The effects of the two rotation programs on the feed value of organic cottonseed

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Key words: Organic, feed value, cottonseed, rotation.

Abstract

The aim of the study was to evaluate the effect of two different rotation programs on the crop yields and feed value (chemical composition and metabolizable energy values) in organic cottonseed cultivation. The crops used in the Rotation-I were Persian clover-silage maize, vetch/triticale mix stand-cotton (cottonseed) during 2014-2015 and 2016-2017. Rotation-II crops were: vetch/triticale mix stand-cotton (cottonseed), Persian clover-silage maize, during 2014-2015 and 2016-2017. The study was carried out in 2 different matched systems with 4 replications in the Menemen Plain in the Aegean Region of Turkey. In Rotation-I, significant differences in crop yield were found for Persian clover, maize silage and cottonseed with an increase of 3050 kg ha^{-1}, 31740 kg ha^{-1} and 530 kg ha^{-1} between 2014-2015 and 2016-2017, respectively ($p<0.05$). The yield of maize silage yield increased significantly by 28840 kg ha^{-1} between 2014-2015 and 2016-2017 in Rotation–II ($p<0.05$), there was no significant yield change in the other crops. Crude ash, crude protein, ether extract, crude fiber, nitrogen free extract and metabolizable energy values of organic cottonseed changed between years and rotations. The crude protein, ether extract and nitrogen free extract were significantly affected by two different rotation programs ($p<0.05$). There is a great need for investigation of organic animal feed crops as a protein source in local organic animal feed production to suit the climate and ecology of the country.

Introduction

Organic feed production is one of the most important inputs in organic animal production and rations prepared for animals have to be made from organic feeds. It is well known that there is insufficient production of organic animal feed crops in Turkey, as in every country. The improvement of organic livestock depends on a sufficient level of quality organic feed input. Considering that feed input constitutes 70% of the costs of production, these problems are among the main reasons why organic livestock farming cannot progress in Turkey and possibly in other countries. It is claimed that an optimal energy to protein ratio in a balanced diet is important to enhance the use of protein, and species, age and growth stage require different protein levels. Cotton *(Gossypium* spp) is mostly used as solvent extracted cottonseed meal or raw cottonseed in cattle rations in some countries as it is somewhat similar to soya meal. However, it's use in monogastric animal diets may be limited because of the presence of gossypol.

Animal husbandry should be an integrated part of the cropping system. The increasing availability of locally produced animal feed should be the foremost element of self-sufficiency in local food systems. It is vital to investigate animal feed crops that suit the climate and ecology of a country to provide a viable protein source for local animal feed production. The aim of this study was to determine the differences in yield and feed value (chemical composition and metabolic energy value) of experimental crops of organic cottonseed used in two different rotations during 2014-2015 and 2016-2017.

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Material and methods

Material: The crops in the study were a Vetch / Triticale mix (Alper / EgeYildizi) (75kg vetch seed+ 25kg triticale seed per ha)), Persian clover, maize silage (Burak) and cotton (Baly 308). The sequence of crops used in Rotation-I were as follows; Persian clover- maize silage, vetch/triticale mix stand-cotton (cottonseed) in both the 2014-2015 and 2016-2017 rotations. Rotation-II was as follows: vetch/triticale mix stand-cotton (cottonseed), Persian clover-silage maize in both the 2014-2015 and 2016-2017 rotations. The trials were conducted in the Menemen Plain in the Aegean Region of Turkey (Figure 1). A typical Mediterranean climate prevails in the Menemen Plain region. The summers are hot and dry, and the winters are warm and rainy. Following a soil sampling analysis, organic fertilizer containing 2 % N, 2.5 % P_2O_5, 2.5 % K_2O, 60 % organic matter and 9/12 C/N was applied to the experimental plots. Fertilization was carried out so as not to exceed 17 kg.da^{-1} nitrogen as stated in the organic farming regulations. The experimental site had an alluvial soil with loamy texture, no salinity problem, medium lime content, low available phosphorus, high available potassium, low organic matter and was slightly alkaline.

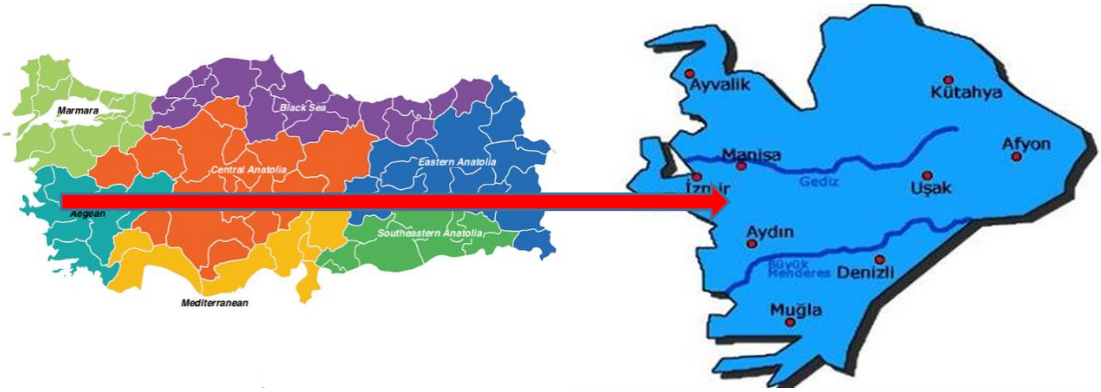

Figure 1: Menemen Plain in the Aegean Region of Turkey

Methods: The experiment was established in 2013 and completed in 2017. It was carried out in 2 different systems for 5 years in a randomized block experimental pattern with 4 replications at the International Agricultural Research and Training Center (ARTC), Aegean Region, Turkey. The experimental plots were 2.8 m x 5 m = 14 m^2, with a distance of 1.5 m between each parcel and a distance of 5 m between the 2 rotation systems. Irrigation was employed at the correct times during the growing season to prevent water stress in each experimental crop. Minimum tillage was used. Certified organic preparations were applied when the insect levels passed a threshold and mechanical weed control was utilised. The yields of the crops, Persian clover as dry hay and the green yield of the Vetch +Triticale mix were expressed as kg ha^{-1}. The plants were harvested with a sickle when 1/3 of the plants reached the flowering stage. The maize silage was harvested at the pulp stage of the product and calculated as green yield. After ginning, the fiber and cotton seeds were separated. The seed yield per plot was calculated as kg ha^{-1}, and comprised 60% raw cottonseed and 40% fiber. The oil was extracted from the cottonseed manually, the cottonseed was then ground to pass through a 1 mm screen before chemical analyses. The chemical composition of the organic cottonseed (crude ash, organic matter, crude protein, ether extract, and nitrogen free extract) was determined according to AOAC (1995). The crude fiber was determined using the Lepper method (Lepper, 1933). The metabolizable energy (ME) values of feed were calculated by using the Turkish Standard Institute equation (TSE9610, 2004) ME, kcal/kg organic matter = 3,260+(0.455×crude protein+3.517×ether extract) –4.037×crude fiber. All tests were carried out using the SPSS statistical package (15.0). The differences between the means were tested by using an Independent Samples Test (T- Test) for yields, and a Duncan test was used for the chemical composition and metabolizable energy values.

Results and Discussion

Table 1 shows the differences of yield (average and standard error of means) of the experimental crops for 2014-2015 and 2016-2017 on the two rotation programs. In Rotation-I, the average yield of crops changed from1700-23260 kg ha^{-1} for 2014-2015, to 2230-55000 kg ha^{-1} for 2016-2017. There was no significant difference between the years for the Vetch +Triticale Mix. Significant differences in crop yield were found for Persian clover, maize silage and cottonseed with an increase of 3050 kg ha^{-1}, 31740 kg ha^{-1}, 530 kg ha^{-1} respectively ($p<0.05$). In the Rotation-II with the exception of maize silage there was no significant difference in the yields of crops. The average yields changed from1580-26340 kg ha^{-1} for 2014-2015, 1720-55180 kg ha^{-1} for 2016-2017. The increase in maize silage yield was significant, increasing by 28840 kg ha^{-1} between 2014-2015 and 2016-2017 ($p<0.05$). Açıkgöz (2001) found watered Persian clover to yield a dry hay value of 600-1200 kg da^{-1}, Çeçen et al.(2005) achieved 12500kg ha^{-1}.These yields were similar to Rotation-11 but lower than the Rotation-1yields recorded in this study.The average yields of maize silage (green) stated as 60000-103720 kg ha^{-1} by Seyithan and Saruhan (2017) and 88760 kg ha^{-1} by Yürekli et al. (2021), were higher than this study (23260-55000 kg ha^{-1} Rotation-I and 26340-55180 kg ha^{-1} Rotation-II). A lower yield can be expected under organic management. Carpici and Celik (2014) found that the average green yield of vetch+triticale (at a ratio of 75:25) was 14480 kg ha^{-1} which was higher than the results of this study. Similarly, in this study the yield of organic cotton was lower than the 3260-4090 kg ha^{-1} reported by Erdal and Sökmen (2017). Notably, this study showed that the yield of organic cottonseed was significantly increased with different crop rotations, being higher in Rotation-I.

Table 1: The differences of yields (average ± standard error of means) of experimental crops (kg ha^{-1}) for 2014-2015 and 2016-2017 years on the two rotation programs

CROPS	Rotation-I		P Value Sig. (2tld)	Sig.	CROPS	Rotation-II		P Value Sig. (2tld)	Sig.
	2014-2015	2016-2017				2014-2015	2016-2017		
Persian clover	17930±350	20980±870	0.017	*	Vetch +Triticale Mix	12390±350	11790±210	0.188	n.s
Maize silage	23260±570	55000±410	0.000	*	Cottonseed	1580±130	1720±50	0.356	n.s
Vetch +Triticale Mix	11430±330	12590±490	0.097	n.s	Persian clover	13300±450	14110±660	0.351	n.s
Cottonseed	1700±70	2230±100	0.005	*	Maize silage	26340±440	55180±980	0.000	*

Sig: Significance * $p<0.05$, n.s: not significant.

The amount of yield obtained from the unit area is as important as the chemical component of animal feed crops. In organic farming, when a proper plant nutrition system in accordance with the organic standards is applied to the soil, a gradual increase in yield can be achieved over the following years. The organic farming system is a holistic approach, that should pay attention to climate conditions, plant nutrient sources, plant variety, choosing rotation crops and sequencing crops carefully, soil tillage techniques, irrigation water sources and efficient use of water. Control of other living organisms contributing to plant disease, weeds and pests should be achieved without harming the environment. It should be clearly understood that the greatest benefits will accrue when the production of livestock and animal feed crops are considered together.

Table 2 shows the change in chemical composition and metabolizable energy values of organic cottonseed on the two rotation programs. Crude ash, crude protein, ether extract, crude fiber, nitrogen free extract and metabolizable energy values were changed between

5.04-5.23%, 20.77-22.27%, 11.93-15.23%, 31.15-34.04%, 24.13-30.95 %, 9.77-10.21 (MJ/kg DM) respectively. Although, crude ash, crude fiber and metabolizable energy values were not significantly affected by the two rotation programs, crude protein, ether extract, nitrogen free extract were ($p<0.05$). The crude ash values in this study were very close to those quoted by Singh et al (2003), however, Pehlevan and Özdoğan (2015) recorded lower crude ash values (4.18, %).
Crude protein and ether extract values were higher in Rotation-I than in Rotation-II for 2014-2015 time period ($p<0.05$). However, for the years 2016-2017 the crude protein and ether extracts in Rotation–II were similar to Rotation-I.
Many authors (Singh et al. 2003, Bertrand et al, 2005, Delgado and Peyes 2017) have noted changes in crude protein and ether extract values of cottonseed (between 22.40-25.4% and 14.4-20.71 %), similar to the changes found in this study. The crude fibre values reported here were very close to those quoted by Pehlevan and Özdoğan (2015) and were higher than the 21.0% quoted by Osti and Pandon (2006)
Nitrogen free extract was higher overall in Rotation-II for than Rotation-I

Table 2: The change of chemical composition (% on DM) and Metabolizable energy values (MJ/kg DM) of organic cottonseed on the two rotation programs

	Rotation-I		Rotation-II			
	Crops: Persian clover / maize silage, Vetch +Triticale Mix, Cottonseed		Crops: Vetch +Triticale Mix, Cottonseed, Persian clover / maize silage		SEM	P value
	2014-2015	2016-2017	2014-2015	2016-2017		
Crude ash	5.04	5.23	5.19	5.12	0.12	0.961
Crude protein	22.27 a	22.22 a	20.77 b	21.79 ab	0.22	0.036
Ether extract	14.53 a	14.90 a	11.94 b	15.23 a	0.37	0.000
Crude Fiber	34.04	31.80	31.15	31.87	0.44	0.082
Nitrogen free extract	24.13 b	25.80 b	30.95 a	25.99 b	0.76	0.001
Metabolizable energy	9.77	10.18	9.82	10.21	0.08	0.103

DM: Dry matter, SEM: Standart error of the means, Different letters (a,b,c) within rows indicate significant differences ($p<0.05$).

Whole cottonseed is a very popular feed for dairy cattle and is uniquely high in fiber, energy (from fat), and protein. There are differences in the nutrient content between the types of cottonseed products and also between the methods used to extract the oil from the whole cotton seed. The limiting factor for using cottonseed as a feed in farm animals is gossypol, a toxin which causes 'cottonseed injuries'. Calves, as they have an undeveloped rumen, and non-ruminants are more sensitive to gossypol toxicity than adult ruminant animals. Toxicity issues occur when raw cottonseed is fed. One of the easiest methods to reduce toxicity is the expeller method of extracting the oil, due to the required heat and pressure the gossypol is inactivated.

In conclusion, alternative protein sources are necessary in addition to soybean and will make significant contributions to the solution of the organic feed protein problem. Cotton cultivation is limited in terms of climatic and ecological requirements. In organic cotton growing countries, cotton-seed can be considered as protein source in organic animal feed. The cropping system is important in organic farming. The selection of plants grown in rotation contributes to the increase in yield. Rotation-I might be preferable to Rotation-II because of the increased experimental crop yields and crude protein values. There is a great need for further investigation on animal feed crops suitable for the ecology of the countries as a protein source in local animal feed production.

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