Article

Conservation agriculture has no significant impact on sheep digestive parasitism

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Simple Summary: This study aims to show the absence of impact of conservation agriculture on sheep digestive parasitism and in return the absence of the negative impact on their growth and their blood parameters in comparision with those of lambs grazing conventional agriculture. The results of this study seem favorable toword adoption of conservation agriculture espicially in a time of the water scarcity.

Abstract: Conservation agriculture (CONS A) is a sustainable agriculture system which is based on rotation crops with no tillage. It has various environmental advantages compared to conventional agriculture (CONV A), namely decrease water evaporation, erosion and CO2 emission.

We report herein the first study aiming evaluation of the impact of this type of sustainable agriculture on sheep gastrointestinal parasites. Two lamb groups aged between 6 and ten months were randomly included to graze separately on CONS A and CONV A pastures. Each group was constituted of two batches of three lambs which were followed up for two rearing months during which liveweight, haematological parameters variation and digestive parasites were studied. At the end of the study period, lambs were slaughtered and the carcass yield was determined and a helminthological autopsy was performed on digestive tracts to estimate different parasitological indicators.

There was no difference between lambs rearing on CONS A and those rearing on CONV A for all parasite indicators (infestation intensity, abundance and prevalence), the same trend was also obtained for haematological parameters, liveweight evolution and carcass yield.

These results prove that there is no impact of the CONS A on the sheep digestive parasitism. Further studies are needed to support these findings on a bigger animal samples and to investigate the impact of this agriculture on other parasites and for other animal species.

Keywords: Conventional agriculture, conservation agriculture, digestive parasites, sheep, Tunisia.

 doi:10.20944/preprints202305.0795.v1

1. Introduction

Between 2009 and 2050, world food needs will increase by 70% and this is following the perpetual increase of the world human population [1]. Moreover, jerky climate changes have been taking hold for quite some time. Thus, the global temperature is increased by 0.7°C which led to an increase in the frequency of natural climatic disasters. All of this has had a negative impact on food security and caused fluctuations in the supply of both human and animal food. On the other hand, the intensification of agriculture has deepened disorders in ecosystems such as depletion of fresh water resources, deforestation, deterioration of the organic and biological quality of cultivated soils, CO2 emissions increase, pressure on animal selection limiting biodiversity by focusing on animal breeds that are highly productive but very fragile and often unsuited to the microclimate of certain countries.

The challenge for both developed and developing countries is to reduce the degradation of the environment, and reach to sustainable increases in crop and livestock productions to secure present and future food supplies for both humans and animals [2][3]. This sustainability is crucially needed to limit poverty in the world, to preserve natural resources and to consecrate all efforts to maintain peace and prosperity for all [4].

To face this environmental degradation, an Eco vigilance has formed and civil awareness has developed in different societies which prompted governments to take the problem of environment degradation seriously. Thus, international organizations such as FAO [5], ICARDA [6], CIRAD [7] have set up research projects to promote new environment-friendly farming techniques in order to "protect the existing and repair the damaged" [4].

On this regard, the world can only seek ways of sustainable food supply to face the continued pressure and the growing global increase in food.

Ecoagronomy is a sustainable development process that we can attempt in order to achieve this objective. Indeed, ecoagriculture, with all its versions, guarantees a relatively satisfactory and sufficient supply of food while preserving natural resources.

Conservation agriculture (CONS A) or regenerative agriculture is a sustainable model which does not disturb the ecosystem and preserves natural resources. Thus, it contributes to the preservation of the physico-biological proprieties of the soil and its microfauna; which has a positive impact on its fertility and its productivity.

Furthermore, CONS A protects the soil from erosion and, thanks to the presence of a permanent vegetal cover, it reduces the evaporation of water. On the other hand, it decreases the release of CO2 gases from the ground, reducing then global warming [8], [9],[10],[11].

In addition to the benefits of CONS A, it is demonstrated that small ruminant livestock can provide food security, alleviate poverty and it is well integrated in the world sustainable nutrition development [12]. Moreover, it was shown that the breeding of small ruminants, particularly sheep, can be carried out in conservation agriculture with success and good productivity [13] and it was proved that there is an efficiency of crop-livestock production systems under CONS A with the guarantee of a sustainable food security in Tunisian dry areas [14]. As far as it could be ascertained, there are no published studies on the impact of CONS A on sheep digestive parasitism. The main objective of this study is to identify the impact of conservation agriculture on the digestive parasitism of sheep by comparing it to that of conventional agriculture during grazing cycles.

At the same time, we seek to follow the weight variation of the animals as well as that of the hematological parameters.

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2. Materials and Methods

2.1. Study farm

The present study was carried out in a private farm located in Krib locality, Siliana district, North west Tunisia (Latitude: 36.374471 E; Longitude: 9.175250 N) (Figure 1).

Krib locality has a Köppen BSk climate type with an average annual rainfall between 250 and 600 mm and a mean winter and summer temperatures of 17.8 and 35°C, respectively [15]. The study land consists of two contiguous plots, one used for conservation agriculture (CONS A) and the other for conventional agriculture (CONV A) (Figure 2). Agricultural activities were similar and performed at the same time in both plots. Both of them were planted with oats (Avena sativa), vetch (Vicia sativa), sulla (Hedysarum coronarium) and alfalfa (Medicago sativa).

Figure 1. Geographical location of the study farm

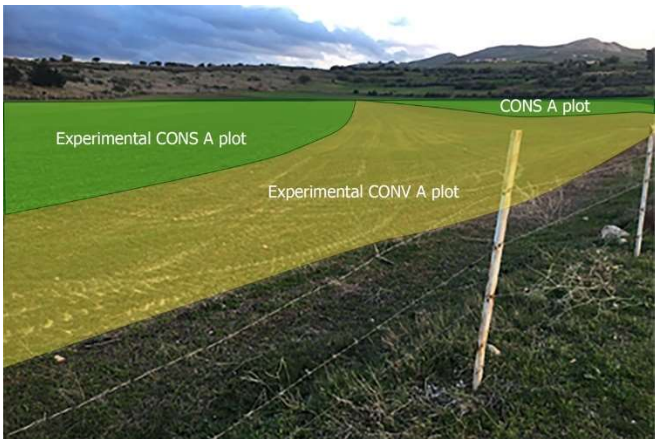

Figure 2: Landscape of CONS A and CONV A plots pastured by experimental lambs in the present study in January

2.2. Animals

Two batches of six male lambs each, were randomly selected from a herd of 130 Noir de Thibar, Queue Fine de l'Ouest and cross-breed sheep. At the inclusion date, lambs were aged between 5 and 9 months, their mean live weight was 24 kg (range: 16 - 32 kg). Animals were vaccinated against enterotoxaemia (Ovipan F®, MCI Santé Animale, Morocco) (subcutaneous injection of 2 ml/animal) and were drenched with 7 mg/kg albendazole (Dalben® 1.9, CEVA, France) during late January 2021. Each lambs' batch was randomly divided into two groups of 3 lambs each and maintained in two separate boxes (Figure 3). The two groups were randomly placed on pastures for two months, one on conservation agriculture (CONS A) plot and the other on conventional agriculture (CONV A) plot. Each batch of lambs pasture daily during 3 days in 25 m2 plot during 6 to 7 hours except during

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raining days where they are kept in their boxes. At the end of the day, lambs were fed with oat vetch hay and approximately 200 g of concentrate for each animal.

Figure 3: Noir de Thibar experimental lambs in their boxes

2.3. Sampling

Lambs were clinically examined, weighted and sampled (5 ml of blood in EDTA tubes, at least 10 gr of faeces) each two weeks.

Red blood cell count (RBC) (109/mL), haematocrit (Ht) (%) and haemoglobin (Hb) (g/dL) were estimated using an Auto Haematology analyser BC-2800Vet® (Shenzen Mindray Bio-Medical Electronics Co., Ltd, China).

All faecal samples were checked for the presence of gastro-intestinal parasites qualitatively (flotation technique) and quantitively (Mc Master technique). The later allowed the estimation of infection intensity that was expressed as egg per gram (epg) of gastro-intestinal nematodes, coccidian oocysts and whipworms.[16].

The lambs were slaughtered after two months of pasturing. Immediately after being slaughtered, the gastrointestinal tract, lungs, liver and epiploon were removed and each carcass was weighed. The organs were thoroughly examined and dissected for the presence of lesions. Each portion of the gastrointestinal tract was separated and longitudinally opened. The digestive mucosa was thoroughly washed and collected in a bucket. All nematodes were collected and conserved in identified tubes containing 70% ethanol and stored at +4°C until analysed. Nematodes and segments of adult cestodes were counted and identified according to the key of Euzeby [17].

2.4. Parasitological indicators

The following parasitological indicators were estimated [18].

Total Worm Count (TWC) = total number of a nematode species found in one examined gastro-intestinal tract. Natural logarithm plus one (Ln(n+1)) was used for the presentation of the figures.

Infestation prevalence = 100 × number of infested lambs/number of examined lambs.

Infestation intensity = Number of worms in the gastro-intestinal tract/number of infested lambs.
Infestation abundance = Number of worms in the gastro-intestinal tract/number of examined lambs.

2.5. Statistical analyses

The mean relative variation was used to compare the variation of lambs' weight, haematocrit, haemoglobin and blood cell count during visits. The relative variation was estimated as follows: Mean relative variation (%) = 100 x (value at visit (n+1) - value at visit (n))/value at visit (n).

The comparison of the infestation prevalence rate between the two lamb groups was performed with the Fisher exact test.

The infestation intensity and abundance between the two groups of lambs was performed using Wilcoxon-Mann-Whitney and Krusskall-Wallys tests. All tests were considered significant at 5% threshold [19].

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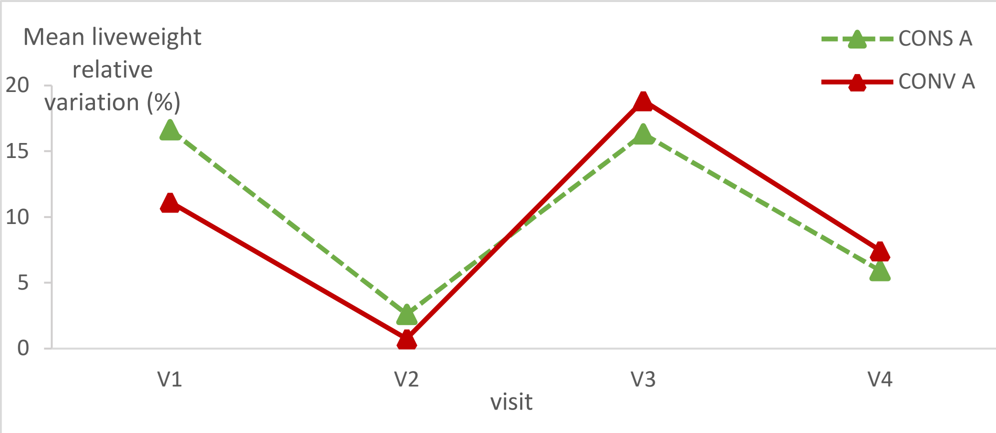
3. Results

3.1. Relative variation of lambs' liveweights

The mean relative variation of lambs' liveweight had exactly the same trend in both animal groups. It decreased considerably at the second visit. There was not statistically significant difference between the liveweights in the two animal groups (Table 1; Figure 4).



CONS A: Conservation Agriculture

CONV A: Conventional Agriculture

Figure 4: Mean relative variation (in %) of lambs' liveweights in conservation and conventional agriculture

It's worth mentioning that there is a significant statistical difference in liveweight relative variation in each batch during all visits (Table 1) (p=0.01 for both lambs batches).

The carcass yield was low for both types of agriculture and did not exceed the lower limit of the range of carcass yield in sheep (44.5 and 45.3% for conservation and conventional agriculture, respectively). No statistically significant variation was recorded for the carcass yield between the two batches of lambs (P = 0.39).

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Table 1: *P* values of lamb' mean weight relative variation, haematological relative variation and Mc Master technique between the two batches of lambs

		CONS A *versus* CONV A				**CONS A visit 1 *versus* visit 5**	**CONV A visit 1 *versus* visit 5**
Parameter	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5		
Relative variation of lambs' weight	NA	0.937	0.589	0.589	0.818	0.01	0.01
Relative variation of haematological parameters							
Haemoglobin (Hb)	NA	0.818	0.937	0.394	0.589	0.04	0.22
Haematocrit (Ht)	NA	0.132	0.818	0.485	0.485	0.02	0.64
Red Blood Cells count (RBC)	NA	0.24	0.818	0.669	0.589	0.12	0.98
Mc Master technique							
Oocyst per gram (Opg)	0.24	0.792	0.589	0.093	1	0.01	0.49
Tapeworms	0.72	0.61	0.5	0.73	0.73	0.99	0.93
Whipworms	0.065	0.662	0.818	0.394	0.18	0.74	0.54
Egg per gram strongyles except whipworms (epg)	0.589	0.662	0.937	0.18	1	1	0.14

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3.2. Relative variation of haematological parameters

Haematological parameters were within the normal values of lamb blood parameters in all animals of both groups [20,21]. The haematological parameters had the same variation in the two lamb groups (Figures 5, 6 and 7; Table 1) ($p>0.05$).

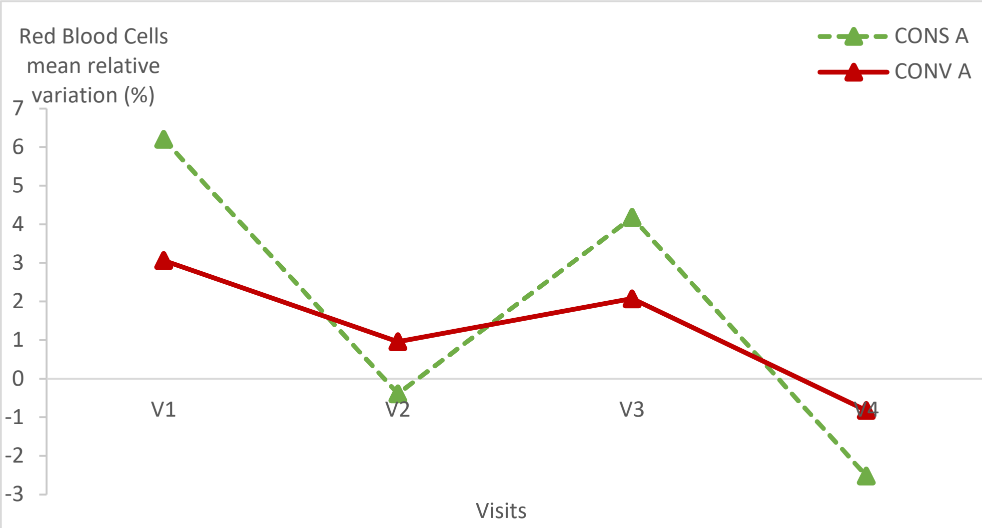

Figure 5: Red Blood Cells mean relative variation in the two lamb groups according to visits

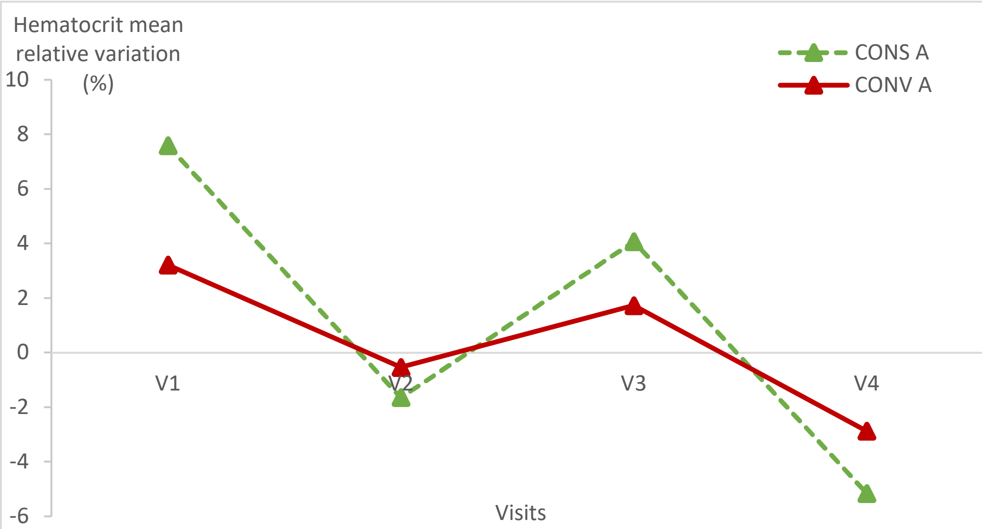

Figure 6: Haematocrit mean relative variation in the two lamb groups according to visits

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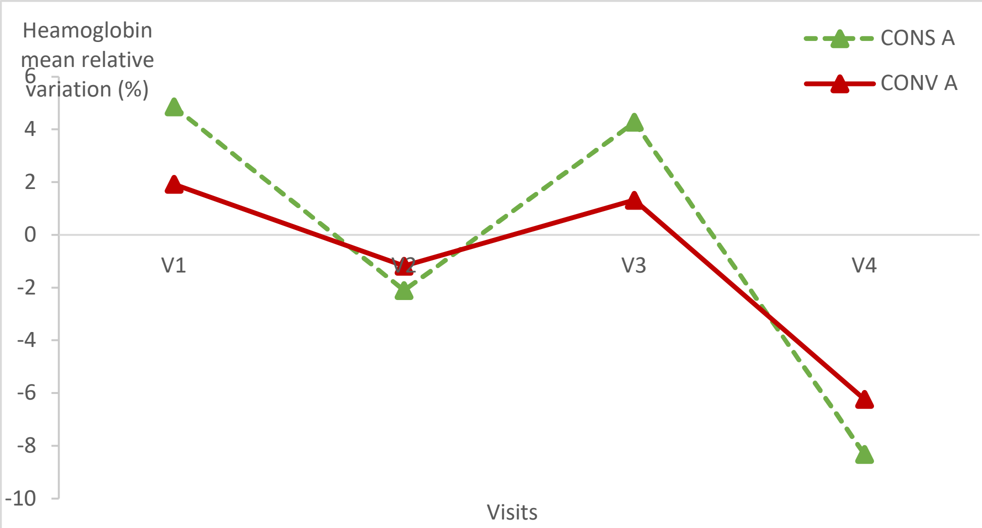

Figure 7: Haemoglobin mean relative variation in the two lamb groups according to visits

There was no statistically significant difference within each group of lambs except the haemoglobin relative variation in lambs kept in CONS A (p = 0.04) (Table 1). Indeed, the haemoglobin level of lambs in CONS A increased from the first to the fourth visit then decreased at the last visit.

3.3. Coproscopic results

The total oocysts count, didn't show a significant change in CONV A lambs' group of the first batch (Figure 8). In the CONS A group, this value decreased at the second and the fourth visit (Figure 8). Within this group, the total oocyst counts showed a significant statistical variation (p=0.01) (Table 1). The opg was high during the first visits, then it decreased at the third and fourth visits, finally it increased slightly at the last visit. The total oocysts count of the CONV A lambs' group, showed the same trend and no statistical significant variation was recorded (Figure 9).

The whipworms relative variation in the CONV A lambs' group of the first batch peaked during the third visit and then it reached naught at the last visit (Figure 10). This value was naught from the second visit in the CONS A lambs' group (figure 10). In the second batch, the whipworms relative variation was naught throughout the visits in the CONV A lambs' group (Figure 11). There was no significant statistical variation between lambs in the two groups during all visits and in the same batch (Table 2).

The epg relative variation wasn't statistically significant between the two lambs' groups and in the same group during all visits (Tables 1 and 2; Figures 12 and 13).

The prevalence rate of tapeworms did not change during all visits and no statistically significant variation was observed (p>0.99) (Table 2).

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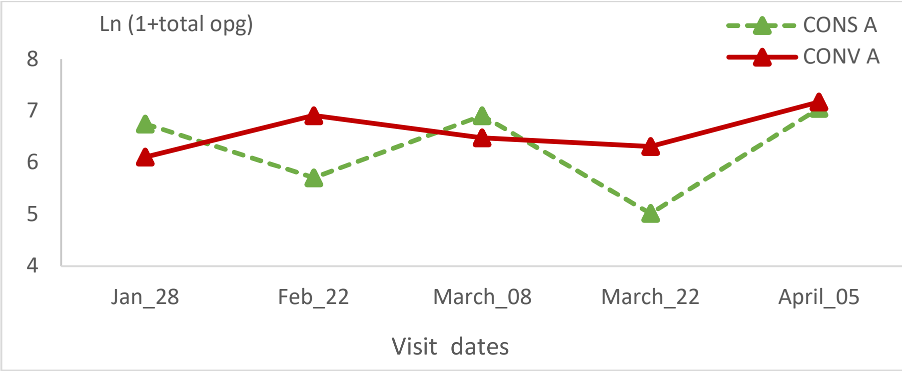

Figure 8: Total oocysts count intensity variation in the two lamb groups in the first batch

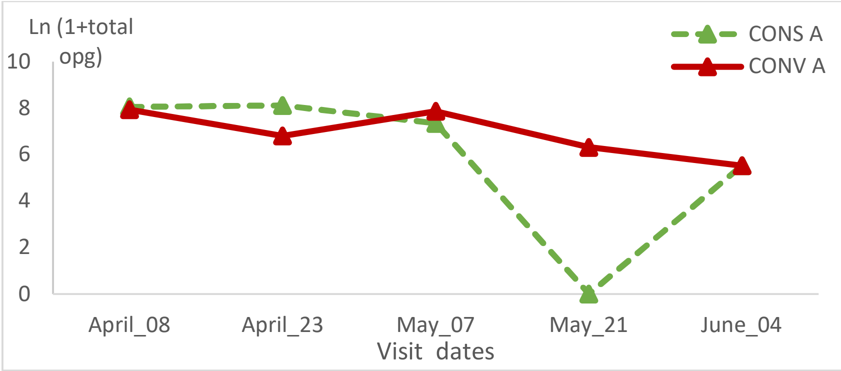

Figure 9: Total oocysts count intensity variation in the two lamb groups in the second batch

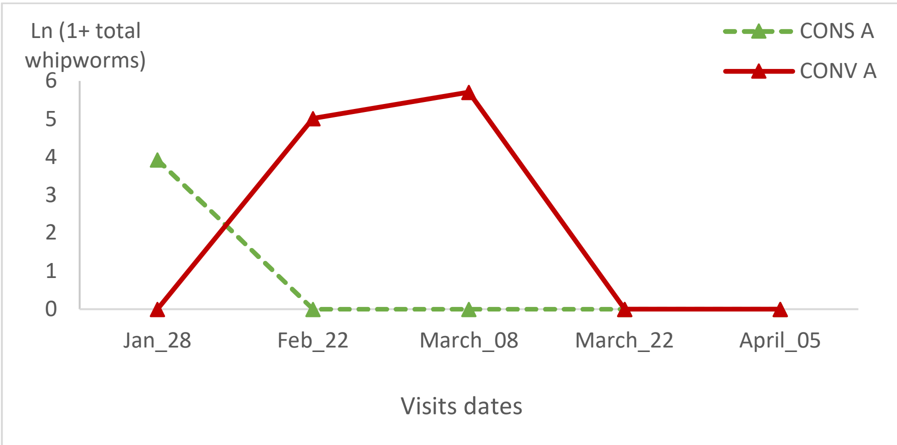

Figure 10: Total whipworms intensity variation in the two lamb groups in the first batch

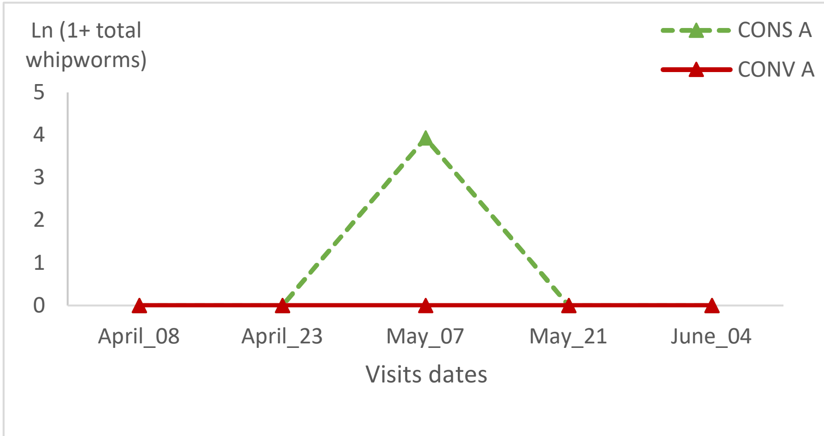

Figure 11: Total whipworms intensity variation in the two lamb groups in the second batch

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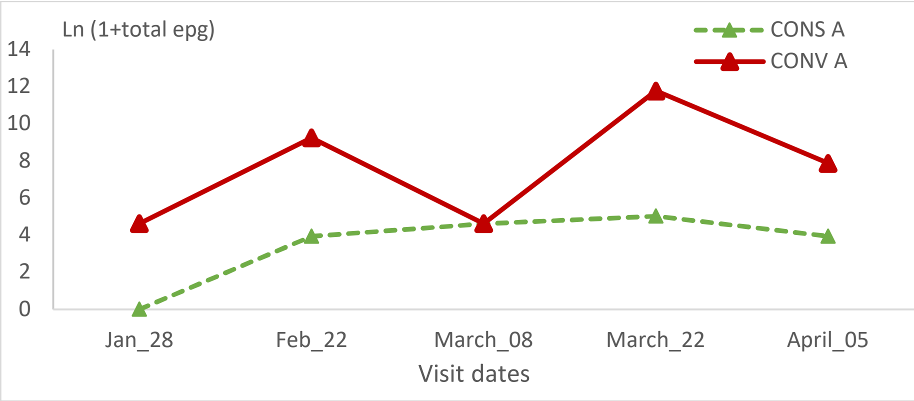

Figure 12: Total epg intensity variation in the two groups of lambs in the first batch

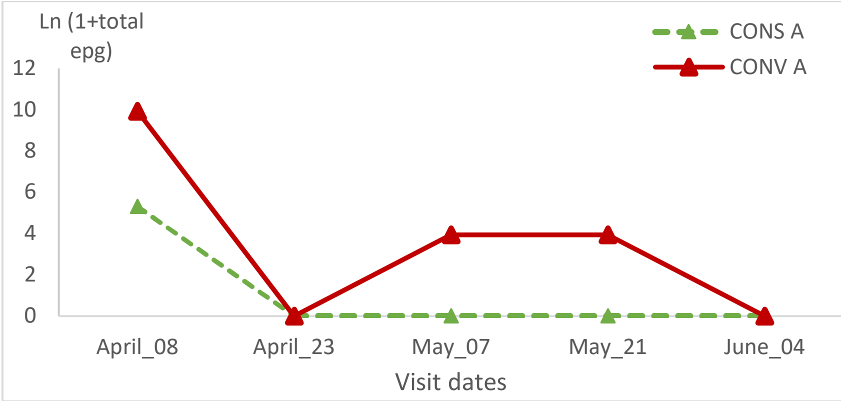

Figure 13: Total epg intensity variation in the two groups of lambs in the second batch

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Table 2: Prevalence rate of digestive parasites in CONS A and CONV A lambs during the visits

	Visit														
	1			2			3			4			5		
Coprological parameters	**CONS A**	**CONV A**	***P* value**	**CONS A**	**CONV A**	***P* value**	**CONS A**	**CONV A**	***P* value**	**CONS A**	**CONV A**	***P* value**	**CONS A**	**CONV A**	***P* value**
Epg	2/6 (33.33 ±0.19)	2/6 (33.33 ±0.19)	> 0.99	1/6 (16.67 ±0.15)	2/6 (33.33 ±0.19)	> 0.99	1/6 (16.67 ±0.15)	2/6 (16.67 ±0.15)	> 0.99	1/6 (16.67 ±0.15)	4/6 (66.67 ±0.19)	0.24	1/6 (16.67 ±0.15)	1/6 (16.67 ±0.15)	> 0.99
Opg	6/6 (100 ±0)	6/6 (100 ±0)	NA	5/6 (83.33 ±0.15)	6/6 (100 ±0)	NA	6/6 (100 ±0)	6/6 (100 ±0)	NA	2/6 (33.33 ±0.19)	5/6 (83.33 ±0.15)	0.24	5/6 (83.33 ±0.15)	4/6 (66.67 ±0.19)	> 0.99
Whipworm eggs	2/6 (33.33 ±0.19)	0/6 (0 ±0)	NA	2/6 (33.33 ±0.19)	1/6 (16.67 ±0.15)	> 0.99	2/6 (33.33 ±0.19)	1/6 (16.67 ±0.15)	> 0.99	2/6 (33.33 ±0.19)	0/6 (0 ±0)	NA	3/6 (50 ±0.2)	0/6 (0 ±0)	NA
Tapeworm eggs	2/6 (33.33 ±0.19)	2/6 (33.33 ±0.19)	> 0.99	2/6 (33.33 ±0.19)	3/6 (50 ±0.2)	> 0.99	2/6 (33.33 ±0.19)	3/6 (50 ±0.2)	>0.99	2/6 (33.33 ±0.19)	2/6 (33.33 ±0.19)	> 0.99	2/6 (33.33 ±0.19)	2/6 (33.33 ±0.19)	> 0.99

CONS A: Conservation Agriculture

CONV A: Conventional Agriculture

EPG: Egg Per Gram

OPG: Oocysts Per Gram

NA: Not Applicable

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3.4. Helminthologic necropsy

A total number of 905 parasites were collected from 12 lambs, among them abomasum nematodes were predominant, mainly Ostertagia sp. which was collected from all the lambs of both groups (Figure 13), it represented 94.25% of the total number of parasites (853 worms). The Total Worms Count (TWC) varied between 9 and 190 worms per lamb.

There was no statistically difference between both infestation intensity, and abundance in the two lamb groups (Table 3).

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Table 3: Infestation prevalence, intensity and abundance of different gastrointestinal parasites in the two lamb groups

	Infestation prevalence (% ± SE)			Infestation intensity			Infestation abundance		
Parasites	**CONS A**	**CONV A**	***P* value**	**CONS A**	**CONV A**	**P value**	**CONS A**	**CONV A**	***P* value**
Ostertagia sp.	100±0	100±0	NA	65.16	77	0.873	65.16	77	1
Marshallagia marshalli	16.67±0.15	0±0	>0.05	1	NA	NA	0.16	0	0.699
Nematodirus	16.67±0.15	16.67±0.15	>0.05	3	1	NA	0.5	0.16	0.937
Cooperia	33.33±0.19	0±0	>0.05	8.5	NA	NA	2.83	0	0.394
Trichuris ovis	50±0.2	16.67±0.15	>0.05	4.66	1	NA	2.33	0.16	0.24
Chabertia ovina	16.67±0.15	0±0	>0.05	14	NA	NA	2.33	0	0.699
Skrjabinema ovis	0±0	16.67±0.15	>0.05	NA	1	NA	0	0.16	0.699
Moniezia sp.	33.33±0.19	33.33±0.19	>0.05	7	15.5	NA	2.33	5.16	0.818

CONS A: Conservation Agriculture

CONV A: Conventional Agriculture

NA: Not Applicable

SE: Standard Error

4. Discussion

Environmental benefits of conservation agriculture, especially regarding climate change and land preservation are very high. As part of the combination of crops with livestock, particularly in semi-arid areas, CONS A and sheep farming can be combined harmoniously [13].

As far as we know, this is the first study investigating the effect of CONS A on sheep digestive parasitism. We found here in that mean relative variation of lambs' liveweight decreases in the second visit in the two animal groups. This was probably due to the impact of adaptation period. The absence of statistical difference between lambs' liveweights in the two batches means that there is no negative impact of CONS A pastures on their growth rate. A statistically significant variation of liveweights was observed in both animal groups during the five visits. This is due to the presence of a physiological high gain weight gain during this age period [22]. Moreover, the mean carcass yield of both lamb groups was slightly lower than the normal yield values for fattening lambs. There was no statistically significant difference between the two animal batches (between 450 and 600 g/kg of body weight) [23].

The parasitological status did not show any statistically significant difference regarding infection by Eimeria, whipworms, digestive strongyle eggs and tapeworms in the two lambs' batches. This result confirms that pasturing on CONS A crops has no negative impact on digestive parasitism of lambs. Furthermore, no statistically significant difference was reported between the two lamb groups concerning infestation prevalence, intensity and abundance of all found parasites.

Eimeria faecal elimination during the grazing period showed the same trend in both types of agricultures with a higher infection intensity during the wet period. This result is in agreement with that reported by De Souza in grazing sheep on semiarid areas in Brazil [24]. There was a statistically significant variation in total oocyst count in lambs grazing on CONS A pasture. The progressive decrease in the total oocyst count in the two batches of CONS A lambs' infection intensity could be explained by a progressive installation of a specific anti-Eimeria immunity. This variation could be explained by the separation of experimental lambs from the rest of the sheep herd that stopped their contamination from carrier adult sheep [25]. The relative increase in total oocyst count at the last visit could be explained by an increase of ambient humidity and temperature during the last visit.

The prevalence rate of worms varied between 16.67 and 66.7% in CONS A lamb's batch and CONV A lamb batches. Therefore, the two lamb batches showed the same trend. Yan et al (2021) reported higher prevalence rate in sheep reaching 96.9% in China [26]. This relatively low prevalence rate is probably related to the absence of promiscuity of the studied flock with others and a good management of pastures. Worms collected from the digestive tract of lambs were mainly represented by abomasum parasites, this is in agree with the two studies conducted on sheep gastrointestinal parasites in North Tunisia [27,28]. We found herein that Ostertagia spp. was the predominant nematode genus (94.25%) unlike the two studies cited above which reported a predominance of Teladorsagia sp. with an infection prevalence reaching 91.25 and 90.03% respectively. This is probably related to the rainfall and ambient temperature which constitute the two main factors conditioning survival of the outdoor parasite stages in soil.

5. Conclusions

We conclude that grazing on CONS A plots has no impact on the sheep digestive parasitism compared to those grazing in CONV A. Similarly, we showed that there is almost no difference in lamb growth rate, carcass yield as well as haematological parameters between lambs kept in the two pasture types. Further studies are needed to support these findings especially on a larger animal sample and to explore the impact of CONS A on other parasites and other domestic animal species.

Author Contributions: Conceptualization, S.E, M.G., M.R. and H.C-M.; methodology, M.G. and S.E.; validation, M.G., M.R. and H.CM.; formal analysis, S.E., S.L. and M.D.; investigation, S.E., L.S. and M.D.; resources, S.E.; data curation, S.E.; writing—original draft preparation, S.E.; writing—review and editing, S.E. and M.G.; supervision, M.G.; project administration, M.G.; funding acquisition, M.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the ICARDA in the frame of CLCA project (BUS200341).

Institutional Review Board Statement: This study was approved by the Animal Ethics Committee - National School of Veterinary Medicine, AEC/IACUC, ENMV- Sidi Thabet, Tunisia (Approval Code: CEEA-ENMV 65/22).

Data Availability Statement: Data available from the corresponding author upon request.

Acknowledgments: We thank ICARDA for funding this work and providing all the material necessary to complete this study in good conditions. Special thanks are addressed to Mr. Adnen ABED RABBAH, the owner of the sheep herd as well as the plots of conservation and conventional agriculture. we commend his continued efforts to preserve and promote this mode of eco-agriculture since the 2000s.

Conflicts of Interest: Authors declare no conflict of interest.

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