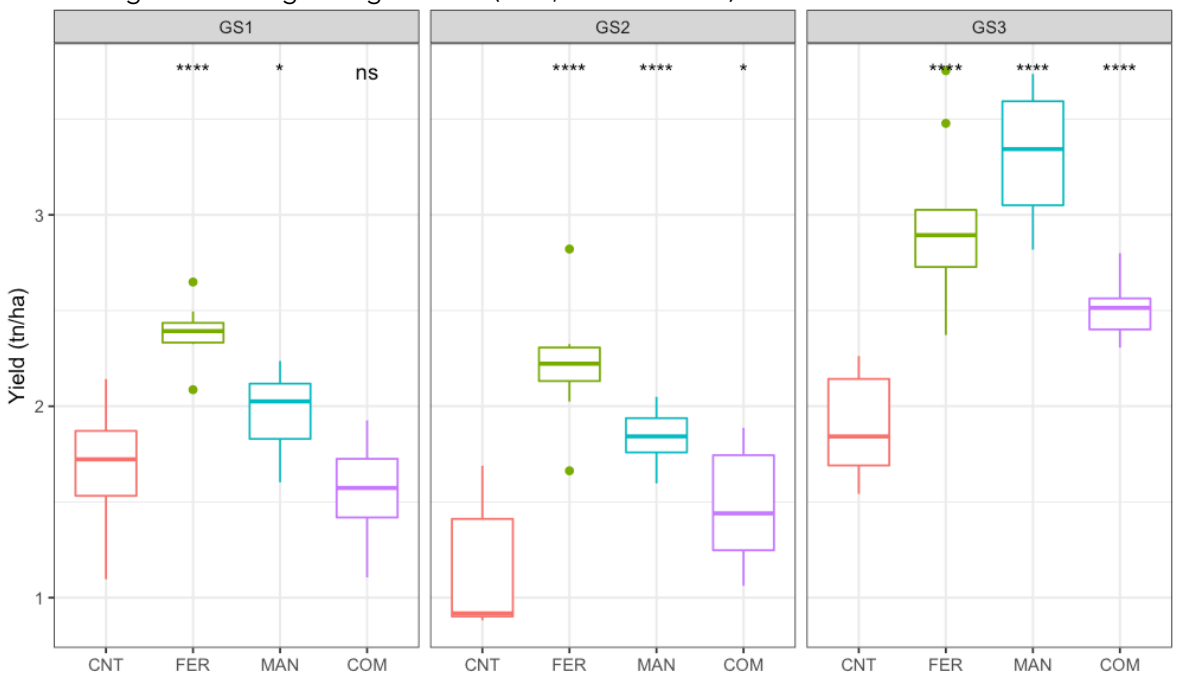
Results

Yields in organic farming

Barley grain production

Both growing season and nutrient management scheme significantly affected barley yield. During the first growing season the addition of compost didn't result in an increase of barley grain yield. On the contrary during the subsequent growing seasons the addition of any type of input (organic or inorganic) resulted in a substantial increase of barley grain production. The highest yield was noticed in plots received ammonium nitrate, followed by manure at least for the first two growing seasons (Figure 1).

Figure 1. Yield of barley (tn grain/ha) grown under different nutrient management strategies in three growing seasons (GS1, GS2 and GS3)



Barley grain production was higher in organic farming nutrient management schemes only during the third growing season and particularly in plots received goat manure. The application of compost resulted in an increase in barley productivity compared to the control only during the second and the third growing season.

The average grain yield of barley grown under the different systems

is depicted in Table 1.

Table 1. Barley seed yield (tn/ha) in three different growing seasons under different nutrient management schemes

	2016-2017	2017-2018	2018-2019
No input	1.67	1.13	1.90
Compost	1.55	1.46	2.52
Ammonium nitrate	2.39	2.21	2.97
Manure	1.98	1.84	3.28

Barley hay production

Hay is of great importance for livestock production in organic farming. Similarly with the results found for barley grains, compost application didn't result in a significant increase of hay production in the three growing seasons. Manure and fertilizer application cause a substantial increase compared to control and compost treated plots (Figure 2). The hay yield of the different nutrient management schemes is depicted in Table 2.

Figure 2. Yield of barley (tn hay/ha) grown under different nutrient management strategies in three growing seasons (GS1, GS2 and GS3)

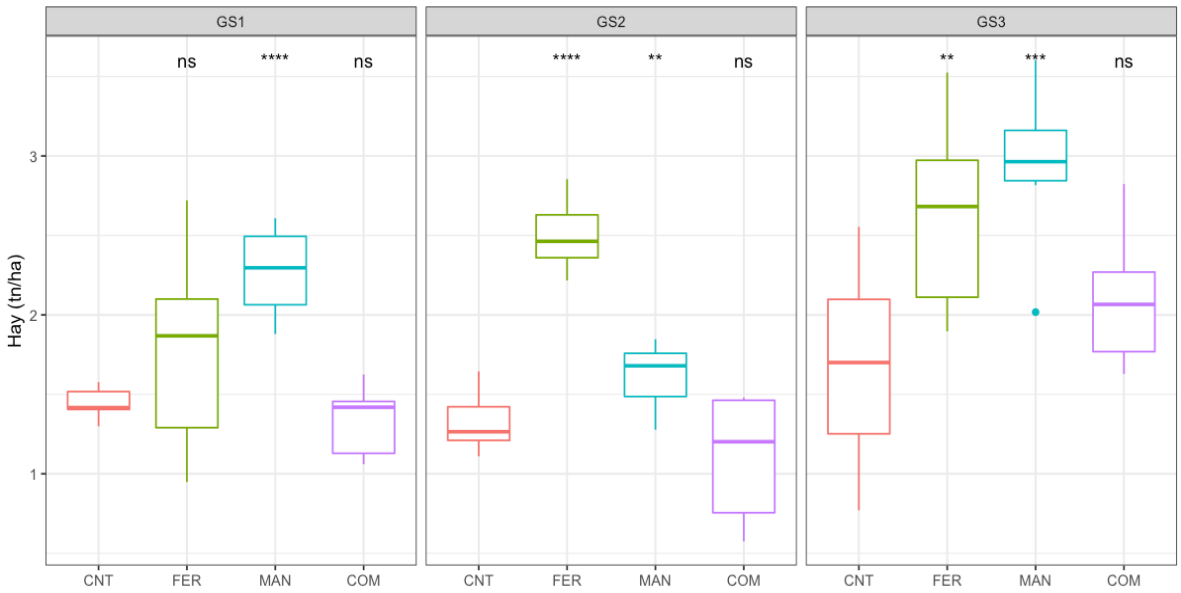


Table 2. Barley hay yield (tn/ha) in three different growing seasons under different nutrient management schemes

	2016-2017	2017-2018	2018-2019
No input	1.44 a	1.31 a	1.66 a
Compost	1.31 a	1.10 a	2.08 b
Ammonium nitrate	1.83 b	2.51 c	2.59 c
Manure	2.24 c	1.61 b	2.95 d

The effect of agricultural system in minerals of barley grains

Overall, growing season and nutrient management strategy significantly significantly affected barley grain content in total N, Ca, Mg, Zn, Mn, Cu and Fe. In Table 3 the two-way ANOVA results for the different nutrients measured during the trials are presented.

Table 3. Two-way ANOVA tests showing the variation between the nutrient minerals measured in Barley seeds from plants grown during three growing seasons at four different nutrient management strategies

	Total N	Ca	Mg	Zn	Mn	Cu	Fe
Season	0,09	*	0,12	0,32	*	***	**
Treatment	***	***	*	***	***	***	***
Interaction	***	***	**	**	***	***	***

Signif. codes: >0.001 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Overall, the highest level of N was observed in plots received ammonium nitrate and goat manure while barley plants grown in plots received no input had the lower N content. However this pattern was also affected by the growing season. For example, the total N in barley grains was always higher in plants received ammonium nitrate compare to control in all growing seasons. On the contrary, the total N

measured in barley grains received organic N inputs was different across the growing seasons. For example, barley grains harvested from compost treated plots, exhibited N content similar with that of control. The same pattern was noticed during the last growing season, in manure treated plots.

Ca levels in organic farming managed plots

The level Ca in organic managed plots ranged from 297 to 653 ppm with the lowest values to be observed in plots received organic compost. The levels of Ca however was different during the growing season. The highest Ca content in barley grain was observed in plots received manure, during the first growing season (2016-2017) and the second growing season (2017-2018) and were equal with 563 and 583 ppm respectively (Figure 3). During the third growing season (2018-2019) the levels of Ca in barley grain harvested from compost treated plots was substantially higher (500 ppm) compared to that of manure (418 ppm).

Mg levels in organic farming managed plots

The level of Mg in organic managed plots ranged from 511 to 1033 ppm in all growing seasons. The lowest content was noticed in plots received goat manure during 2018-2019 and the highest in barley grain harvested from plots received compost. Differences between COM and MAN treatments were noticed only during the first growing season (2016-2017) where seed content in Mg was 897 and 711 ppm in manure and compost treated plots respectively (Figure 3).

Zn levels in organic farming managed plots

Zn level in organic farming managed plots was substantially higher in plots received compost in all growing seasons. The amount of Zn in the grain received compost was 37.3, 41.4 and 46.7 compared to 29.4, 29.1 and 27.1 manure treated plots during the three growing seasons respectively (Figure 3).

Zn levels in organic farming managed plots

Zn level in organic farming managed plots was similar between compost and manure treated plots. higher in plots received compost in all growing seasons. The amount of Zn in the grain received compost was 37.3, 41.4 and 46.7 compared to 29.4, 29.1 and 27.1 manure treated plots during the three growing seasons respectively (Figure 3).

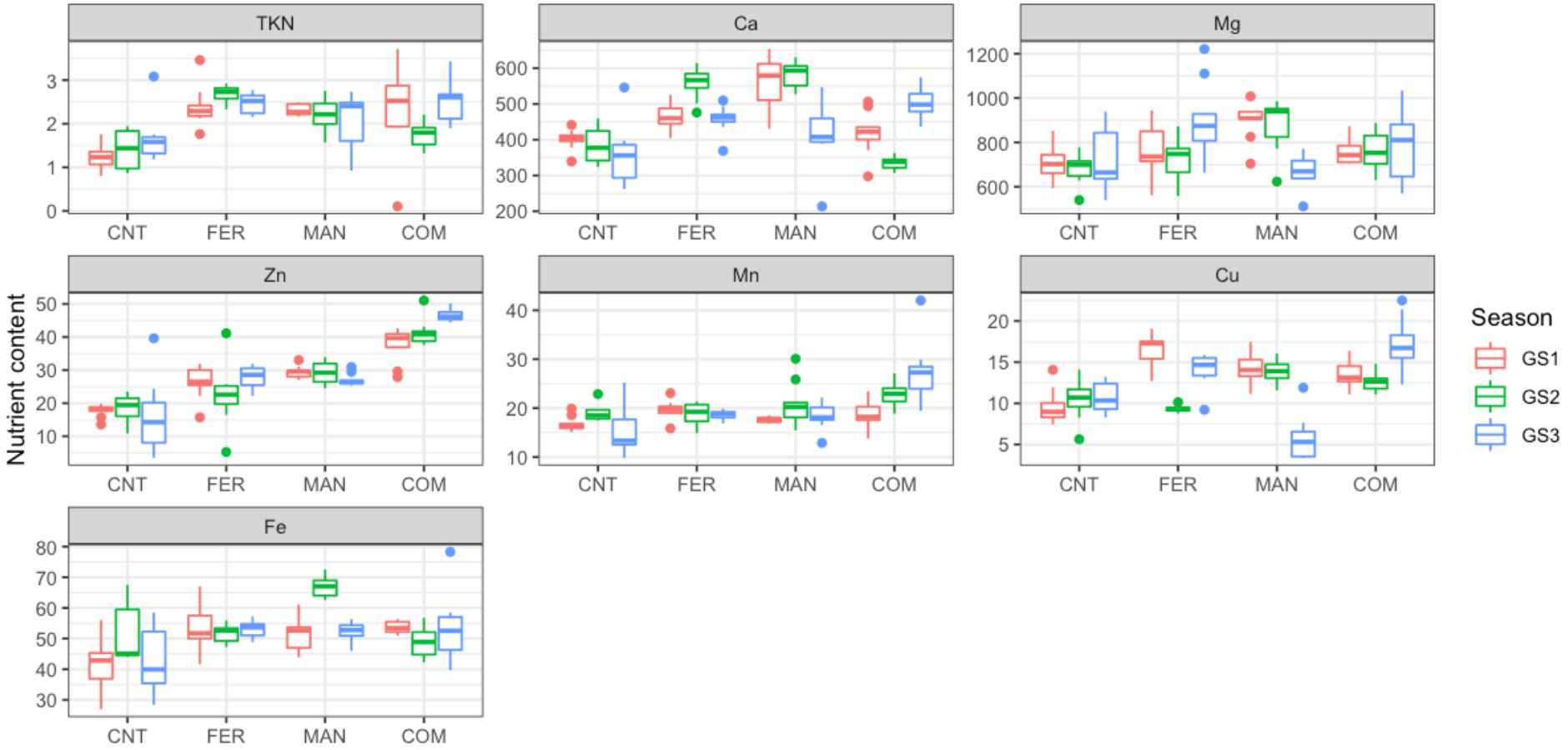
Cu levels in organic farming managed plots

The level of Cu in organic managed plots ranged from 5.94 to 17.27 ppm in all growing seasons. During the first two growing seasons (2016-2018) no differences have been noticed between the levels of Cu in barley grain harvested from plots received compost or manure. The level of Cu during the first growing season was 13.6 and 14.2 ppm in compost and manure treated plots respectively. During the second growing season (2017-2018) the seed Cu contend was 12.6 and 13.9 n compost and manure treated plots respectively. Interestingly during the third growing season (2018-2019) the Cu contend of barley grain harvested from plots received compost was 5.9 ppm while in manure treated plots, seed Cu content was 17.27 ppm (Figure 3).

Fe levels in organic farming managed plots

A completely different and variable response was noticed for Fe content in barley grain harvested from plots under organic farming nutrient management practices. These findings clearly show that seasonality has a substantial impact on Fe seed content. In particular, the Fe content of barley grain in compost and manure treated plots was similar during the first growing season (2016-2017) and the third growing season (2018-2019). The level of Fe content ranged from 50.7 to 53.5 ppm in both growing seasons and in both nutrient management strategies. During the second growing season (2017-2018) the Fe content of barley grain in manure treated plots was 66.6 ppm compared to 49.0 ppm found in compost treated plots.

Figure 3. Nutrient content in barley grain harvested from plots grown under different nutrient management strategies in three growing seasons (GS1, GS2 and GS3). TKN (total N (% dry matter), Ca, Mg, Zn, Mn, Cu and Fe (mg/kg dry weight)



The effect of agricultural system in the quality of barley hay as organic feed

The effect of agricultural system and particularly the different nutrient management strategies significantly affected the main properties determining the quality of barley and vetch. In particular, we thoroughly examined total N level, ADF, NDF, lignin content (%) and DOMD in barley and vetch hay in three growing seasons.

In the following section we present the differences between organic and conventional practices in main characteristics of hay products from vetch and barley that could be used in organic animal sector.

Barley

Hay Crude protein (%) in organic farming managed plots

The amount of CP found in barley hay was significantly affected from the nutrient management strategy implemented as well as the growing season ($F=4.09$, $p<0.01$). For example, the hay CP content in compost and manure treated plots was similar in all growing seasons. The highest hay N content was observed in plots received ammonium nitrate during the second and the third growing season, and was 12.4 and 13.1 % respectively (Figure 4).

Hay Acid Detergent Fiber (ADF) in organic farming managed plots

A significant interaction between growing season and nutrient management strategy was noticed for ADF. The highest ADF values were consistently measured in barley hay harvested from plots received no input. The % of ADF measured in control plots during the three growing seasons ranged from 35.1 to 39.7%. On the contrary, the ADF % in barley hay received compost and manure 30.7 to 36.6% and 28.9 to 37.7% respectively. The lowest ADF was observed in hay harvested from manured treated plots during the first and the third growing season and was substantially lower from that measured during the same growing season in compost treated plots. During the second (2017-2018) season the opposite pattern was observed (Figure 4).

Hay Neutral Detergent Fiber (ADF) in organic farming managed plots

Neutral Detergent fiber (NDF) in all growing seasons was higher than 40% of the total dry weight and a significant interaction between nutrient management strategy and season was observed (F=5.02, *p<0.01*). The lowest % of NDF during the first growing season was observed in hay harvested from plots received nutrient inputs. During the 2017-2018, the highest % of NDF was observed in manure treated plots and was significantly different only from the hay harvested from plots received ammonium nitrate (Figure 4). During 2018-2019, the lowest NDF % was noticed in plots received ammonium nitrate.

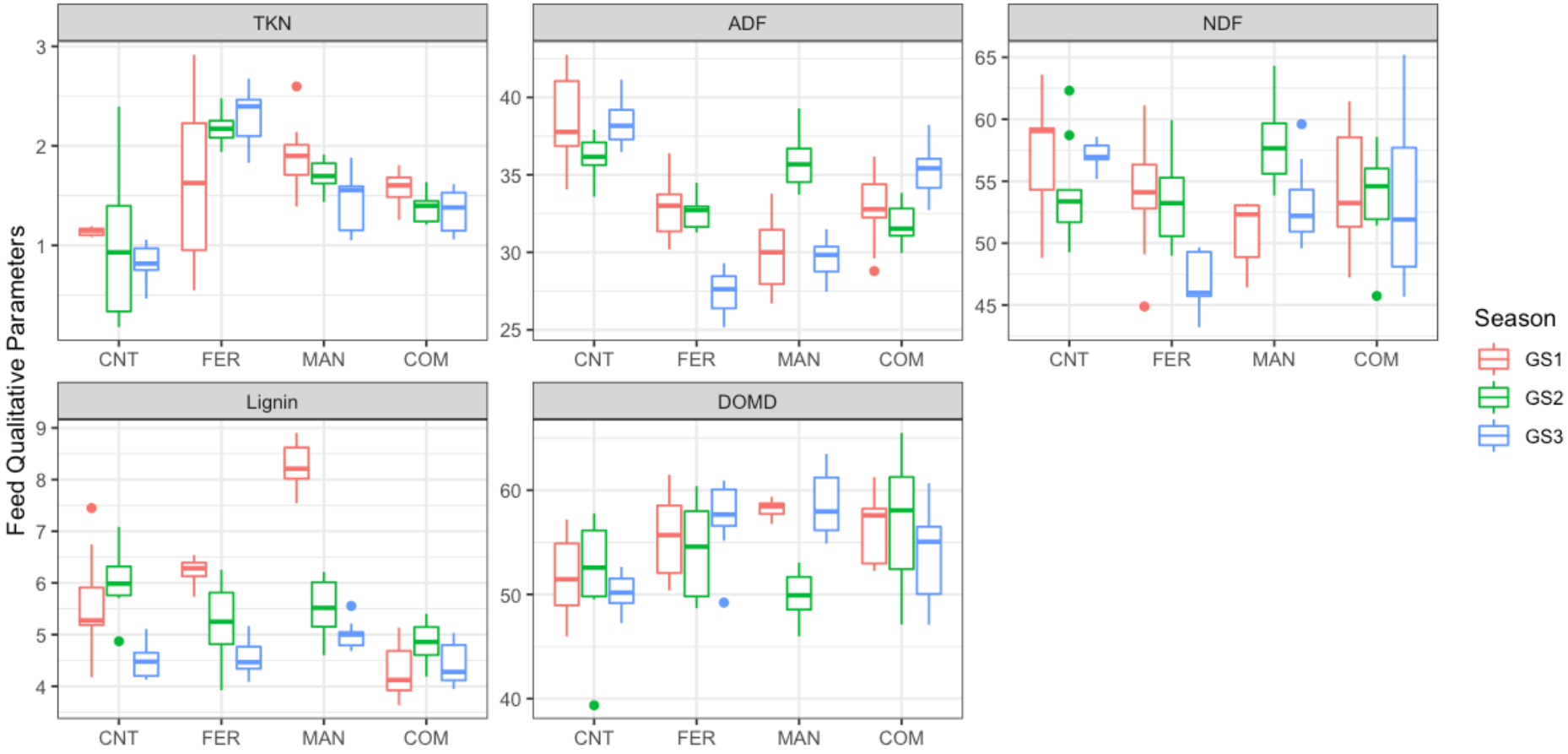
Hay lignin content in organic farming managed plots

Similarly to the rest of feed quality traits, the lignin content of barley hay was significantly affected from the interaction of growing season and nutrient management strategy (F=25.01, p<0.01). For example, the lignin content of the hay during the third 2018-2019 growing season, was not affected from the nutrient management strategy since the lignin content of hay harvested from all nutrient treatments ranged from 4.44 to 5.00 %. During the first growing season the lowest lignin content was observed in compost treatments while during the second growing season the lowest lignin content was measured in both compost and fertilized plots.

Hay DOMD content in organic farming managed plots

Statistical analysis shows that there is an interaction between growing season and nutrient management strategy (F=25.01, p<0.01) regarding the proportion of organic matter in the dry matter that can be digested. However the differences between the different strategies are low. Overall the DOMD range from 50 to 58.7% depending on the growing season and the nutrient management strategy followed (Figure 4).

Figure 4. Feed qualitative characteristics of barley hay harvested from plots grown under different nutrient management strategies in three growing seasons (GS1, GS2 and GS3). TKN (total N (% dry matter), ADF, NDF, lignin and DOMD (%)



Vetch

In vetch, all parameters examined regarding the performance of the crop as hay were significantly affected from the interaction of season and nutrient management strategies. Main effects of season and nutrient management strategy only, were reported only for lignin.

The highest biomass production was observed in plots received either ammonium nitrate or organic inputs (manure and compost). The hay production in non-treated plots ranged from 1.67 to 2.36 tn/ha while the hay production ranged from 2.96 to 3.65 tn/ha in the plots received chemical or organic inputs (Table 4).

Table 4. Vetch hay yield (tn/ha) in three different growing seasons under different nutrient management schemes

	2016-2017	2017-2018	2018-2019
No input	1.49 a	2.09 a	2.64 a
Compost	3.37 b	3.39 b	3.19 b
Ammonium nitrate	2.96 b	3.33 b	3.47 b
Manure	3.13 b	3.65 b	3.00 ab

Hay Crude protein (%) in organic farming managed plots

The amount of CP found in vetch hay was significantly affected from the nutrient management strategy implemented as well as the growing season ($F=6.81$, $p<0.01$). During the first growing season the highest CP was measured in manure treated plots and was 25.6% while during the second and the third growing season the CP was similar in both organic nutrient management schemes. The CP in these plots ranged from 21.9 to 23.8%. (Figure 5).

Hay Acid Detergent Fiber (ADF) in organic farming managed plots

The ADF in vetch grown under organic farming nutrient management schemes was substantially lower during the first and the second growing season and ranged from 19.3 to 24.1 % and 19.9 to 26.4%. During the third growing season, fertilizer exhibited the lower ADF values ranking from 26.1 to 30.8%. In all growing seasons, the highest ADF values were noticed in plots received no input (Figure 5).

Hay Neutral Detergent Fiber (NDF) in organic farming managed plots

The NDF % in vetch hay was affected both from growing season and nutrient management schemes ($F=5.08$, $p<0.01$). During the first growing season, the highest NDF values were noticed in manure treated plots ranging from 44.4 to 51.4% and was similar with that of ammonium nitrate treated plots ranging from 41.2 to 48.2%. Lower NDF% was determined in compost treated plots as well as from plots received no input ranging from 36.8 to 44.1% . During the second growing season, no differences have been observed between the different nutrient management practices. The mean NDF % in all treatments ranged from 40.1 to 44.1%. On the contrary, during the third growing season, the highest NDF value was observed in composted treated plots (52.8%) and the lowest in plots with no inputs (41.0%). The NDF in vetch hay harvested from plots received manure and ammonium nitrate was similar ranging from 46.0 to 49.7% (Figure 5).

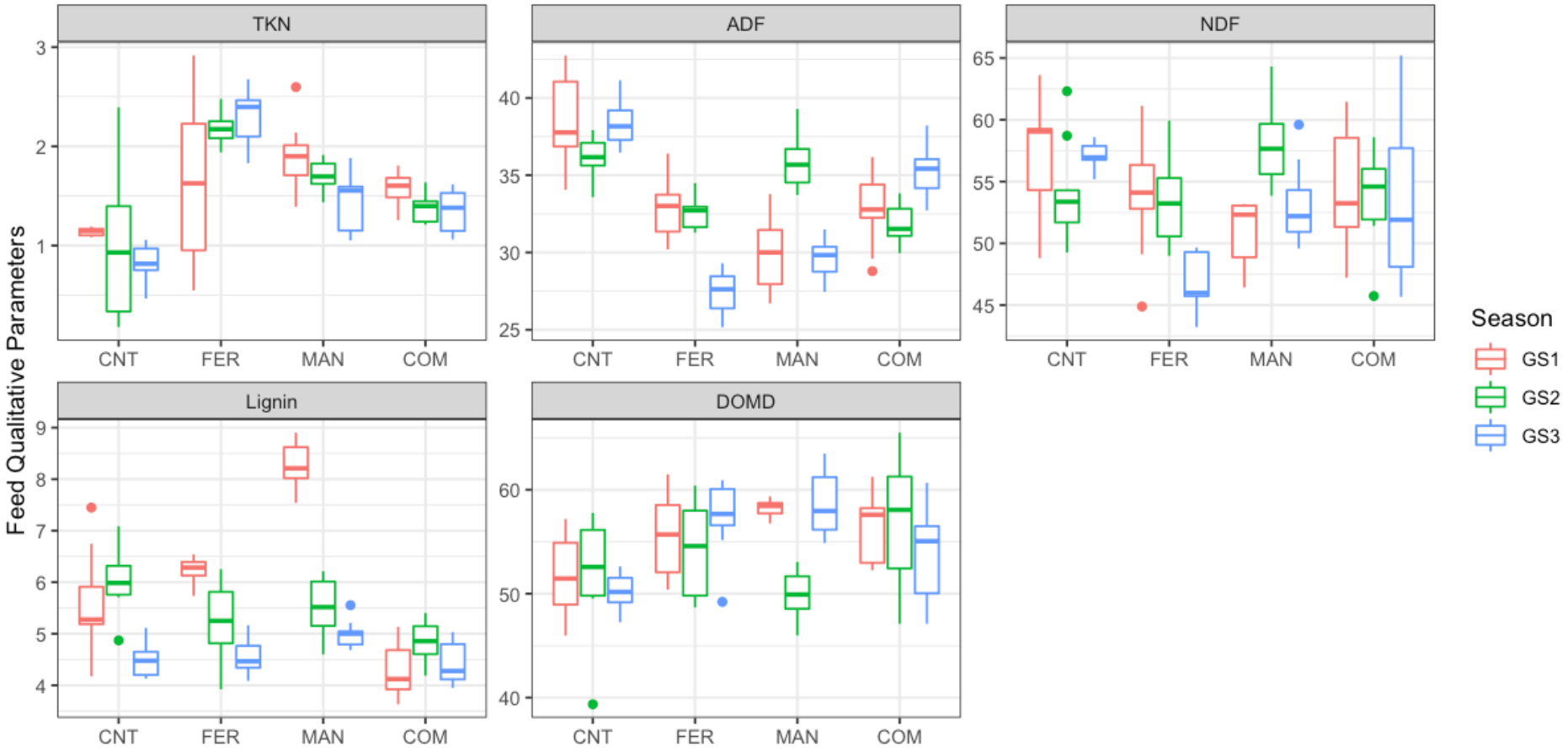
Hay Lignin in organic farming managed plots

The lignin content was always higher in vetch hay received no inputs. Overall, the findings of the pilot trials showed that the agricultural system is not affecting the lignin content of vetch hay. An increased content of vetch hay lignin was noticed in plots received no inputs only during the second growing season. During the first and third growing season, the lignin content was similar among the different nutrient management practices (Figure 5).

Hay DOMD content in organic farming managed plots

The DOMD in all nutrient management practices was higher than 55% in all growing seasons (Figure 5). The digestibility of organic matter of the vetch hay dry matter is significantly higher than that of barley. The application of manure, caused a significant increase of DOMD compared to compost only during the second and the third growing season. The DOMD values were similar between hay harvested from plots received ammonium nitrate and manure (Figure 5).

Figure 5. Feed qualitative characteristics of vetch hay harvested from plots grown under different nutrient management strategies in three growing seasons (GS1, GS2 and GS3). TKN (total N (% dry matter), ADF, NDF, lignin and DOMD (%)



Discussion

Under the semi - arid conditions of Cyprus and the Eastern Mediterranean Region it is evident that the climate variability, crop species as well as agricultural system are affecting the yield and the quality of the products (seed and hay) that are harvested from barley and vetch.

Our findings clearly demonstrate a seasonal effect on barley and vetch productivity that was also depended on the nutrient management strategy that was followed. This is particularly evident in plots received no-inputs. In detail, barley seed production was similar in GS1 (2016-17) and GS3 (2018-19) and higher from GS2 (2017-18). The higher productivity noticed during 2018-19 is attributed to the higher precipitation occurred.

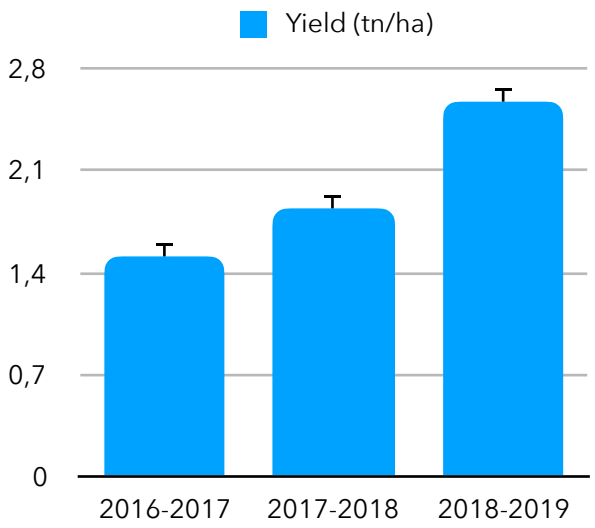


Figure 6. Mean barley seed yield in tn/ha during three consecutive seasons. Bars denotes standard error of the mean and different letters statistically significant differences according to Tukey HSD (a=0.05)

Particularly, within nutrient organic management schemes differences have been noticed. For example, in compost treated plots a significant increase was observed during time suggesting that the annual application of compost improves soil fertility and increases barley hay and seed yield (Figure 6). On the contrary, vetch hay productivity was not affected during the time in plots received compost. The application of manure results in a substantial increase of barley grain and hay compared to compost.

The application of manure results in a substantial increase of barley grain and hay compared to compost

The use of ammonium nitrate in barley plots resulted in significantly higher yields compared to compost in all growing seasons. On the contrary, barley seed and hay yield in manure treated soils was similar with that measured in ammonium nitrate treated plots.

Previous studies demonstrated the superiority of conventional farming systems compared to organic. Ponti et al. (2012) in an extensive meta-analysis review showed that the average yield of organic farming products is 80% of that grown under conventional farming systems. However, the same authors, mentioned that the variation of organic farming yields is substantially high reaching the 21%. The increasing yield gab between organic and conventional farming practices of the current trials in Cyprus are related to nutrient availability since no losses due to pest and diseases have been noticed. In practice, no differences between conventional and organic farming was noticed when manure was included in nutrient management strategy.

The productivity of the plots received compost on the contrary was substantially lower and this was possibly related to the reduced availability of the different nutrients in this material. Previous studies demonstrated that the compost, especially those derived from green residues, are poor in nutrients and their importance for plant growth is related to soil physical improvement (Aleantri et al., 2015; Nahum et al., 2007). However, compost incorporation into the soil contributes to the overall improvement of soil fertility through the replenishment of soil carbon stocks, the increase of soil microbial activity, functioning and biodiversity (Celano et al., 2012; Pane et al., 2015) while under some conditions, composts are providing pathogen suppression (Pane et al., 2011). These findings suggest that under specific conditions, and in the long term, the addition of compost might affect soil fertility in combination with the adoption of crop rotations and the reduction of chemical inputs into the system, factors , that are affecting soil organic matter depletion.

The quality of agricultural products is of great importance. For barley protein content is critical when seeds will follow the track of malting or human consumption. The use of barley grain for animal feed, means that the protein content of the grain is not critical since, it is used to provide animals energy rather than protein. However, despite the low

importance, results from previous studies and reports are contradictory. For example, in wheat, higher protein content was measured in conventional farming systems compared to organic (Mader et al., 2007; Jones et al,. 2010). In contrast, earlier studies found no difference in wholemeal protein content between organic and conventional management systems (Shier et al., 1984). It is evident also from our study, that N supply is affecting both yield and protein content. In compost treated soils, the N availability was lower leading to lower yields and grain protein content (Mader et al., 2007).

Grain chemical composition influence its nutritional quality

The barley grain mineral composition influences its nutritional quality. The uptake of macro and micronutrients is affected from the interactions between the different nutrients that are available in the soil and of course from the nutrients externally applied. In addition, the differences in the nutrient management practices are affecting soil functioning, plant metabolism are shaping the microbial community structure which are in turn changing nutritional quality and plant composition in an ecological perspective (Omirou et al., 2011). For example, for iron (Fe), the stimulation of siderophore producing bacteria after the application of organic amendments could improve the Fe use efficiency of the plants. Siderophores are secondary metabolites produced by bacteria and fungi to sequester iron in the soil. These chelating compounds are making Fe available to plant and microbial cells. The increase of Fe in barley grain during the second growing season in plots treated with manure could be related with this kind of mechanisms. *Pseudomonas* showed a seasonal response and an increase of the population was observed when composted manure was applied into the soil (Zaccardelli et al., 2013). Further and more studies are needed to examine whether the different nutrient management strategies are affecting mineral levels in barley grain under the semi-arid conditions of Eastern Meditteranean and reveal the mechanisms responsible for any changes. In any case, our findings showed that seasonal effects are critical for mineral levels in barley

grain, depending however on the nutrient management scheme followed. Detailed analysis, excluding plots received no inputs (Control) showed that the type of nutrient management scheme affected the accumulation of the different minerals however this was depended on the growing season. The results, are also contradictory for some minerals. For example, the level of Ca was substantially lower in compost treated plots during the first growing season but the opposite was noticed during the third growing season during which the amount of Ca accumulated in barley grain harvested from compost treated plots was the highest measured.

The impact of agricultural system was more clear on some qualitative traits of barley and vetch hay. For example, the amount of CP found in barley hay was substantially higher in conventional nutrient management schemes and this is similar with that observed in other studies and could be related to the higher availability of N into the soil (Mader et al., 2007). Also seasonal effect had a substantial effect of the quality of barley digestibility. For example, during the third growing season, the lowest ADF and NDF values have been observed in plots received ammonium nitrate. This is probably related with the precipitation levels since during 2018-2019 the amount of rainfall was substantially higher compared to that occurred during the previous growing seasons. Similar findings have been observed for vetch hay.

Conclusions

Under the semi - arid conditions of Cyprus and the Eastern Mediterranean Region it is evident that the climate variability, crop species as well as agricultural system are affecting the yield and the quality of the products (seed and hay) that are harvested from barley and vetch.

The increasing yield gab between organic and conventional farming practices of the current trials in Cyprus are related to nutrient availability since no losses due to pest and diseases have been noticed. In practice, no differences between conventional and organic farming was noticed when manure was included in nutrient management strategy. Lower yields have been observed when compost was applied and this was attributed to the lower nutrient mineralization rates of the compost.

These findings denote firstly high variability within the different treatments and secondly, stress that the seasonal variation has a tremendous effect on the quality of organic farming products (grain or hay) in all crops. The trials in the pilot farm of ORGANIKO project suggest that organic farming practices and particularly, different organic nutrient management strategies are not affecting the mineral composition of barley grain and similar digestibility properties have been noticed under semi-arid conditions. The increase in rain fall was associated to the decrease of digestibility on barley hay.

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