American-Eurasian J. Agric. & Environ. Sci., 15 (3): 388-398, 2015
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2015.15.3.12548

Adoption of Agricultural Innovations: Investigating Current Status and Barriers to Adoption of Heat Stress Management in Small Ruminants in Jordan

Amani Al-Dawood

Ph.D. in Animal Physiology, National Center for Agricultural Research and Extension (NCARE), P.O. Box: 639, Baqa, 19381 Jordan

Abstract: Heat stress (HS) is a major constraint to small ruminants' productivity in tropical, subtropical, arid and semiarid areas of the world including Jordan. Therefore, this study aimed at assessing the current status and barriers of HS management and proposing solutions to adopt HS management by questioning farmers about their social aspects, farm demographics, HS knowledge and practices and farmers' resources of HS management. Results indicated that there was an adequate representation of responses based on age, experience and education level of farmers and herd size. Half of the respondents have never heard about HS or not sure what HS is? Almost 32% of the farmers reported that animals exposing to HS cause deaths. Signs of HS observed on animals, the most HS management methods used and the major barriers to use HS management by farmers were herein well presented. In conclusion, the findings of this study may provide guidance to animal husbandry farmers, administrators and researchers for managing HS in Jordan.

Key words: Heat stress · Management techniques adoption · Heat stress symptoms · Small ruminants · Sheep · Goats · Animal welfare

INTRODUCTION

Small ruminants' production is the main source of income for farmers living in arid and semiarid regions of the world [1, 2]. Sheep and goats' rearing is the mainstay of the land and most of the rural population depends on them and their by-products [3]. Globally, small ruminants play an important role in the economy of thousands poor livestock owners who earn their livelihood by rearing them in different climatic conditions [4]. In the developing countries, sheep and goats make a very valuable contribution, especially to the poor in the rural areas [4]. The number of sheep and goats in Jordan is 2,311,100 and 836,500 heads, respectively [5].

The increasing demand for animal products owing to urbanization, growing developing economies and growing populations, paralleled by frequent hot climate are serious threats for the agriculture sector and for the livelihoods of rural populations. Heat stress (HS) is the major constraint to animal production in most of world, especially tropical and subtropical [6, 7], arid [8] and semiarid areas [9]. The HS compromises animal welfare and it is a major cause of mortality in ruminants [10]. In Jordan, climate is particularly characterized by very hot and dry nature, which plays an important role in causing HS to animals. The semiarid region of Jordan has high temperature, high radiation and low relative humidity (RH) and this can cause physiological, biochemical and hormonal changes in ruminants in response to these environmental conditions [11, 12]. This means that animals will have to work more under harsh climatic conditions for scattered feed resources to meet their basal nutritional requirements and they will frequently experience chronic episodes of HS. Although sheep and goats are resistant to thermal stress at a greater extent but they suffer from HS beyond their comfort zone (13-27°C) [13] and this zone is often prevailed in many times in Jordan, especially in summer. The physiological adjustments that animal makes to prevent body temperature from rising during HS help prevent death from heat stroke, but also reduce productivity [8]. Animals' growth, milk production and reproduction are impaired under HS as a result of the

Corresponding Author: Amani Al-Dawood, Ph.D. in Animal Physiology, National Center for Agricultural Research and Extension (NCARE), P.O. Box: 639, Baqa, 19381 Jordan. Tel: +962 (6) 4725071, Fax: +962 (6) 4726099, E-mail: amani623@yahoo.com.

changes in biological functions caused by stress [4, 14]. In Jordan, Al-Dawood [12] reported that goats lose 10.3% of their body weight under HS conditions.

The general homeostatic responses to HS in sheep and goats include raised respiration rates [15], panting [16], decreased feed intake [17, 18], reduced milk production [19], depressed dry matter intake [10] and increased body temperature [17]. In severe cases of HS, lack of coordination, trembling and down animals may be seen. In addition, exposure of sheep and goats to elevated temperatures results in a decrease of body weight, average daily gain, growth rate and body total solids [4, 20]. Dairy goats kept under HS decreased their dry matter intake by 30%, doubled their water consumption, reduced their milk yield by 10% and produced milk with lower contents of fat and protein [19].

Animals' farmers have adopted a variety of ways to combat HS. Relieve techniques may include the use of fans, shades, water bathing and adequate air circulation [10]. Feeding strategies, which include dietary fiber adjustment, the use of high quality fiber forage, supplemental protected fat and feeding at cool hours can greatly help in reducing the negative effect of HS on reproductive performance [10]. One of the best practices to reduce HS is to provide adequate fresh and cool drinking water. The provision of shade shelter is probably the easiest and cheapest option to help animals cool themselves under HS conditions [9].

Since sheep and goats are considered very rustic animals, their ability to cope with hot environmental conditions and inadequate management practices, without harming their welfare and productive performance, has been often overrated. However, information on if and how much specific factors influence the adoption of HS management may offer insight into better design policies needed to provide guidance in efforts to promote more efficient management. In addition, it is evident, more than any time before that there is need for application of new technologies in the agricultural sector. However, adoption is an outcome of a decision to accept a given innovation. It is a mental process an individual passes from first hearing about an innovation to final utilization [21]. However, summer high temperature prevails all over Jordan. This exposes small ruminants to HS and requires feasible relief techniques and feeding strategies to be used in sheep and goats' herds during summer. Thus, there is an urgent need to develop sustainable strategies to reduce the side effect of HS on small ruminants in Jordan. To date and to the best of our knowledge, no attention has been paid on HS management techniques used by small ruminants' farmers in Jordan. Bearing this purpose in mind, this study aimed at assessing the current HS management status, barriers and practices used and proposing solutions to adopt HS management by farmers. For this purpose, Jordanian small ruminants' farmers were questioned about their social aspects, farm characteristics, HS knowledge and practices and farmers' resources of HS management. Finally, by pointing out factors that influence HS management, this study will provide guidance to animal husbandry farmers, administrators and researchers for effectively managing HS in Jordan.

MATERIALS AND METHODS

Questionnaire Development: For developing the questionnaire, questions were proposed in Arabic language and sent to panel of experts in small ruminants for their critique and suggested additions. After responses were received from the specialists, their suggestions and comments were utilized in developing the final questionnaire. The survey questionnaire instrument was developed to better understand and document the current HS management status, barriers and practices used by small ruminants' farmers and to gather information regarding perception of farmers' in Jordan. Although sampling was random, an effort was made to ensure that the selected farmers represented different regions of Jordan (North, Middle and South), farmers' age groups, literally levels and herd sizes. The paper format questionnaire was accompanied by a cover letter to explain the goal of the study to seek their consent. In addition, phone calls, when necessary, to farmers who have received the questionnaire, were done to encourage their participation and explain any unclear question in the questionnaire, if any. The study was carried out by survey throughout 2014.

Structure of the Survey Data: The questionnaire used in this survey was consisted of three main parts; (1) demographics of the farmers, (2) farm characteristics and (3) HS knowledge, practices, signs, barriers and management resources. The first part in the questionnaire determined the demographics of the farmers, i.e. location, age, agricultural experience and educational level. The second part probed into the demographics of the farm, i.e. farm system, type of animals, breeds, herd size, forage type and veterinary control over the farm. The third part of the questionnaire was divided into 5 subsections.

Subsection one determined HS knowledge and addressed the level of farmers' familiarity with HS and if they heard about fogging, misting or fans. Subsection 2 addressed how often and when farmers experience high temperatures during the last year, death cases due to HS, how often and how they monitor HS and what are the most commonly HS practices used by farmers. In the 3rd subsection farmers were asked in details about which HS symptoms observed on their animals. Subsection 4 addressed why farmers are not using management techniques to reduce HS. Subsection 5 determined farmers' resources of HS management, involvement in training program, if farmers seek for HS information and how they would like to have information? A series of yes/no answers and agree/no opinion/disagree answers were included in the questionnaire.

Response Outcomes and Statistical Analysis: Sixty three completed questionnaires were returned to me, who did an initial evaluation of the returned surveys for completeness. In order to code the data, the respondents reported answers of implementation (that is, not implementing a practice = 0 or implementing a practice = 1). A codification manual was prepared and numbers ranging from 1 to 3 were assigned to the possible responses, disagree, no opinion and agree, respectively. The final point value of each item was obtained by multiplying the assigned value by the number of responses. Because multiple choices could be checked by each respondent in some questions, percentages do not sum to 100. Data were analyzed using descriptive and inferential statistics such as mean, standard error mean, percentages and frequencies [22]. For correlation of education level with other variables, the illiterate, schooling, tawjihi, diploma and BSc were assigned values of 1, 2, 3, 4 and 5, respectively. Spearman's correlation analysis procedure was used to examine pair-wise associations between demographics' variables of farmers and farm (age, experience, education and herd size) and a particular HS issue [23]. All analyses were performed using the Proc GLM of the statistical package Sigma Stat version 17.0 [24].

RESULTS

Demographics of the Respondents

Respondents' Geographical Distribution and Their Age: Survey responses were obtained from 63 respondents from three governorates representing three different regions of Jordan (North: Mafraq, Middle: Balqa and South: Karak). The highest percent of responses was obtained from Karak (52.38%); in contrast, the lowest responses' percent was recorded for Mafraq with only 17.46% (Table 1). The overall average farmers' age was 47.83±2.21 years old, in which the youngest farmer was 20 years old and the eldest was 85 years old. Splitting the farmers age into groups (Table 1) showed that 20.63% of farmers is in the forties of age, followed by those in the thirties and fifties of age with 19.05% for each, meanwhile the minority of the respondents was in the eighties of age (4.76%). On average, survey respondents were middle-aged.

Animal Husbandry Experience and Educational Level of Respondents: The total number of farmers' experience in animal husbandry was 1,094 years with an overall average of 17.37±1.37 years/farmer. About 51% of the farmers have an average of 16.91 years of experience, while only 9.52% of them have an average experience of 27.00 and 43.17 years/farmer (Table 2). Schooling educational level was the most dominant among the farmers with 42.86%, followed by tawjihi and BSc with 19.05% for each. Meanwhile, illiterate (7.94%) was the lowest among the respondents (Table 2).

Demographics of the Farm: Each respondent had on average 138.60±22.77 animals/farmer (range: 10-1000). The overall average age of the animals was 3.61±0.21

Table 1: Geographical representation of respondents according to governorate and groups for respondents' age (n=63).

Governorate	Frequency of farmers	Percent of farmers (%)	Age interval (years)	Frequency of farmers	Percent of farmers (%)
Karak	33	52.38	20-29	10	15.87
Balqa	19	30.16	30-39	12	19.05
Mafraq	11	17.46	40-49	13	20.63
			50-59	12	19.05
			60-69	05	07.94
			70-79	08	12.70
			≥ 80	03	04.76

Table 2: Animal husbandry experience and educational level of respondents (n=63).

Experience interval	Aver. no. of years	Frequency of farmers	Percent of farmers (%)
1-10 years	06.95±0.58	19	30.16
11-20 years	16.91±0.41	32	50.79
21-30 years	27.00±1.37	06	09.52
> 30 years	43.17±3.61	06	09.52
Education level		Frequency of farmers	Percent of farmers (%)
Illiterate		05	07.94
Schooling		27	42.86
Tawjihi*		12	19.05
Diploma		07	11.11
University graduate, BSc		12	19.05

*Finishing the secondary school successfully.

Table 3: Groups for herd numbers owned by respondents (n=63).

Herd size (head)	Frequency of farmers	Percent of farmers (%)
1-200	53	84.13
201-400	04	06.35
401-600	05	07.94
601-800	00	00.00
801-1,000	01	01.59

Table 4: Farm system, animals' type and breed and veterinary control over the farm as reported by respondents (n=63).

	Item	Frequency of farmers	Percent of farmers (%)
Farm system	Open	36	57.14
	Closed	16	25.40
	Semi-open	11	17.46
Type of animals	Goats	27	42.86
	Sheep	12	19.05
	Both	24	38.10
Breeds*	Baladi (goat)	47	74.60
	Awassi (sheep)	32	50.59
	Shami (goat)	18	28.57
	Assaf (sheep)	03	04.35
Veterinary control over the farm	Yes	38	60.32
	No	25	39.68

*Because multiple choices could be checked by each respondent, percentages do not sum to 100.

years (range: 1-7). The forage types provided to the animals were barley, bran, straw, soy, grass and maize. In addition, the animals were grazed on natural pastures or rangelands. Splitting the herd size into groups (Table 3) showed that 84.13% of farmers owned 200 heads or less, followed by those who owned 201-400 and 401-600 heads with 6.35% and 7.94%, respectively.

Open farm was the most dominant system among the farmers with 57.14%, followed by closed farm system with 25.40% (Table 4). The highest percent of respondents owned goats with 42.86% and only 19.05% owned sheep. Baladi was the most dominant goats' breed with 74.60%, followed by Awassi sheep with 50.59%. Around 60% of the respondents (60.32%) stated that veterinary control was taken over the farm (Table 4).

Heat Stress

Heat Stress Knowledge: Results indicated that 52.38% of the respondents have never heard about HS and not sure what HS is prior to completing the survey (Table 5). About two-fifth of respondents indicated that they are familiar with HS concepts and practices. Only 9.52% of the respondents were regularly using HS management. Almost 46% of the respondents have heard about misting system, while only 3.17% of farmers interviewed have heard about fogging system (Table 5).

Heat Stress Practices: Data on how often farmers experience high temperature during the last 12 months indicated that around 48% and 24% of the respondents experience HS sometimes and often, respectively, in contrast, only 9.52% of the farmers did not experience any

Table 5: Level of familiarity with heat stress and knowledge of cooling systems as reported by respondents (n=63).

	Item	Frequency of farmers	Percent of farmers (%)
Familiarity with HS?	Never heard about HS	17	26.98
	Not sure what HS is?	16	25.40
	Familiar with HS concepts and practices	26	41.27
	Regularly use HS management	06	09.52
Have you ever heard about?	Misting system	29	46.03
	Fans	17	26.98
	Fogging system	02	03.17

Table 6: Some selected issues related to heat stress management as reported by respondents (n=63).

	Item	Frequency of farmers	Percent of farmers (%)
How often did you experience high temperature during the last 12 months?	Sometimes	30	47.62
	Often	15	23.81
	Rarely	12	19.05
	Never	06	09.52
When you experience high temperatures?*	May	03	04.35
	June	21	33.33
	July	41	65.08
	August	35	55.56
	September	02	03.17
Did you experience death due to heat shock at your farm?		20	31.75
If yes, how many cases of death? (n=20)	1-5	10	50.00
	6-10	05	25.00
	11-15	03	15.00
	More than 15	02	10.00
Monitoring HS*	Once a day	03	04.35
	Once a week	01	01.59
	Once a month	04	06.35
	Once during summer season	14	22.22
	During specific hot outbreaks	43	68.25
	None	12	19.05
Measured parameters at farm	Temperature	10	15.87
	RH	00	00.00
	Nothing	53	84.13
HS management methods used*	Shading facility	42	66.67
	Grazing time (early morning)	30	47.62
	Feeding time (early morning, evening)	30	47.62
	Water providing frequency	20	31.75
	Stocking	20	31.75
	Cooling	01	01.59
	Nothing used	01	01.59

*Because multiple choices could be checked by each respondent, percentages do not sum to 100.

HS during the last year. Around 65% of the farmers experience high temperatures during July and then followed by August (~56%) (Table 6). Almost 32% of the farmers reported that animals exposing to HS cause deaths, in which half of them reported 1-5 death cases in their animals. Almost 68% of the respondents monitor HS during specific hot outbreaks. In contrast, almost 19% of the farmers indicated that no monitoring is done. In addition, a high percent (~84%) of the farmers did not measure temperature and RH in their farms (Table 6). Data showed that the most HS management methods used by respondents are shading facility (66.67%), grazing time at early morning (47.62%) and feeding time at early morning or evening (47.62%) (Table 6).

Heat Stress Symptoms/signs: The most HS symptoms/signs observed on the animals as reported by respondents are increase water consumption (~65%), move toward cooler places (~46%), decrease food intake (~44%) and decrease milk production (~40%) (Table 7).

Table 7: Heat stress symptoms/signs observed on the animals as reported by respondents (n=63).

	Item	Frequency of farmers	Percent of farmers (%)
HS symptoms/	Increase water consumption	41	65.08
signs observed*	Move toward cooler places	29	46.03
	Decreasing food intake	28	44.44
	Decreasing milk production	25	39.68
	Increased body temperature	15	23.81
	Try to move away from other animals	10	15.87
	Reproductive problems	08	12.70
	Aggressiveness time spent movement and standing	03	04.35
	Others	04	06.35

*Because multiple choices could be checked by each respondent, percentages do not sum to 100.

Table 8: Barriers for not using heat stress management in farms as indicated by respondents (n=63).

Task	Final point value (Mean of 3)
Heat control is not effective	2.09
The use of heat control requires special skills and knowledge that farmers do not have	1.91
Cost of HS control is too high	1.68

Heat Stress Barriers: The major barriers to use HS management techniques by farmers are due to perception that heat control is not effective and the use of heat control requires special skills and knowledge that farmers do not have. In contrast, the least barrier cited by respondents is the cost of HS control is too high (Table 8).

Heat Stress Management Resources: There is no single source of information which farmers rely upon for HS management in their farms although private consultant (44%) and extension meetings and training of Ministry of Agriculture (MOA) (32%) were the most popular (Table 9). Other information sources were also listed by the respondents. Almost 80% of the respondents indicated that HS management is neither required nor recommended by MOA. Only 3% of those respondings had been involved in HS management program. Almost 70% of the respondents would like to change to adopt HS management in their farms. About 57% of respondents reported looking for information about HS management, of them 56% looked for general information and 33% technical information (Table 9). Almost 57% of the respondents would like to have information about HS management through extension of the MOA. In contrast, online information and written manuals were the least preferred by farmers.

Correlation Analysis: The results indicated that farmer's age is correlated positively with experience ($r = 0.558$, $P < 0.01$) and herd size ($r = 0.211$, $P > 0.05$) and negatively with education ($r = -0.486$, $P < 0.01$) (Table 10). There was a positive non-significance correlation between education level of farmers and familiarity with HS ($r = 0.189$, $P > 0.05$) and involve in HS training ($r = 0.185$, $P > 0.05$). Age was negatively non-significantly correlated with familiarity with HS ($r = -0.176$, $P > 0.05$), involve in HS training ($r = -0.118$, $P > 0.05$) and farmer attitude towards HS ($r = -0.132$, $P > 0.05$). Furthermore, herd size was significantly and positively correlated with farmer attitude towards HS ($r = 0.416$, $P < 0.01$) (Table 10).

DISCUSSION

The present data showed that there is an adequate representation of responses based on age, experience and education level of farmers and herd size. The long experience period in animal husbandry (aver. 17.4 years/farmer) could strengthen our results and give a wider view on awareness of farmers toward HS management in Jordan. In the current study, age and education level of farmers played unclear role in practicing HS management techniques. In contrast, in Jordan age and education level of farmers was negatively and significantly correlated with adoption of other agricultural innovations such as integrated pest management and biological control [25, 26]. However, in general, as farmers advance in age, risk aversion increased and adoption of a new technology seemed less likely, thus, younger farmers are more likely to adopt and more interested in trying out new agricultural technologies than elder ones [27] because of their risk taking character. Generally, education is thought to create a favorable mental attitude for the acceptance of new practices especially of information-intensive and management-intensive practices [28] and reduce the amount of

Table 9: Heat stress management resources and required information indicated by respondents (n=63).

	Item	Frequency of farmers	Percent of farmers (%)
HS management resources*	Private consultant	28	44.44
	Extension meetings and training (MOA)	20	31.75
	Other resources	19	30.16
	Extension newsletters	03	04.35
	Websites	01	01.59
	Books	01	01.59
	Trade publications	01	01.59
Does the ministry of agriculture require or recommend the use of HS management from you?	Required and recommended	13	20.63
	Neither required nor recommended	50	79.37
Involving in training or practical agriculture program about HS		02	03.17
Would you like to adopt HS management in your farm?		44	69.84
Seeking for HS information		36	57.14
Type of information needed (n=36)	General and principles information	20	55.56
	Technical information	12	33.33
	Other information	06	16.67
How you would like to have information about HS? *	Extension (MOA)	36	57.14
	Workshop	15	23.81
	Training	13	20.64
	Continuing education	06	09.52
	Phone calls	06	09.52
	Online information	04	06.35
	Written manuals	04	06.35

*Because multiple choices could be checked by each respondent, percentages do not sum to 100.

Table 10: Some important correlations' analysis between demographics variables of the farmers/farm and particular heat stress issues (n=63).

Correlated variables	r	Significance
Age vs. Experience	0.558**	0.000
Age vs. Education	-0.486**	0.000
Education vs. Experience	-0.396**	0.001
Age vs. Herd size	0.211	NS
Education vs. Familiarity with HS	0.189	NS
Education vs. Involve in HS training	0.185	NS
Age vs. Familiarity with HS	-0.176	NS
Age vs. Involve in HS training	-0.118	NS
Age vs. Farmer attitude towards HS	-0.132	NS
Herd size vs. Farmer attitude towards HS	0.416**	0.001
Experience vs. Farmer attitude towards HS	-0.146	NS

**Correlation is significant at the 0.01 level. NS: Not significant.

complexity perceived in a technology by increasing a technology's adoption. Since schooling level is the most dominant among farmers, thus, increases education level is expected to improve HS management adoption. For optimal results, the people who care for animals should have appropriate education, experience, understand the species requirements and have good observational and communications skills. Results indicated that half of the respondents have never heard about HS and not sure what HS is? It is to be mentioned that awareness of HS is the first step towards its management adoption. Thus, efforts should be done by the MOA in order to increase farmers' knowledge through training and education about how to deal with HS.

The forage types provided for animals in the current study were barley, bran, straw, soy, grass and maize. In addition, the animals were grazed on natural pastures or rangelands. In dry hot conditions, harvested feed resources and desirable forage are key determinants of area requirements [29]. Sheep and goats raised under these conditions are generally grazing on degraded rangelands and offered low quality fibrous feedstuffs like

cereal straws. Concentrate feeds (i.e. barley, maize and soybean meal) are commonly used to tackle this objective [2]. Thus, semiarid region like Jordan justifies the needs for a serious reflection on the readjustment of new feeding strategies targeting the improvement of animal production. Our data showed that open farm was the most dominant system among the farmers followed by closed farm system. Actually, in sunny, hot environments, the animals avoid crowding because they need to dissipate body heat and they spend much time in the shade. Thus, fully enclosed shelters are not recommended for hot climate because of the decreased natural air velocity and it is preferred to use partially ones [30]. Therefore, adequate space allowance and monitoring of temperature and RH are crucial aspects in sheep and goats housing.

Data on how often farmers experience high temperature during the last 12 months indicated that around 48% and 24% of the respondents experience HS sometimes and often, respectively and 65% of them experience high temperatures during July and then followed by August. This indicates that animals are under HS in Jordan. Our results agree with the findings of Silanikove [16] who stated that the most severe HS is expected during the months of July and August. In addition, Elbeltagy *et al.* [31] mentioned that sheep and goats are most naturally exposed to HS under direct solar radiation in July and August. Our data showed that 32% of the farmers reported that animals exposing to heat shock cause deaths, in which half of them reported 1-5 death cases in their animals. The parameter used to measure animal welfare is mortality [32]. This was associated with respiratory rates approaching 300 breaths/min (bpm), with open-mouthed panting, indicating severe HS [16]. Thus, farmers should measure breath rate and deciding if an animal is panting and qualifying the severity of HS according to panting rate (low: 40-60 bpm, medium high: 60-80 bpm, high: 80-120 bpm and severe HS: > 200 bpm) appears to be the most accessible and easiest method for evaluating the impact HS on farm animals under extensive conditions [9].

The current data indicated that the most HS management methods used by farmers are shading facility, grazing and feeding time at early morning or evening and providing water frequency. In this regard, Sevi *et al.* [33] reported that when sheds are provided, adequate ventilation is necessary to improve air quality and increase animal comfort. In addition, providing shade shelter to sheep and goats leads to improve their reproductive performance [1]. During hot weather, handling or driving of sheep and goats should be restricted to the cooler times of day [34]. In semiarid-Mediterranean hot conditions, grazing ruminants tend to lie down and to reduce their locomotion during the day. Instead, they tend to graze before sunrise, at dawn and during the night [16]. In addition, cooling by spraying could reduce HS symptoms and improve sheep and goats welfare [19].

In the current study, HS signs observed on the animals as reported by respondents are increase water consumption, move toward cooler places, decrease feed intake, decrease milk production, increased body temperature and reproductive problems. Our results agree completely with the findings of Silanikove [16], Caroprese [29] and Facanha *et al.* [18] who reported that HS decrease feed intake, reproductive performance, growth and milk production and increase water requirements of sheep and goats. Furthermore, water intake doubled and feed intake dropped to zero under HS conditions [10]. Body weight, average daily feed intake and gain of sheep and goats decreased under hot semiarid conditions [17, 20, 35]. The major barriers to manage HS by Jordanian farmers are due to perception that heat control is not effective, the use of heat control requires special skills and knowledge that farmers do not have and the costs of HS control is too high. Thus, to start using HS management techniques farmers need training and workshop to build up their capacity. Given that HS management strategy is scientifically feasible, the successful farmer is most likely to adopt the strategy if it is an economically feasible decision for the farm. Hence, an understanding of the context for an innovation provides a basis for drawing inferences about the reasons why farmers do or do not adopt an agricultural innovation.

Our data showed that there is no single source of information which farmers rely upon for HS management in their farms although private consultant was the most popular. Almost 80% of the respondents indicated that HS management is neither required nor recommended by MOA and 70% of the respondents would like to change to adopt HS management in their farms. The excellent way to accelerate the adoption is by means of education and a good contact with extension agents [36]. The current data indicated that 97% of farmers have never received any training on HS management. The absence of farmer' training further increases the danger of HS. This suggests that designing and implementing educational and training programs to make huge contribution to reduce the HS effect on animals. Our results indicated that 84% of the farmers do not measure temperature and RH in their farms.

Measuring the heat load imposed on an animal using wet bulb temperature (both temperature and RH) can lead to an efficient way of reducing HS [37]. In addition, respiratory rate is often used to assess the ability of animals to cope with heat load. In sheep, panting rate, which has been proposed as a better measure of HS than respiratory rate, could be used under field conditions [38]. Rectal temperature is also considered as a good index of body temperature [6, 12, 39]. Thus, all of these parameters should be taken into account and measured once animals exposed to HS.

CONCLUSIONS

Since heat stress negatively affects animals comfort, reproduction and milk yield, thus, management strategies must be applied to counter hot environmental conditions. Heat control is based on providing with fresh and cool drinking water and increasing energy density of rations as well as using of cooling mechanisms including shade and commercial coolers. To minimize heat generated, the greater part of the animals' ration should be fed during the cooler periods of the day. Sheep and goats should not be handled, worked, grazed or transported during the hottest time of the day and animals should be sheared prior to the onset of hot weather. Extension, training programs, education, workshops and presentations should be directed to farmers to increase existing knowledge, skills and practice of sheep and goats management with newly acquired knowledge and skill in field of sheep and goats housing, feeding, health and HS management. Unfortunately, sheep and goats in Jordan often have shelters that are not appropriate, in terms of design, materials and size, thus, much attention must be given to the micro-environment control and to the choice of proper house structures, materials and design in order to avoid crowding and aggressive behavior. Active cooperation among meteorologists, veterinarians, nutritionists, scientists, technicians, extension people, local organizations and farmers is required to successfully reduce the side effects of HS on animals. There is a need to intensify both extension/farmer relationships and researcher/ extension linkage to improve farmers' knowledge on the use of HS management techniques and strengthen the role of extension services in HS management. The findings of this study might contribute to ongoing efforts to promote HS management adoption in Jordan. Finally, our hope is that the current results will serve as a catalyst for the adoption of HS management and will therefore contribute to the sustainability of agriculture in Jordan.

REFERENCES

1. Berger, Y., P. Billon, F. Bocquier, G. Caja, A. Cannas, B. McKusick, P.G. Marnet and D. Thomas, 2004. Fundamentals of sheep dairying in North America. Cooperative Extension Publishing, University of Wisconsin Extension, Madison.
2. Ben Salem, H., 2010. Nutritional management to improve sheep and goat performances in semiarid regions. Revista Brasileira de Zootecnia, 39: 337-347.
3. Ben Salem, H. and T. Smith, 2008. Feeding strategies to increase small ruminant production in dry environments. Small Rumin. Res., 77: 174-194.
4. Gupta, M., S. Kumar, S.S. Dangi and B.L. Jangir, 2013. Physiological, biochemical and molecular responses to thermal stress in goats. Int. J. Livest. Res., 3: 27-38.
5. Jordan Statistical Yearbook, 2013. Department of Statistics/Annual Agriculture Surveys. Issue no. 64, pp 276. http://www.dos.gov.jo/dos_home_a/ main/cd_yb 2013/pdf/agri.pdf.
6. Marai, I.F.M., A.A. El Darawany, A. Fadiel and M.A.M. Abdel Hafez, 2007. Physiological traits as affected by heat stress in sheep a review. Small Rumin. Res., 71: 1-12.
7. Nardone, A., B. Ronchi, N. Lacetera, M.S. Ranieri and U. Bernabucci, 2010. Effects of climate changes on animal production and sustainability of livestock systems. Livest. Sci., 130: 57-69.
8. Silanikove, N., 1992. Effects of water scarcity and hot environment on appetite and digestion in ruminants: a review. Livest. Prod. Sci., 30: 175-194.
9. Silanikove, N., 2000a. Effects of heat stress on the welfare of extensively managed domestic ruminants. Livest. Prod. Sci., 67: 1-18.
10. Caulfield, M.P., H. Cambridge, S.F. Foster and P.D. McGreevy. 2014. Heat stress: A major contributor to poor animal welfare associated with long-haul live export voyages. Vet. J., 199: 223-228.
11. Al-Tamimi, H.J., 2007. Thermoregulatory response of goat kids subjected to heat stress. Small Rumin. Res., 71: 280-285.
12. Al-Dawood, A., 2014. Evaluation of the acute phase proteins as indicators of animal health and performance capability in Baladi goats in Jordan. Submitted to Livest. Res.
13. Mishra, R.P., 2009. Role of housing and management in improving productivity efficiency of goats. *In:* Goat production-processing of milk and meat. 1st edn., pp: 45.

14. Habeeb, A.A.M., I.F.M. Marai and T.H. Kamal, 1992. Heat stress. *In:* Phillips, C. and D. Pigginns (Eds.), Farm Animals and the Environ. CAB Inter. Wallingford, UK, pp: 27-47.
15. Mortola, J.P. and P.B. Frappell, 2000. Ventilatory responses to changes in temperature in mammals and other vertebrates. Ann. Rev. Physiol., 62: 847-874.
16. Silanikove, N., 2000b. The physiological basis of adaptation in goats to harsh environments. Small Rumin. Res., 35: 181-193.
17. Marai, I.F.M., L.B. Bahgat, T.H. Shalaby and M.A. Abdel-Hafez. 2000. Fattening performance, some behavioural traits and physiological reactions of male lambs fed concentrates mixture alone with or without natural clay, under hot summer of Egypt. Ann. Arid Zone, 39: 449-460.
18. Facanha, D.A.E., L. Sammichelli, R. Bozzi, W.S.T. Silva, J.H.G. Morais, R.M.O. Lucena, P.P.L. Escossia and W.P. Costa, 2010. Performance of Brazilian native goats submitted to a mix supply under thermal stress conditions. 11th Intern. Conf. on goats, 23-27 September, Gran Canaria, Spain.
19. Salama, A.A.K., S. Hamzaoui and G. Caja, 2012. Responses of dairy goats to heat stress and strategies to alleviate its effects. Proc. 11th Intern. Conf. on goats, 23-27 September, Gran Canaria, Spain.
20. Kandemir, C., N. Kosum and T. Taskin, 2013. The effects of heat stress on physiological traits in sheep. Macedonian J. Anim. Sci., 3: 25-29.
21. Feder, G., R.J. Just and D. Zilberman, 1985. Adoption of agricultural innovations in developing countries: A survey. Econ. Develop. Cul. Change, 33: 255-298.
22. Samiee, A., A. Rezvanfar and E. Faham, 2009. Factors influencing the adoption of integrated pest management (IPM) by wheat growers in Varamin County, Iran. Afr. J. Agric. Res., 4: 491-497.
23. Zar, J., 1999. Bio-statistical analysis. Prentice Hall, Upper Saddle River, NJ, pp: 663.
24. SPSS, Statistical Product and Service Solutions INC. 1997. SIGMASTAT 2.03: SigmaStat Statistical software user's manual, Chicago, United States.
25. Al-Zyoud, F., 2014a. Adoption range of integrated pest management (IPM) techniques by greenhouse vegetable growers in Jordan. Jordan J. Agric. Sci., 10: 504-525.
26. Al-Zyoud, F., 2014b. Investigating barriers to adoption of biological control technology by vegetables and fruit trees' growers in Jordan. (Accepted in Jordan J. Agric. Sci.).
27. Rogers, E.M., 1995. Diffusion of Innovations. 4th Edition, New York, the Free Press.
28. Caswell, M., K. Fuglie, C. Ingram, S. Jans and C. Kascak, 2001. Adoption of agricultural production practices: Lessons learned from the US. Washington DC. US Department of Agriculture. Economic Research Service, Agriculture Economic Report No. 792.
29. Caroprese, M., 2008. Sheep housing and welfare. Small Rumin. Res., 76: 21-25.
30. Da Silva, R.G., N. LaScala Jr., A.E. Lima-Filho and M.C. Catharin, 2002. Respiratory heat loss in the sheep: A comprehensive model. Int. J. Biometeor., 46: 136-140.
31. Elbeltagy, A.R., A.M. Aboul-Naga, T.M.M. Abdel Khalek, M.H. Elshafie and B. Rischkowsk, 2012. Tolerance to abiotic stresses in Egyptian desert sheep and goats raised under hot dry conditions: Response to natural and acute heat stresses. 11th Intern. Conf. on goats, 23-27 September, Gran Canaria, Spain.
32. Ferguson, D., A. Fisher, B. White, R. Casey and B. Mayer, 2008. Review of the Livestock export heat stress risk assessment model (Hot Stuff). Meat and Livestock Australia, North Sydney, NSW, Australia.
33. Sevi, A., M. Albenzio, G. Annicchiarico, M. Caroprese, R. Marino and A. Santillo, 2006. Effects of dietary protein level on ewe milk yield and nitrogen utilization and on air quality under different ventilation rates. J. Dairy Res., 73: 197-206.
34. Webster, A.J.F., 1983. Environmental stress and the physiology, performance and health of ruminants. J. Anim. Sci., 57: 1584-1593.
35. Padua, J.T., R.G. Da Silva, R.W. Bottcher and S.J. Hoff, 1997. Effect of high environmental temperature on weight gain and food intake of Suffolk lambs reared in a tropical environment. In: Proc. 5th Intern. Symp., Bloomington, Minnesota, USA, pp: 809-815.
36. Odendo, M., G. Obare and B. Salasya, 2009. Factors responsible for differences in uptake of integrated soil fertility management practices amongst smallholders in Western Kenya. Afr. J. Agric. Res., 4: 1303-1311.

37. Sparke, E.J., B.A. Young, J.B. Gaughan, M. Holt and P.J. Goodwin, 2001. Heat load in feedlot cattle. Meat and Livestock Australia, North Sydney, NSW, Australia.
38. Mader, T.L., M.S. Davis and T. Brown-Brand, 2006. Environmental factors influencing heat stress in feedlot cattle. J. Anim. Sci., 84: 712-719.
39. Phulia, S.K., R.C. Upadhyay, S.K. Jindal and R.P. Misra, 2010. Alteration in surface body temperature and physiological responses in Sirohi goats during day time in summer season. Indian J. Anim. Sci., 80: 340-342.