NICRA PROJECT

On

Assessing Resilience of Small Ruminant Production under Changing Climatic Condition in Semi-arid Zone

FINAL REPORT
(2011-2014)

Dr A. Sahoo
PRINCIPAL INVESTIGATOR

Co-operating Center

Central Sheep and Wool Research Institute
Avikanagar, Rajasthan - 304501

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1. **Reporting year: 2011-2014**

2. **Title of the project:** Assessing resilience of small ruminant production under changing climatic condition in semi-arid zone

3. **Name of the institute:** Central Sheep and Wool Research Institute Avikanagar, Rajasthan-304501

4. **Name of P.I.:** Dr S.M.K. Naqvi (up to 13.08.12)
   Dr A. Sahoo (w.e.f. 14.08-12)

5. **Name of the Associates with responsibilities:**

Dr Davendra Kumar	Management of animals and shelter and experiment on reproductive profile, data interpretation and report writing
Dr S.M.K. Naqvi	Planning and guidance on shelter and stress management
Dr O.H. Chaturvedi	Implementation of nutrition related experimental protocol, laboratory analysis, compilation and reporting
Dr Kalyan De	Implementation of experimental protocol, laboratory analysis, compilation and reporting
Dr Satish Kumar	Exploring HSP 70 gene and studying down and upward regulation profile of genes(s) to different stresses

6. Brief Technical Program implemented

Objectives

1. Documenting information on availability and quality of water accessible to sheep/goat in arid and semi-arid areas.
2. To study the adaptive capability of ewe and ram to compound abiotic stresses (thermal and water restriction) based on growth, physiological, endocrine and biochemical responses and reproductive performance
3. To identify the feeding and water managemental strategies to combat environmental stresses in sheep.
4. Evolving shelter management strategies to combat environmental stresses in small ruminants

Objective 1

Documenting information on availability and quality of water accessible to sheep/goat in arid and semi-arid areas.

Experiment 1: *To analyzed the quality of water available for livestock in five districts of Rajasthan.*

This experiment mainly concerned with survey of different districts of Rajasthan to assess the quality of water available for livestock in reprehensive districts of Rajasthan. Survey was conducted during peak summer months of May- Jun, 2011. For this purpose five districts – Jalor, Tonk, Jodhpur, Bikaner and Bhilwara was selected. Care was taken that samples were collected from all water resources available in a particular district. Water sample were collected in sterilized bottle and stored properly until analysis. From each source one litter water sample was collected. The collected water samples were sanded for quality analysis.

Parameter studied:-

→ Color, Odor, Turbidity, pH,

→ Fe, TSS, Cl, Residual Free Chlorine, F, TDS, Ca, Mg, SiO_2, Cu, Mn, SO_4,NO_3, Zn, C_6H_5OH, alkalinity ($CaCO_3$), alkalinity (P), Total Hardness ($CaCO_3$), As, Cyanide, Na, Pb, Cr_6,

→ Total Coliform Count, Test for *E. coli*

→ Specific Conductivity.

Objective 2

To study the adaptive capability of ewe and ram to compound abiotic stresses (thermal and water restriction) based on growth, physiological, endocrine and biochemical responses and reproductive performance

Experiment 1: *To study the effect of heat stress on growth, water, water requirement, physiological adaptability and blood biochemical changes on Malpura ewes.*

THI during study period

S.No.	Week	Covered (Shed)		Open (Solar radiation)	
		Morning	Afternoon	Morning	Afternoon
1.	Week-1	28.03	35.64	31.08	37.74
2.	Week-2	29.09	36.96	31.8	38.21
3.	Week-3	29.39	35.64	32.54	37.3
4.	Week-4	29.07	35.76	33.62	35.85
5.	Week-5	29.63	37.7	32.82	38.03
6.	Post stress	28.8	36.8	-	-

The experiment conducted during peak summer session (May-June) for 42 days. Twenty four healthy adult Malpura ewes were used and were randomly divided into two group viz. GI (Control; n=12) and GII (Heat Stress; n=12). The control animals were maintained under shed, while heat stress animals were subject to heat stress by exposing them to direct solar radiation for 6 hours per day between 10:00 h and 16:00 h. GII ewes were exposed to average ambient temperature of 42- 46 ^{0}C during the experiment. This experimental procedure were fallowed for 35 days and remaining 7 days both group were maintained in animal shed to study the recovery of GII animals from heat stress. Body weight, Body condition score, Physiological response, and Blood collection was carried out at weekly interval.

Parameter studied:-

→ Feed and Water Intake

→ Body Weight (BW), Body Condition Score (BCS),

→ Respiration Rate (RR), Pulse Rate (PR), Rectal Temperature (RT), Sweating Rate (SR),

→ Estrus Percentage, Esturs Duration, Estrus Interval,

→ Hemoglobin (Hb), Packed Cell Volume (PCV), Plasma Glucose, Urea BUN, Total Plasma Cholesterol,

→ T_3 and T_4, Cortisol, Estradiol and Progesterone.

→

Figure 1: Animals kept under controlled condition in the shed

Figure 2: Animals exposed to natural heat stress

Experiment 2: *Seasonal variation of physiological response in ewes of farmers' flocks under semi-arid tropical environment*

This study was conducted to document the seasonal variation in physiological responses of sheep in farmers' flocks under extreme climatic conditions of semi-arid tropical regions. The study was carried out for one year (2012–2013). Forty-eight ewes of 2–4 year age were selected from three villages (two farmers from each village, eight ewes from each farmer). All the ewes were maintained by the farmers in their own management system. They used to take the animals for grazing morning (07:30 h) to evening (17:30 h). No extra mineral and concentrate supplementation were provided to the animals by the farmers. Farmers used to keep the animals in open areas within a surrounding during the night without any shelter above head. Respiration rate (RR), pulse rate (PR), and rectal temperature (RT) were recorded at morning (08:00 h), after noon (14:00 h), and evening (19:00 h) in summer (May–June), autumn (September–October) and winter (December–January) seasons three times at 15 days interval. The meteorological data in the farmers field were recorded twice daily at 8:00 h and 14:00 h for the entire study period

Fig:-2 Morning (08:00 h, at formers shed), Fig:-2 Afternoon (14:00 h, during resting time), Fig:-3 Evening (19:00 h, at formers shed)

Parameters Studied

- Physiological responses: Respiration Rate (RR), Pulse Rate (PR), Rectal Temperature (RT),
- Climate profile: Dry bulb Temperature (DB), Wet bulb Temperature (WB), Relative Humidity (RH).

Experiment 3: *The effect of water restriction on the adaptability of Malpura ewes under semi-arid tropical environment*

The experiment to study resilience in native Malpura ewes was conducted during peak summer season (May – June) for a period of 7 weeks including 5 weeks restriction covering two oestrous cycles and 2 weeks recuperation. Twenty-eight ewes were randomly divided into four groups with 7 animals each viz., G-I (Control: water ad libitum), G-II (20% water restriction of ad libitum), G-III (40% water restriction of ad libitum) and G-IV (water ad libitum on alternate day). The animals were stall fed ad libitum with the diet consisting of 70% roughage and 30% concentrate. All the ewes were maintained under well ventilated shed. Individual feed and water intake was recorded on daily basis. Physiological responses were recorded twice daily at weekly intervals.

Parameter studied

- Physiological responses: Body Weight (BW), Respiration Rate (RR), Pulse Rate (PR), Rectal Temperature (RT),
- Feed and Water Intake,
- Reproductive profile: Estrus percentage, Estrus Duration, Estrus Interval, Estradiol, Progesterone
- Metabolic profile: Haemoglobin (Hb), Packed Cell Volume (PCV), Plasma Glucose, Chloride, Albumin, Total plasma cholesterol,
- Stress profile: Cortisol, Aldosterone,
- Water and Nitrogen Balance.

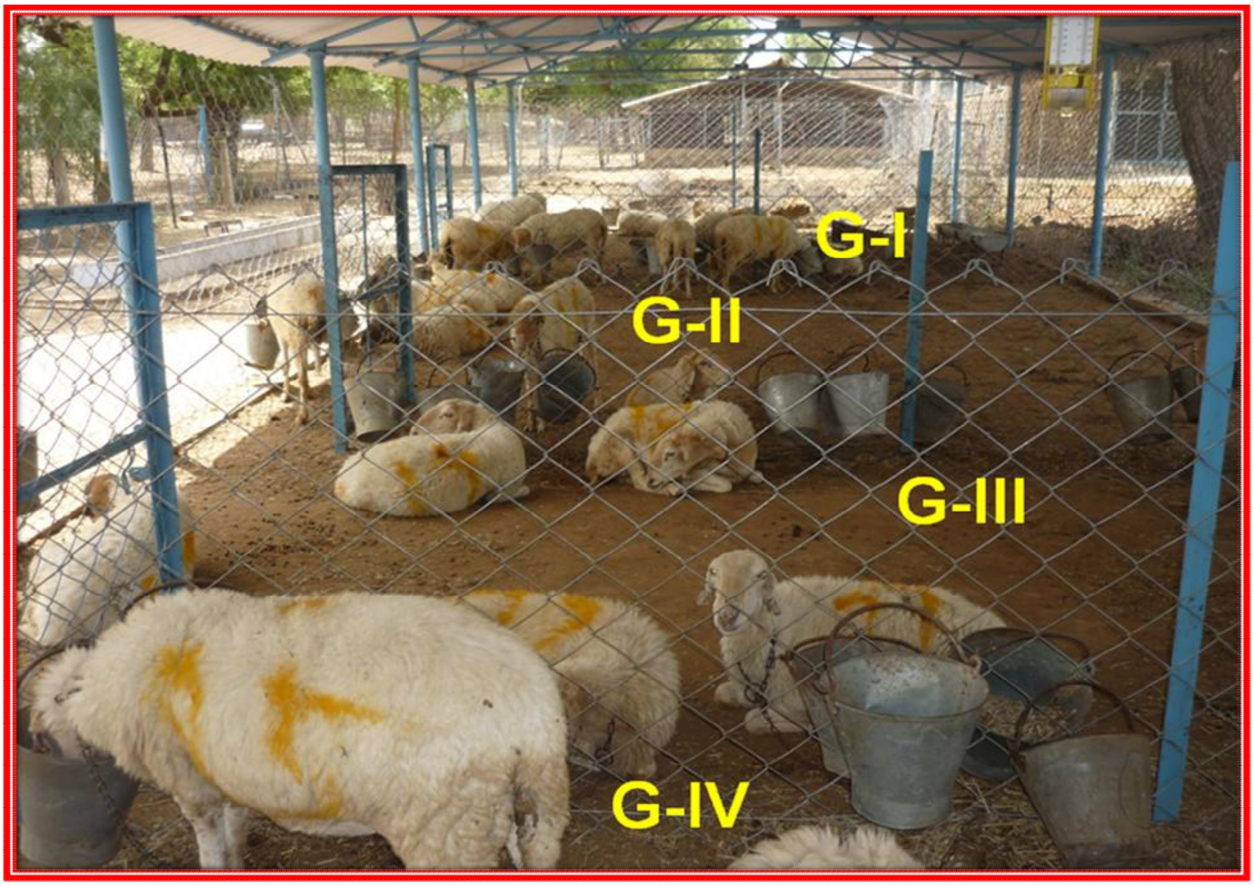


Figure 1: Animals kept in well ventilated shed exposed to water deprivation

Experiment 4: *Differential expression of genes in sheep under nutritional and climatic stress conditions*

Technical programme:

- Collection of periodic blood samples from animals exposed different stress conditions (detailed below)

- Standardization and validation of protocol for amplification of HSP 70 gene of sheep for deriving phylogenic relationship among different species and for determining expression and identifying new functions considering its importance in conferring thermotolerance
- Isolation of RNA from the blood samples and designing of primers
- Optimization of PCR conditions for the HSP family of genes
- Molecular characterization and sequencing of HSP70 and 90

Stress condition I

An experiment was conducted during peak summer season (May – June) for a period of 35 days. The ewes were randomly divided into four groups with 7 animals each viz., G-I (Control), G-II (20% water restriction), G-III (40% water restriction) and G-IV (*ad libitum* watering on alternate day).

Stress condition II

A total of 14 adult Malpura ewes were randomly divided into 2 groups of 7 animals each (GI- Control, GII- heat stress). G-I ewes were kept under shed, while G-II ewes were exposed to different temperatures at different hours of the day (38°C, 40°C, 42°C, 43°C, 44°C and 42°C h in the climatic chamber).

Experiment 5: *To assess the effect of mineral mixture supplementation on growth and physiological adaptability of Malpura ewes subject to heat stress.*

THI in Shed condition during study period

S. No	Weak	THI	
		Morning	Afternoon
1	Weak-1	25.97	33.63
2	Weak-2	20.88	29.87
3	Weak-3	22.03	30.42

THI in Climate chamber during study period

Chamber THI (42^{0}C)	35.42

The experiment conducted during the month of September for 21 days. Twenty one healthy adult Malpura ewes were used and were randomly divided into three group viz. GI (Control; n=7), GII (Heat Stress; n=7) and GIII (Heat Stress + Mineral Supplementation; n=7). The control (GI) animals were maintained under shed, while heat stress (GII) and heat stress + mineral supplementation(GIII) animals were subject to heat stress by exposing them at 42^{0}C for 6 hours per day between 10:00 h and 16:00 h in climatic chamber. This experimental procedure was fallowed during experimental period of 21 days. Body weight, Body condition score, Physiological response, and Blood collection was carried out at weekly interval.

Mineral Mixture Composition per Kg diet: Zinc Sulphate 164.0 mg, Colbalt sulphate 0.95 mg, Chromium acetate 1.2g, Selenium chloride 0.1mg, and Vitamin E 40.0 mg. Dose: 20gm/Kg body weight

Parameter studied:-

→ Feed and Water Intake

→ Body Weight (BW), Body Condition Score (BCS),

→ Respiration Rate (RR), Pulse Rate (PR), Rectal Temperature (RT),

→ Estrus Percentage, Esturs Duration,

→ Hemoglobin (Hb), Packed Cell Volume (PCV), Plasma Glucose, Urea BUN, Total Plasma Cholesterol,

→ T_3 and T_4, Cortisol, Estradiol and Progesterone.

Experiment 6: *Effect of selenium-yeast supplementation on growth and physiological adaptability of Malpura ewes subjected to heat stress*

A study was conducted to assess the effect of selenium-yeast supplementation on growth and physiological adaptability of Malpura ewes subjected to heat stress. The experimental heat-stress period lasted for a period of 6 weeks involving 12 adult Malpura ewes. The ewes were randomly divided into two groups of 6 animals each viz., GI (Heat stress; n=6), GII (Heat stress + selenium-yeast supplementation n=6). The animals were stall fed with *ad libitum* feeding of a ration consisting of 70% roughage and 30% concentrate. Both the group ewes were maintained under controlled climatic condition and were exposed to increasing temperature starting from 38°C to 42°C in the climatic chamber. The animals were subjected to heat stress for 6 hrs a day between 10:00 to 16:00 h. Individual feed and water intake was recorded on daily basis. Physiological responses were recorded twice daily at weekly interval on day 0, day 7, day 14, day 21 day 28 and 35. Blood samples were collected on day 0, middle of the experiment (21 d) and at the end (42 d) for studying molecular profiling of stress-response gene.

Parameters studied

- Feed and water intake
- Change in live weight and body condition score
- Alteration in blood-metabolic profile
- Alteration in hormonal profile including reproductive hormones
- Alteration in oxidative stress response
- Effect on reproductive behavior, e.g. estrous and its duration

Figure 3: Animals exposed to heat stress in chamber

Objective 3

To identify feeding and water managemental strategies to combat environmental stresses in sheep

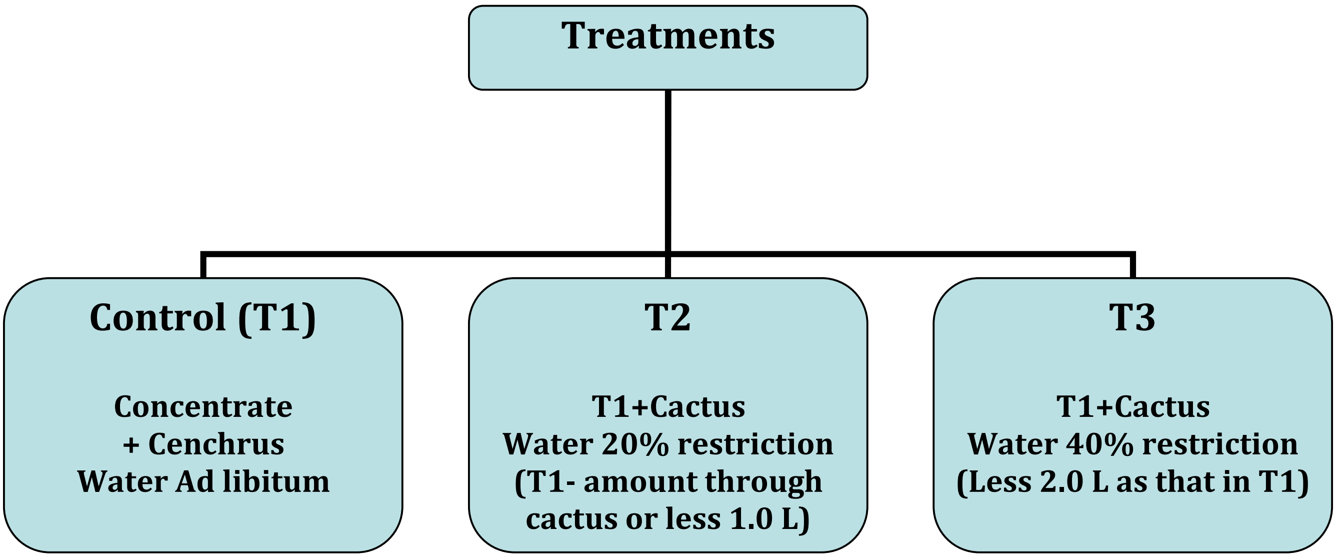
Experiment 1: *Establishment of cactus field to provide biomass during hot summer*

Work plan:

- Development of a field for cactus implant
- Collection and propagation of cactus

Experiment 2: *Amelioration of water deprivation stress vide feeding of prickly-pear cactus [Opuntia ficus indica (L.) Mill.] and its nutritional evaluation in the feeding of sheep during summer*

<u>**Technical Program:**</u> The fallowing feeding schedule was fallowed over the experimental period



Development of cactus field

Feeding of Cactus to sheep

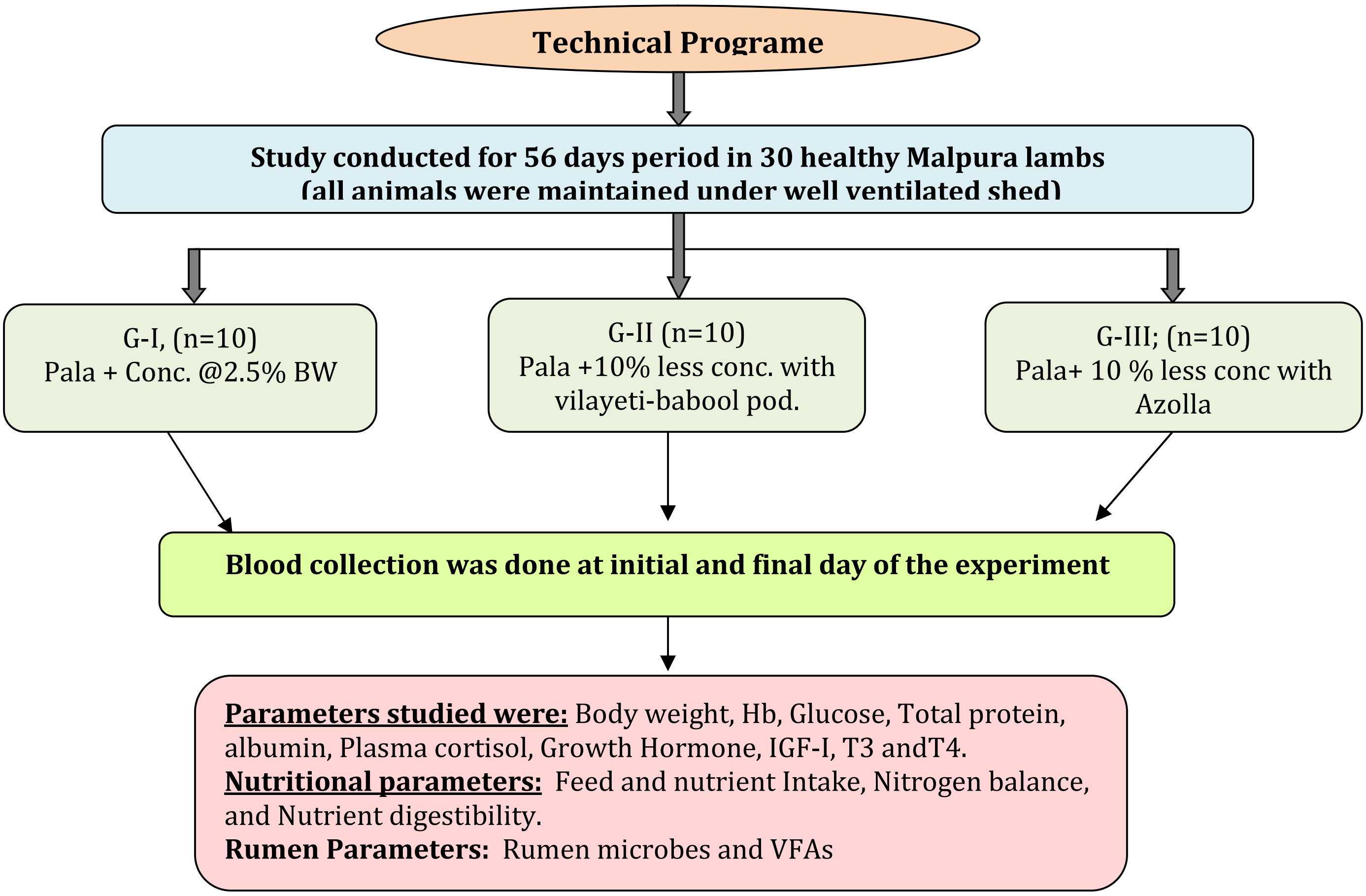
Parameter studied:
Feed intake: Intake of concentrate, cenchrus and cactus
DM and nutrient intake,
Nutrient digestibility,
Nitrogen balance,
Water balance
Alteration in body weight and body condition

Experiment 3: *Propagation and cultivation of Azolla (Azolla pinnata) in semi-arid regions as a biotic and protein supplement*

Work plan:

- Development of low-cost Azolla Production Unit at Institute Farm area
- Cultivation of *Azolla pinnata,* maintenance and harvesting for feeding of animals

Experiment 4: *Incorporation of Azolla as a biotic feed source in the diet of native Malpura lambs during summer nutritional scarcity*



G-I, n=10

G-II, n=10

G-III, n=10

Experiment 5: *Establishment of cactus field to provide biomass during hot summer*

Work plan:

- Field development, collection of cactus varieties and propagation
- Fencing of the cactus field with low-height concrete foundation reinforced with wire mat
- Maintenance of cactus filed: weeding, periodic re-propagation of stem
- Feeding experiment in sheep to assess acceptability, intake and nutritive value of different varieties of cactus

Experiment 6: *Establishment of Senjana (Moringa oleifera) field to harvest biomass during scarcity*

Work plan:

- Field development, collection of saplings and propagation
- Fencing of the Senjana field with low-height concrete foundation reinforced with wire mat
- Maintenance of Senjana filed: weeding, periodic re-propagation of stem and occasional watering
- Feeding experiment in sheep to assess acceptability, intake and nutritive value of Senjana as a scarcity fodder

Experiment 7: *Establishment of herbal garden with plants rich in secondary metabolites and herbal properties*

Work plan:

- Field development, plot-making for implantation of promising herb species
- Fencing of the Herbal garden with galvanized wire net reinforced with iron angles
- Collection of different herb species and propagation

Experiment 8: *Collection, drying and storage of monsoon herbage to feed during scarcity*

Work plan:

- Harvesting monsoon herbage namely, Chaulai and Jojhru
- Wire bed preparation for shade drying during monsoon
- Chaffing and preparation of feed block to store for the scarcity

Objective 4

Evolving shelter management strategies to combat environmental stresses in small ruminants

Experiment 1: *To assess the efficiency of indigenously devised bamboo dome structure as cold protection device and to observe its effects on adaptive capability of Malpura lambs during winter season.*

The study was conducted with the primary objective to assess the efficiency of indigenously devised bamboodome structureas cold protection device and to observe its effects on adaptive capability of Malpura lambs during winter season. The study was conducted in 16 Malpura lambs of one month old. The lambs were randomly dived into 2 groups of 8 animals each viz., GI (Cold protected; n=8) and GII (Cold exposed; n= 8). GI lambs were protected with help of bamboo dome structure while GII lambs were kept on the shed with all four sides open. The study was conducted for a period of 5 weeks. Blood collection was carried out at weekly interval.

Figure 4: Lambs housed under bamboo dome structure covered with gunny bags

Figure 5: Picture showing lambs inside the bamboo dome structure

Parameter studied:-

Body Weight (BW), Respiration Rate (RR), Pulse Rate (PR), Rectal Temperature (RT), Skin temperature, Hemoglobin (Hb), Packed Cell Volume (PCV), Plasma Glucose, T_3 and T_4, and Cortisol

Experiment 2: *Development of shelter to combat heat and cold stress*

- Preparation of special shelter/ housing for protection of sheep from thermal stress (heat as well as cold stress)
- Preparation of felt coat for lambs to protect against extreme cold

Experiment 3: *Effect of micro environment manipulation on growth performance, physiological response, blood metabolites and endocrine profile of Malpura lambs in semi-arid region during winter*

Technical program: Twenty one Malpura lambs of 3-5 week age (average body weight 10.0 kg) were used in the present study. The lambs were divided into three groups, viz. GI (control, lambs kept in conventional asbestos roof shed), GII (lambs kept in bamboo dome structure) and GIII (lambs kept in thermocol insulated shed). Asbestos roof shed had side wall wire netted that were covered with curtains at night). Local hand-made bamboo dome structure that had enough space to keep two lambs at night, and the thermocol insulated had roofs and doors made up of asbestos, thermocol and PVC sheet with brick side wall having ventilators for indirect light and wind. The houses were fitted with dry and wet-bulb thermometer to record micro-environment profile inside the shed. Animals were kept in different shed from evening 1830 h to morning 0700 h. The lambs were allowed to stay with their mother in the morning (0700 h to 0730 h) and evening (1730 h to 1800 h) for suckling milk. They were provided with *adlibitum* green fodder, dry roughage and concentrate in an open area 0800 h to 1730 h. The study was conducted for one month during winter (January- February).


Fig:-Dome' type easy to carry shed made of bamboo


Fig:-House with thermocol-insulated roof

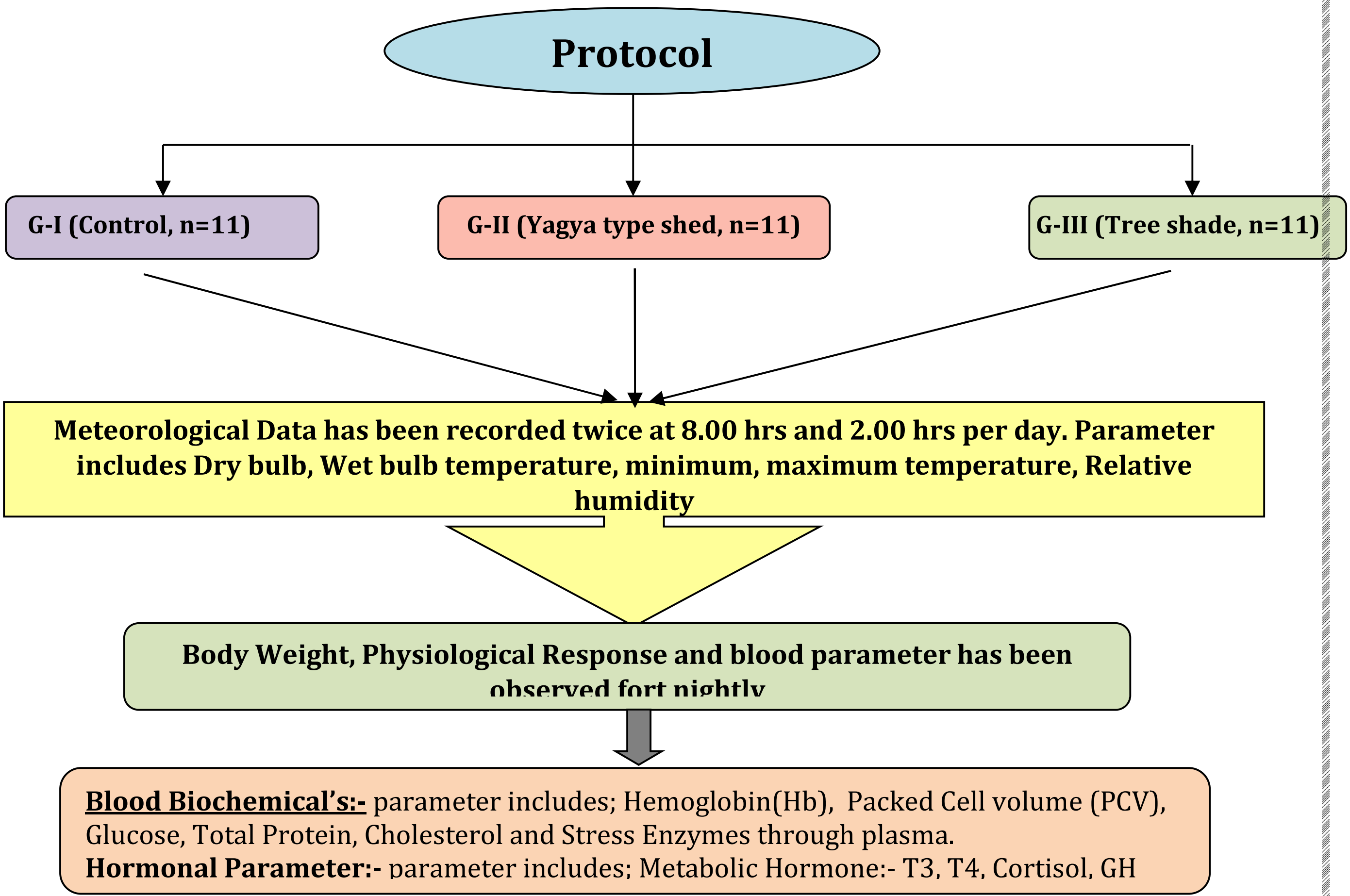
Parameter studied:-

- Physiological responses: Respiration Rate (RR), Pulse Rate (PR), Rectal Temperature (RT), Skin Temperature (ST),
- Alteration in body weight (BW),
- Blood metabolic profile,
- Endocrine profile
- Temperature and Humidity: {Dry bulb Temperature (DB), Wet bulb Temperature (WB) and Relative Humidity (RH). Minimum and Maximum Temperature}.

Experiment 4: *Effect of different type shelters on physiological response, growth performance, blood biochemical and endocrine profile of lambs under hot semi-arid environment*

Technical programme: A study was conducted to see the effect of different types of shelter on physiological response, growth performance, blood biochemical and endocrine profile of lambs under hot semi-arid environment. Thirty three Malpura lambs of 3-5 months age (average body weight 19.5 kg) were used in the present study. The lambs were divided into three groups, viz. GI (control, lambs kept in conventional asbestos roof shed), GII (lambs kept in yagga type shed) and GIII (lambs keptopen area under tree-shade). The side walls of asbestos roof were made up of wire netted fencing where as in

Yagga type shed; the side walls are double walled. The empty space between the two walls,were filled with sand. The sand was kept in moist condition by continuous water drip. The Yagga type shed was basically constructed with bamboo. Tree-shade was made the shade of large trees. The shaded area was protected by wire fence. The experiment was conducted for two months during extreme summer (May-june, 2013). The experimental set ups were fitted with maimum-minimum, dry and wet-bulb thermometer to record micro-environment profile. The lambs were provided with *adlibitum* green fodder, dry roughage and concentrate in an open area 0800 h to 1730 h. The detail experimental programme is given below.



Experiment 5: *Development of low-cost shed to protect lambs from cold stress*

Work plan:

- Construction of low cost shed made up of local grass material to protect lambs from chilling cold
- Sheltering of lambs during night to protect from winter
- Record of climatological attributes e.g. environmental temperature, humidity
- Record of physiological response parameters to assess resilience against cold

Experiment 6: *Establishment of Climate-resilient all-weather shed to protect from winter as well as summer*

Work plan:

- Area identification and shed orientation based on exposure to sunlight
- Construction of shed with partitioning to assess resilient against climatic stress management in sheep

7. Summary of work done

- **Water sample survey:** The water samples from different sources available for livestock were analyzed from 5 districts (water dark zone) of Rajasthan and found that specific conductivity, chloride magnesium, sodium, silica and total solids were above the range of maximum limits permissible. In addition, calcium was lower than the permissible range.Severity of heat stress (Solar radiation: 42- 46^{0}C)was established in Malpura ewes on productive and reproductive parameters. Malpura ewes showed signs of recovery from heat stress within a period of one week.
- **Effect of heat stress on adaptability of Malpura ewes:** Severity of heat stress (Solar radiation: 42- 46^{0}C) was established in Malpura ewes on productive and reproductive parameters. Malpura ewes showed signs of recovery from heat stress within a period of one week.
- **Effect of water restriction on the adaptability of Malpura ewes:** Despite significant effects of water restriction on physiological response, blood biochemical, endocrine profile and feed intake, Malpura ewes showed capability to adapt and tolerate up to 40% water restriction. However, alternate day water restriction that simulates periodic water deprivation in arid and semi-arid regions had more adverse effect on feed and nutrient intake including production (growth).
- **Identifying heat shock protein (HSP):** Amplification of HSP 70 gene of sheep was established which will be helpful for deriving phylogenic relationship among different species and for determining expression and identifying new functions considering its importance in conferring thermotolerance.
- **Mineral mixture supplementation on growth and physiological adaptability of Malpura ewes subject to heat stress:** Effect of heat stress on the productive and reproductive efficiency of Malpura ewes was reduced considerably by mineral mixture supplementation (Mineral mixture composition per Kg diet: Zinc Sulphate 164.0 mg, Colbalt sulphate 0.95 mg, Chromium acetate 1.2g, Selenium chloride 0.1mg, and Vitamin E 40.0 mg. Dose: 20gm/Kg body weight). This shows the protective effect of mineral mixture to relieve heat stress in Malpura ewes.
- **Amelioration of heat stress through selenium-yeast supplementation:** Supplementation of *Saccharomyces cerevisiae* grown in selenium enriched media provided resilience to counter heat stress in Malpura ewes.
- **Establishment of cactus field:** A cactus field was developed in an area of 0.8 ha and four different types of cactus (*Opuntia ficus-indica (L.) Mill.*) propagated successfully to provide feed biomass during summer scarcity.
- **Amelioration of water deprivation stress through feeding of cactus:** An experiment on Opuntia (prickly pear cactus) feeding was conducted in adult sheep to evaluate water and nutrient metabolism during summer. Three treatment groups involved control G1 (ad lib cenchrus hay + concentrate at 1% of body weight + water ad lib) and two experimental groups G2 (control diet + Opuntia 1.0 kg + water reduced by 1L) and G3 (control diet + Opuntia 1.0kg + water reduced by 2L). In both G2 and G3 Opuntia feeding provided 0.88 L of water. There was reduced DM intake from cenchrus due to Opuntia feeding and thus the effect on total feed intake was non-significant ($P>0.05$). However, the digestibility was similar between G1 and G2, but reduced in G3 that exposed to water restriction by 2L. Feeding of Opuntia compensated mild water restriction up to 1 L without any significant effect on feed intake. Thus, Opuntia can be successfully fed to sheep during feed scarcity meeting water and nutrient requirement. The native sheep Malpura exhibited adaptability to conserve water in the face of deprivation/scarcity.
- **Establishment of herbal garden:** A herbal garden was under establishment to harbour promising herbs having medicinal and veterinary care properties. A collection of plants rich in secondary

metaboliteswould have promise to ameliorate nutritional and health anomalies including resilience against thermal and environmental stress. Establishment of the garden will act as a demonstration unit to the farmers as well as researchers.

- **Cultivation of Azolla (*Azollapinnata*) as a biotic and protein supplement:** *A*zolla is finding increasing use for sustainable production of livestock by providing a rich source of protein (CP 25%). It is reported to concentrate other plant biofactors (flavonoids, carotenoids) including vitamins and minerals. Part (10%) of the concentrate moiety of the ration was successfully replaced withAzollaon DM basis in the diet of sheep.
- **Development of different shelters for protection against heat and cold stress:** Four different types of shelters were developed, viz. Yangya-type and Silvi-pasture system for protection against summer and portable Bamboo-Dome-type and low-ground Thermocol-insulated-type for protection against winter.
- **Protection of sheep from adverse climatic conditions through shelter management:** Various shade management systems were developed and evaluated. Innovative low-cost 'YANGYA' type shed observed to facilitate heat dissipation and maintains relatively lower temperature at the ground level and could be constructed for rest during grazing in semi-arid and arid regions. Introduction of silvi-pasture system or implantation of fodder trees in grazing area could be a successful integrated-farming type approach that provides feed as well as shelter during summer. To protect the lambs from extremely low temperature at night during winter a 'Dome' type easy to carry shed made of bamboo could be considered useful for migratory sheep flocks. For sedentary sheep flocks a house protected against direct wind-flow (cold wave) with thermocol-insulated roofing could be a very good strategy to conserve day temperature to provide warmth at night.
- **Effect of different type of shelters on physiological response, growth performance, blood biochemical and endocrine profile of hogget's under hot semi-arid environment:** The open area tree-shade had higher THI than the other two housing types (asbestos and Yagya type). The animals sheltered in Yagya-type shed experienced maximum comfort with lower physiological responses, and relatively balanced haemato-biochemical and hormonal profile with better growth response. **Low cost shed establishment for protection of lambs during winter:** The shade was constructed with locally available material (*Panipuli*) that can be easily made by farmers in their field or during temporary stay en-route migration. The material is having insulation property because of its sharp blade leafs and is not usually consumed by the animals due to its tough plant structure and unpalatability.
- **Climate-resilient all-weather shed:** Construction of shed that can protect the animals throughout the year against all environmental stressor during climatic variability in different seasons is under progress.

8. Results in detail

Objective 1

Experiment 1: *To analyzed the quality of water available for livestock in five districts of Rajasthan.*

Table 1. Water Quality of Tonk district (Sample No.25)

Parameters within maximum limits
pH, Cl, Sulphate, Total hardness, Na, Fe, Color, Ca, Mg, Total dissolved solids
Parameters which are nil
Residual free Chlorine, Cu, Phenolic compound, Arsenic, Zn, Cr

Parameters	Maximum limits	Mean ± SE
Specific conductivity	300-700 µ siem/cm	1802±200.6
Silica	0.01 mg/l	8.42±0.74
Fluoride	1 mg/l	1.45±0.08
Total Coli form Count	10	21.97±1.84
Odour	Unobjectionable	56 %
Alkalinity	200 mg/l	344.0±32.32
Maganese	0.1 mg/l	0.126 (n=1)
Nitrate	45 mg/l	60.52±5.2
Lead	0.05 mg/l	0.00342±0.00062 (n=18)
Turbidity	5	8.82±2.38
Cyanide	0.05 mg/l	0.0339±0.0059 (n=3)
E. Coli	Absent	Present (n=2)

Table 2. Water Quality of Bhilwara district (Sample No. 25)

Parameters within maximum limits
pH, Chloride, Fluoride, Sulphate, Na, Fe, Color, Calcium
Parameters which are nil
Residual free Chlorine, Cu, Mn, Zn, Cr, E. Coli

Parameters	Maximum limits	Mean ± SE
Specific conductivity	300-700 µ siem/cm	1326±217.3
Silica	0.01 mg/l	5.62±0.80
Total dissolved solids	500 mg/l	861.9±126.9
Total Coli form Count	10	17.7±1.99
Odour	Unobjectionable	83 %
Alkalinity	200 mg/l	326.8±35.01
Magnesium	30 mg/l	40.33±5.58
Nitrate	45 mg/l	52.01±5.7
Total hardness	300 mg/l	336.0±43.1
Turbidity	5	9.61±2.58
Phenolic compound	0.001 mg/l	0.0549 (n=1)
Arsenic		0.126 (n=1)
Cyanide	0.05 mg/l	0.0514 (n=1)
Lead	0.05 mg/l	0.265 (n=1)

Table 3. Water Quality of Jodhpur district (Sample No.19)

Parameters within maximum limits
pH, Sulphate, Nitrate, Mg, Na, Fluoride, Fe, Color, turbidity, Total dissolved solids
Parameters which are nil
Residual free Chlorine, Lead, Cu, Mn, Phenolic compound, Arsenic, Cyanide, Zn, Cr, E. Coli

Parameters	Maximum limits	Mean ± SE
Specific conductivity	300-700 µ siemens/cm	1569±237.7
Silica	0.01 mg/l	4.92±0.88
Chloride	250 mg/l	330.2±61.7
Total Coli form Count	10	15.0±2.18
Odour	Unobjectionable	84 %
Alkalinity	200 mg/l	238.5±38.29
Total hardness	300 mg/l	341.1±47.1
Calcium	75 mg/l	77.31±10.0

Table 4. Water Quality of Bikaner district (Sample No. 19)

Parameters within maximum limits
pH, Chloride, Sulphate, Nitrate, Total hardness, Ca, Mg, Na, Fluoride, Fe, Color, turbidity, alkalinity
Parameters which are nil
Residual free Chlorine, Cu, Mn, Phenolic compound, Arsenic, Cyanide, Zn, Cr, E. Coli

Parameters	Maximum limits	Mean ± SE
Specific conductivity	300-700 µ siemens/cm	8905±230.3
Silica	0.01 mg/l	4.03±0.85
Total Dissolved Solids	500 mg /l	597.2±134.5
Total Coli form Count	10	16.55±2.11
Odour	Unobjectionable	79 %
Lead	0.05 mg/l	0.365 (n=1)

Table 5. Water Quality of Jalor district (Sample No. 21)

Parameters within maximum limits
pH, Sulphate, Nitrate, Mg, Na, Fe, Color, turbidity, Total hardness, Calcium & Total dissolved solids.

Parameters which are nil
Residual free Chlorine, Lead, Cu, Mn, Phenolic compound, Arsenic, Cyanide, Zn, Cr &E.Coli.

Parameters	Maximum limits	Mean ± SE
Specific conductivity	300-700 µ siemens/cm	1609±219.0
Silica	0.01 mg/l	2.74±0.81
Chloride	250 mg/l	364.2±56.9
Total Coli form Count	10	15.1±2.01
Odor	Unobjectionable	90 %
Alkalinity	200 mg/l	247.5±35.27
Fluoride	1 mg/l	1.26±0.09

Table 6. Comparison of Primary data with Secondary data for Water Quality Parameters:-

Parameters	Max. limits	Primary data (n=107)	Secondary data (n=107)
pH	6.5-8.5	7.66±0.35 [a]	8.18±0.41 [b]
Specific conductivity	300-700 µ seim/cm	1409±160.5 [a]	2405±185.9 [b]
Chloride	250 mg/l	255.65±46.2 [a]	464.12±53.5 [b]
Sulphate	200 mg/l	100.94±13.8 [a]	201.56±15.9 [b]
Magnesium	30 mg/l	27.17±4.2 [a]	50.51±4.9 [b]
Sodium	200 mg/l	100.58±26.9 [a]	425.26±31.2 [b]
Fluoride	1 mg/l	0.94±0.1 [a]	1.56±0.1 [b]
Iron	0.3 mg/l	0.042±0.06 [a]	0.49±0.07 [b]
Silica	0.01 mg/l	5.12±0.8 [a]	25.18±0.9 [b]
Total dissolved solids	500 mg/l	889.4±101.7 [a]	1563±117.8 [b]
Nitrate	45 mg/l	46.07±10.1 [a]	85.88±11.7 [b]
Total hardness	300 mg/l	258.33±29.5	342.01±34.15
Calcium	75 mg/l	56.26±6.1	53.8±7.1

Table 7. Effect of source of water on its quality parameters:-

Parameters	Max. limits	Ground water* (n=71)	Surface water** (n=36)
pH	6.5-8.5	7.68±0.05	7.61±0.07
Specific conductivity	300-700 µseim/cm	1518±132.97	1301±185.42
Chloride	250 mg/l	305.4±33.6 [a]	162.7±46.9 [b]
Sulphate	200 mg/l	120.3±14.2 [a]	65.1±19.9 [b]
Total hardness	300 mg/l	275.1±24.3	229.9±33.9
Calcium	75 mg/l	60.6±5.1	48.1±7.1
Magnesium	30 mg/l	29.7±3.1	23.7±4.4
Sodium	200 mg/l	113.6±12.7	89.1±17.8
Fluoride	1 mg/l	1.02±0.07	0.87±0.60
Total dissolved solids	500 mg/l	984.8±74.6	743.8±104.1
Alkalinity	200 mg/l	269.6±21.6	238.6±30.1
Color	5	0.16±0.15 [a]	1.57±0.21 [b]
Odor	Unobjectionable	93%	50%
Turbidity	5	3.25±1.33 [a]	12.63±1.86 [b]
Total suspended Solids	-	17.23±4.86 [a]	70.05±6.78 [b]
Total coli form count	10	14.96±1.07 [a]	22.64±1.49 [b]
Silica	0.01 mg/l	3.84±0.43 [a]	8.18±0.60 [b]
Nitrate	45 mg/l	40.63±3.05 [a]	59.89±4.26 [b]
Iron	0.3 mg/l	0.036±0.01	0.057±0.01
Lead	0.05 mg/l	0.00253±0.0055 (n=7)	0.0518±0.033 (n=13)
Cyanide	0.05 mg/l	Nil	0.0383±0.005 (n=4)
E. Coli	Absent	Absent	Present (n=2)
Manganese	0.1 mg/l	Nil	0.126 (n=1)
Arsenic	-	Nil	0.0549 (n=1)
Phenolic compound	0.001 mg/l	Nil	0.126 (n=1)

Residual free chlorine, Copper, Zinc, Chromium : Nil

***Ground water** : Tube well, Hand pump, Well

****Surface water** : Pond, Canal, River, Dam

Conclusions:-

- The water samples from different sources available for livestock were analyzed from 5 districts of Rajasthan and found that specific conductivity, chloride magnesium, sodium, silica and total solids were above the range of maximum limits permissible. In addition, calcium was lower than the permissible range.

Objective 2

Experiment 1: *To study the effect of heat stress on growth, water, water requirement, physiological adaptability and blood biochemical changes on Malpura ewes.*

Table 8. *Effect of heat stress on RR (breaths/Min), PR (beats/Min), RT (^oF) and SR ($g/m^2/h$) of Malpura ewes*

Items	**RR (Morning)**	**RR (Afternoon)**	**PR (Morning)**	**PR (Afternoon)**	**RT (Morning)**	**RT (Afternoon)**	**SR (Afternoon)**
μ±SE	35.92 ±0.94	94.21 ±1.44	57.74 ±0.63	70.95 ±0.58	100.72 ±0.48	101.63 ±0.61	106.54 ±7.16
Group	*	**	NS	**	*	NS	NS
Control	38.36	74.70	57.86	67.98	100.82	101.96	99.18
Heat Stress	33.48	113.73	57.62	73.92	100.63	101.30	113.90
Pooled SE for treatment	±1.33	±2.04	±0.89	±0.82	±0.07	±0.86	±10.13
Week	**	**	**	**	*	NS	**
1	21.25	56.75	57.42	68.83	100.67	101.98	113.42
2	27.67	82.08	48.58	73.08	100.46	98.08	165.07
3	40.08	109.04	64.33	80.00	101.03	102.44	91.64
4	38.25	99.17	55.92	71.33	100.53	102.71	27.40
5	46.25	117.96	62.50	70.04	100.82	102.06	106.62
6	37.25	121.58	58.25	68.17	100.56	102.33	134.34
7	40.25	72.92	57.17	65.17	101.02	101.84	107.30
Pooled SE for Week	±2.49	±3.81	±1.66	±1.53	±0.13	±1.62	±18.95
Group*Week	NS	**	NS	**	NS	NS	NS

RR- respiration rate; PR-pulse rate; RT-rectal temperature; SR-sweating rate
μ indicates the overall mean for the parameter. * ($P<0.05$), ** ($P<0.01$) and NS- Non-Significant

Table 9. Effect of heat stress on Body Weight, BCS and ADG of Malpura ewes

Items	**BW (Kg)**	**BCS**	**ADG (g)**
μ±SE	38.76 ±0.26	2.91 ±0.03	-43.51 ±14.23
Group	NS	**	NS
Control	39.09	3.13	-35.83
Heat Stress	38.44	2.69	-51.20
Pooled SE for treatment	±0.37	±0.05	±20.13
Week	**NS**	**	**
1	40.26	3.44	-187.50

2	38.60	2.68	-124.11
3	37.82	2.65	140.75
4	38.80	2.68	-57.12
5	38.60	2.79	33.91
6	38.83	2.83	-67.00
7	38.44	3.27	
Pooled SE for week	±0.70	±0.09	±34.86
Group*Week	**NS**	**NS**	**NS**

BW: Body Weight, BCS: Body Condition Score and ADG: Average Daily Gain

μ indicates the overall mean for the parameter. * (P<0.05), ** (P<0.01) and NS- Non-Significant

Table 10. Effect of heat stress on Feed and Water Intake of Malpura ewes

Items	**Feed Intake (DMI gm/w^.75/day)**	**Water Intake (Lt/DMI Kg/day)**
μ±SE	53.23 ±0.42	5.70 ±0.04
Group	**	**
Control	57.42	4.24
Heat Stress	49.04	7.15
Pooled SE for treatment	±0.59	±0.06
Week	**	**
1	43.66	6.92
2	49.44	6.38
3	54.55	5.37
4	54.34	5.45
5	56.92	5.66
6	60.49	4.40
Pooled SE for week	±1.02	±0.11
Group*Week	*	**

DMI: Dry Mater Intake

μ indicates the overall mean for the parameter. * (P<0.05) and ** (P<0.01), NS- Non-Significant

Table 11. Effect of heat stress on Hb and PCV concentrationsof Malpura ewes

Items	**Hb (g/dl)**	**PCV (%)**
μ±SE	9.27 ±0.10	35.27 ±0.60
Group	**NS**	**
Control	9.13	32.90
Heat Stress	9.33	37.63
Pooled SE for treatment	±0.13	±0.85

Week	**	**
1	12.14	38.24
2	11.79	36.99
3	11.11	30.30
4	8.35	40.03
5	7.87	34.74
6	6.13	32.96
7	7.24	33.62
Pooled SE for Week	±0.25	±1.60
Group*Week	**NS**	*

μ indicates the overall mean for the parameter. * (P<0.05) and ** (P<0.01), NS- Non-Significant

Fig. 1. Effect of heat stress on T3 concentrations of Malpura ewes

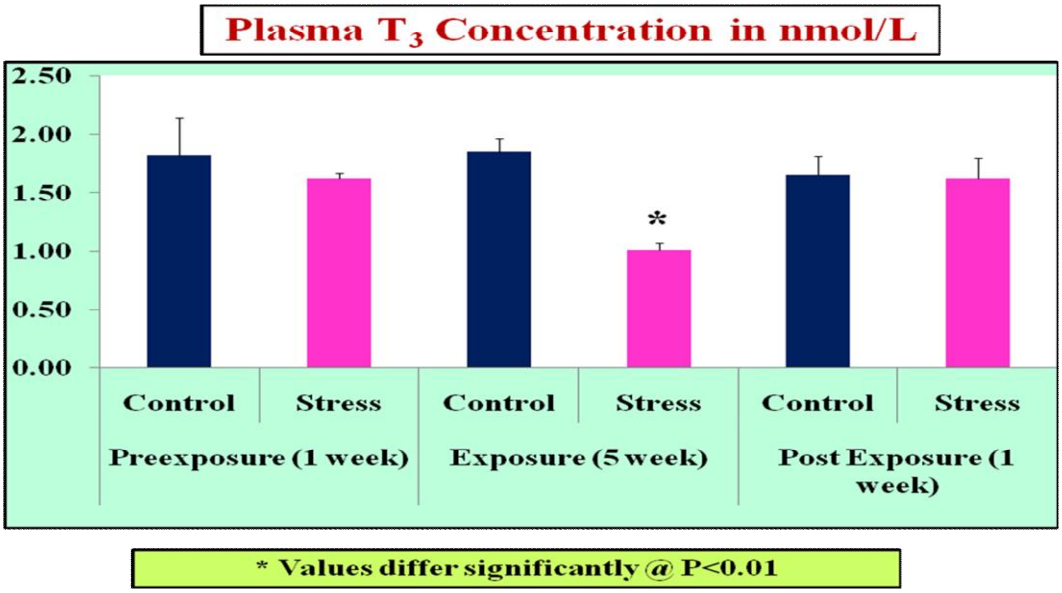


Fig. 2. Effect of heat stress on T4 concentration of Malpura ewes.

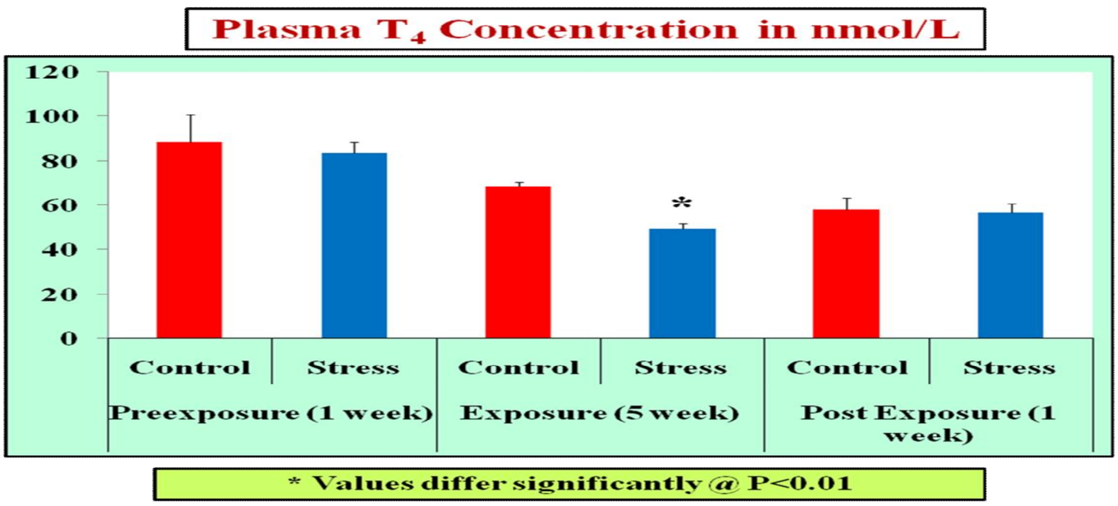


Fig.3. Effect of heat stress on plasma cortisole concentration of Malpura ewes

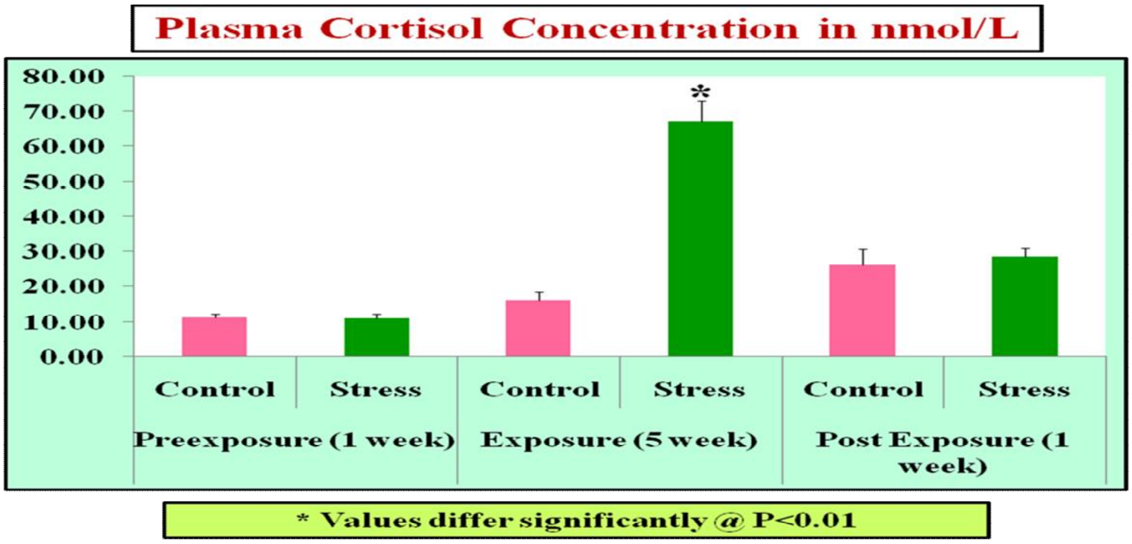


Fig.4. Effect of heat stress on plasma estradiol concentration of Malpura ewes

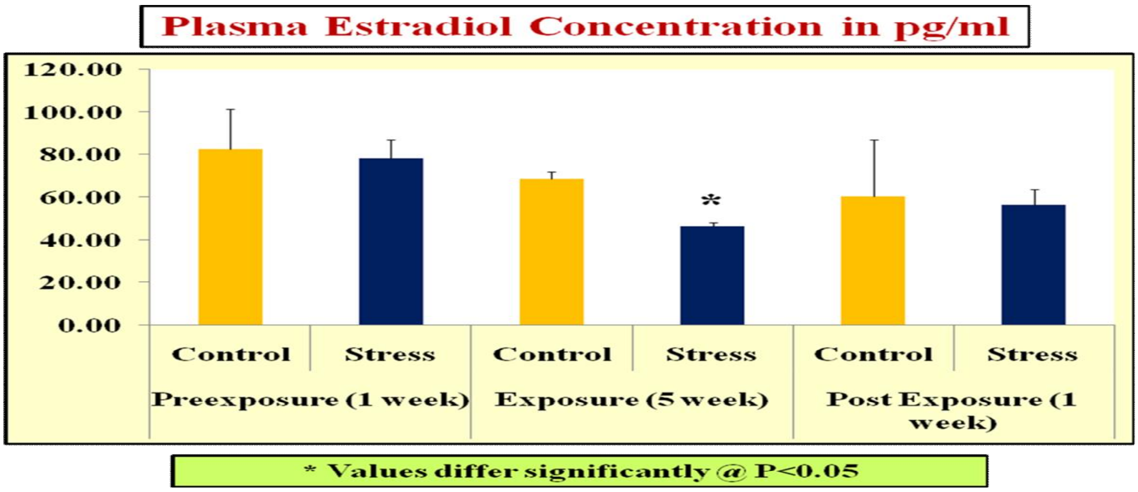
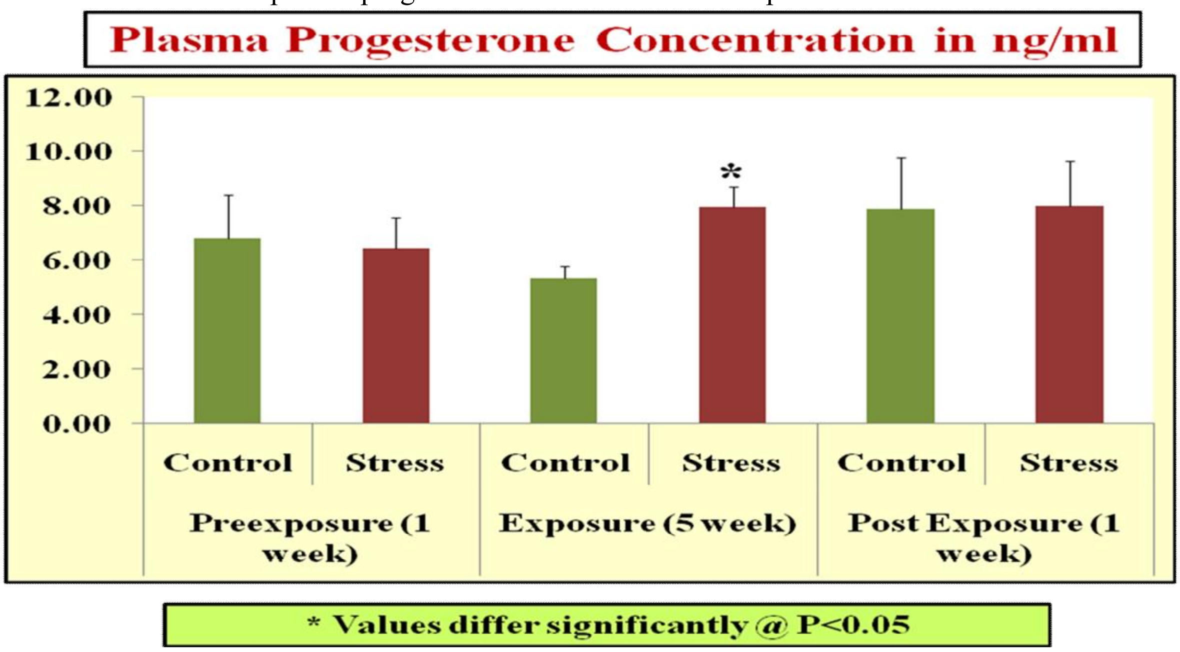


Fig. 5. Effect of heat stress on plasma progesterone concentration of Malpura ewes.



Conclusion:-

- The study establishes the adaptive capability of Malpura ewes to summer season by altering their feeding behavior and physiological responses. This is reflected on the low feed intake, high water intake and significant differences in the physiological responses in heat stressed ewes. Further, the study proved that heat stress during summer season is detrimental to reproductive performance and this is evident from the significant ($P < 0.05$) changes in the reproductive hormone levels in these ewes.

- Physiologically the animals showed recovery efficiency within a week period of time. This is evident from the non significant changes in all physiological measurements between control and stress groups. Further, the results show that Malpura ewes were able to recover their reproductive efficiency within a week time.

- Although the animals showed signs of recovery from the heat stress within 7 days post exposure, still the values of stress hormone is significantly higher indicating more time period is required to completely recover from heat stress under hot semi-arid environment.

Experiment 2: *Seasonal variation of physiological response in ewes of farmers' flocks under semi-arid tropical environment*

Table 12. Climatological data measured during the experimental period.

	THI morning	THI afternoon	THI evening	Max T (° C)	Min T (° C)	RH (%) morning	RH (%) afternoon	WV (m/sec)	Day Length (hrs)
Summer	26.51 ± 0.36	32.77 ± 0.49	31.14 ± 0.29	44.32 ± 1.61	30.75 ± 0.55	61.17 ± 4.19	41.83 ± 1.66	5.90 ± 0.30	10.28± 0.12
Winter	12.13 ± 0.81	18.92 ± 1.19	14.77 ± 1.10	26.07 ± 1.26	9.58 ± 1.95	79.83 ± 1.08	53.33 ± 2.14	1.85 ± 0.09	8.15 ± 0.22
Autumn	18.67 ± 0.65	28.45 ± 0.44	21.63 ± 0.56	36.72 ± 1.19	17.63 ± 0.68	83.67 ± 1.56	63.00 ± 4.07	1.89 ± 0.15	9.51 ± 0.11

THI temperature humidity index, MinT Minimum temperature, MaxT maximum temperature, RH relative humidity, WV wind velocity. Morning reading was taken at 0800 h, and afternoon reading was taken at 1400 h.

Fig. 6. Effect of season on respiration rate of ewes of farmers flock.

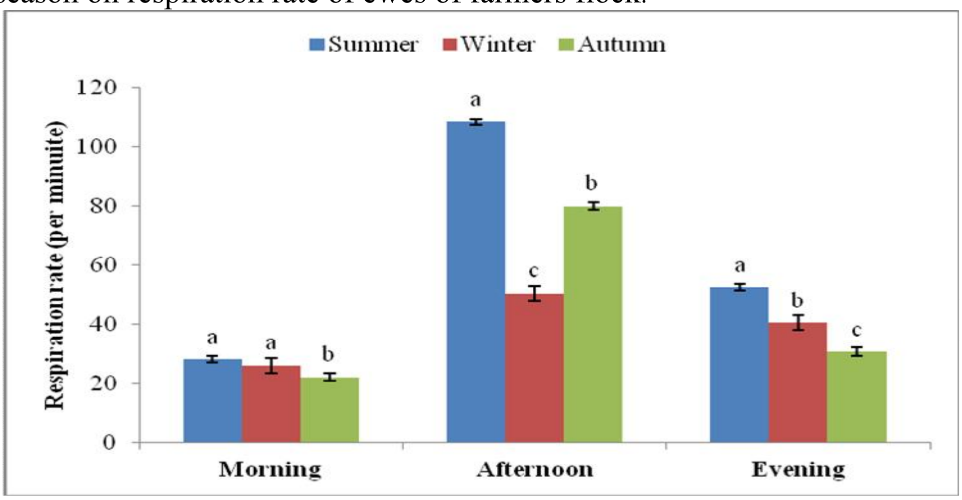


Fig. 7. Effect of season on pulse rate of ewes of farmers flock.

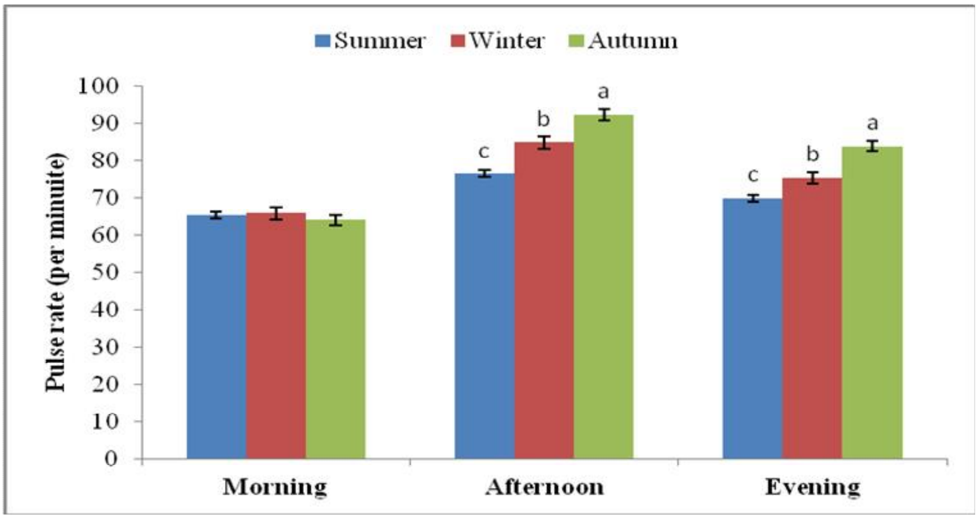
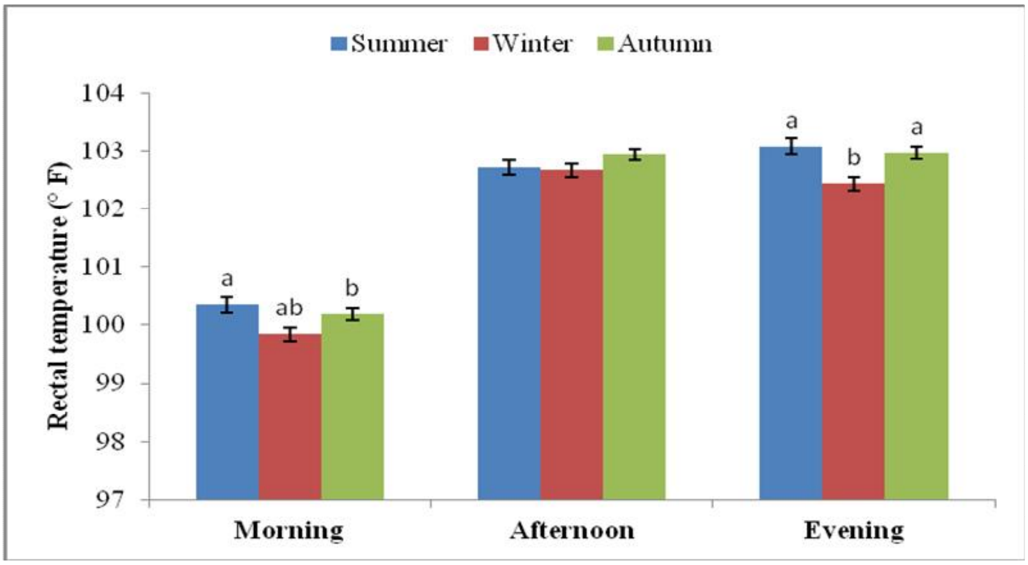


Fig. 8. Effect of season on rectal temperature of ewes of farmers flock**.**



Conclusion:-

- The present study clearly indicates that seasonal variation has severe impact on physiological responses to maintain thermo regulations. This is evident from the significant variation in physiological responses. Rhythmic changes in physiological response with the season definitely reflects that, although the local breed is well adapted to the semiarid tropical climate; still they need protection during the afternoon (14:00 h) in summer and autumn, along with that they should be provided with shelter in nights during the winter season to maintain their body temperature and hence production.

Experiment 3: *The effect of water restriction on the adaptability of Malpura ewes under semi-arid tropical environment*

Effect on physiological responses and endocrine profile

In addition to high temperature and deficient nutrition, water scarcity is another important limiting factor to small ruminants during summer season in semi-arid tropical environment under changing climatic scenario. Water is considered as an essential nutrient and is involved in every metabolic function of the body. Considering its importance in sheep productivity we have conducted a study to examine the effect of water restriction on physiological responses, blood metabolites and growth of Malpura sheep. The results of this study (Tables 2-6, Fig) indicate that despite of significant effects of water restriction on physiological response, blood biochemical and feed intake, Malpura ewes have capability to adapt and can tolerate up to 40% water restriction as well as alternate day water restriction with little effect on growth performance of animals during summer season under semi-arid tropical environmental conditions.

Table 13. Effect of water restriction on RR (breaths/Min), PR (beats/Min), and RT (ºF) of Malpura ewes

Items		G-I	G-II	G-III	G-IV	S.E.M
Respiration Rate (Breath/Min)	Morning	46.23[a]	38.23[b]	40.40[ab]	37.03[b]	2.54
	Afternoon	67.26[a]	59.43[b]	62.87[ab]	60.69[ab]	2.63
Pulse Rate (beat/Min)	Morning	64.46[a]	62.86[ab]	59.57[b]	61.43[ab]	1.55
	Afternoon	71.37[a]	66.11[b]	68.60[ab]	68.80[ab]	1.32
Rectal Temperature(°F)	Morning	101.35	101.39	101.22	101.43	0.13
	Afternoon	101.85	101.63	101.84	101.73	0.1

Table 14. Effect of water restriction on body weight and feed intake of Malpura ewes

Items	G-I	G-II	G-III	G-IV	S.E.M
Body Weight (Kg)	38.42	38.81	39.51	38.05	1.36
Feed Intake (DMI)	59.68[a]	57.34[ab]	54.94[ab]	51.24[b]	2.15

Table 15. Effect of water restriction on blood biochemicals

Items	G-I	G-II	G-III	G-IV	S.E.M
Glucose (mg/dL)	51.17[a]	47.38[ab]	46.30[b]	40.88[c]	1.36
Hb (g/dL)	11.27[ab]	10.92[ab]	12.28[a]	10.03[b]	0.52
PCV (%)	41.56[ab]	41.27[ab]	44.01[a]	37.32[b]	1.77
Albumin (g/dL)	3.55	3.35	3.55	3.26	0.11
Chloride (mg/dL)	134.31[a]	124.56[ab]	128.50[ab]	121.16[b]	3.41
Cholestrrol (mg/dL)	65.38[a]	58.39[b]	55.51[b]	55.83[b]	1.62

Hb- Hemoglobin; PCV-Packed Cell Volume

Means with different superscripts in a row differ significantly ($P<0.05$)

Table 16. Effect of water restriction on reproductive parameters

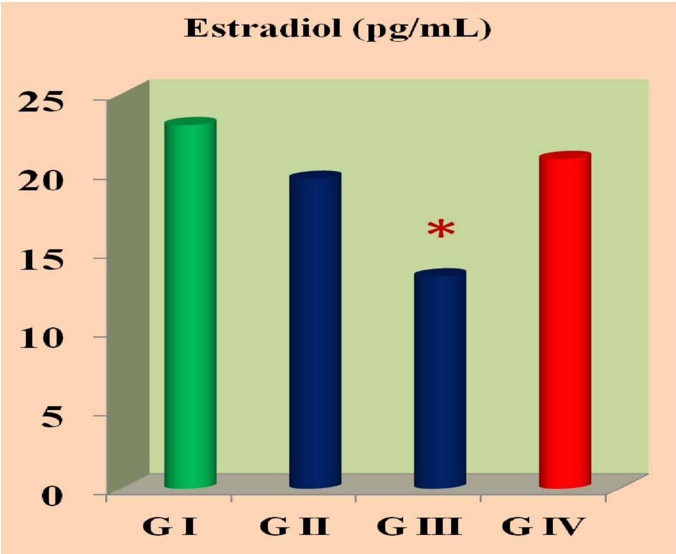
Parameters		**G-I**	**G-II**	**G-III**	**G-IV**
First oestrous cycle	Estrus %	100 (7/7)	100 (7/7)	85.7 (6/7)	85.7 (6/7)
	Estrus duration (h)	34.3±5.96	27.4±5.96	28.0±6.4	40.0±6.4
Second oestrous cycle	Estrus %	100 (7/7)	85.7 (6/7)	85.7 (6/7)	85.7 (6/7)
	Estrus duration (h)	53.1±6.94	32.0±7.5	38.0±7.5	50.0±7.5
Oestrous cycle length (d)		17.0±0.42	17.0±0.45	17.0±0.45	17.3±0.45

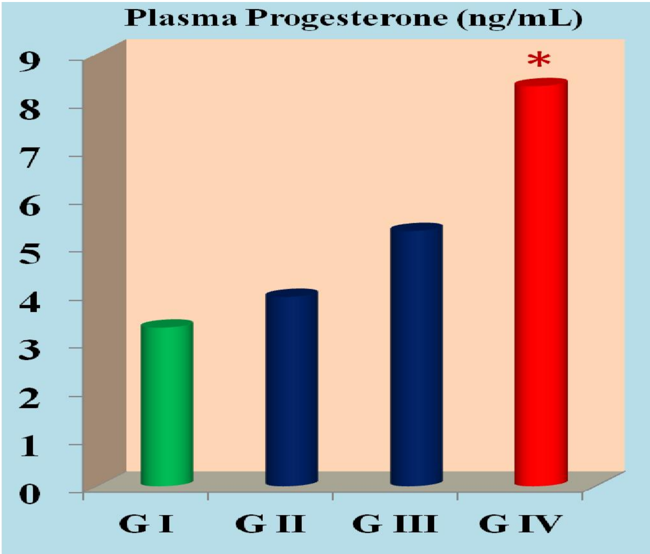
Table 17. Effect of water restriction on reproductive and stress hormones

Parameters	**G-I**	**G-II**	**G-III**	**G-IV**	**SEM**
Aldosterone	60.9^{a}	46.1^{b}	42.9^{b}	48.9^{ab}	4.16
Cortisole	87.5^{a}	81.5^{ab}	69.3^{b}	91.7^{a}	5.93
Progesterone	3.30^{b}	3.94^{ab}	3.59^{ab}	4.18^{a}	0.30
Estradiol	27.7^{a}	21.4^{ab}	19.2^{b}	20.5^{ab}	3.09

Means with different superscripts in a row differ significantly (P<0.05)

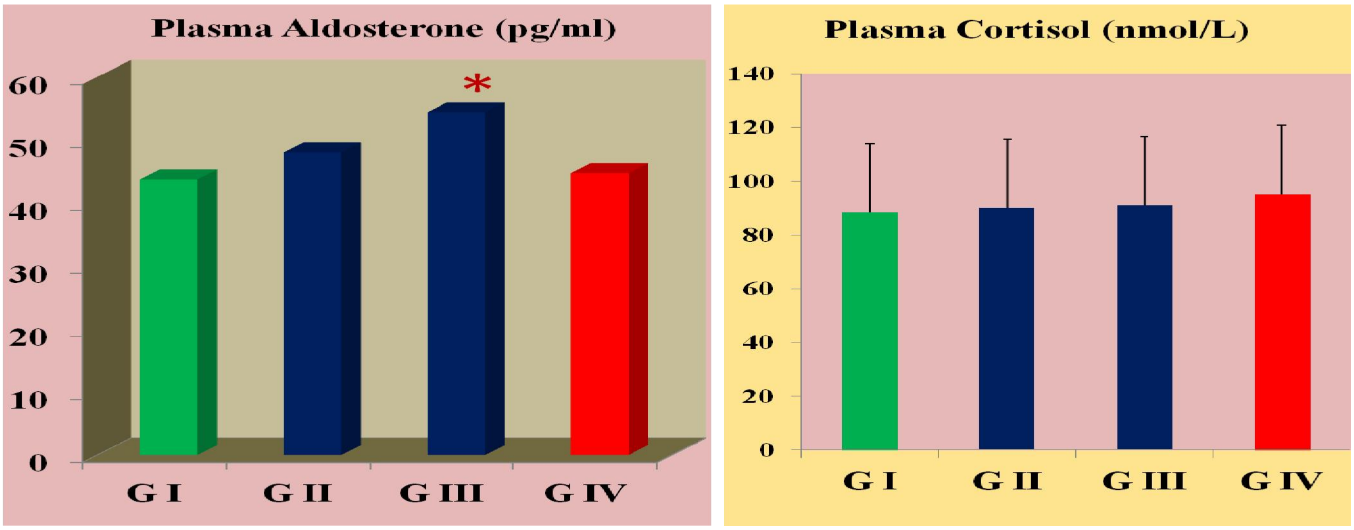
Fig.9. Effect of water restriction on plasma estradiol and plasma progesterone level





* (P<0.05)

Fig. 10. Effect of water restriction on plasma aldosterone and plasma cortisol level



* (P<0.05)

Recuperative response after withdrawal of water restriction

Physiologically the animals showed recovery during the next 2 weeks of recuperation with ad libitum water to all the groups. This was evident from the non-significant variation in all physiological measurements between control and stress groups after withdrawal of water restriction (Table 7). Although, the animals showed signs of recovery from the water restriction within 2 weeks post exposure, still the higher values of stress hormone (cortisol) in treatment groups indicating more time required (>2 wks) for complete recovery from water stress. The reproductive hormone profile (Table 8) also came back to normal during this recuperation period.

Table 18. Physiological response of animals following recuperation with ad libitum water

Parameters		G-I	G-II	G-III	G-IV
Respiration rate/min	Morning (8.00AM)	38.67	38.00	37.00	36.33
	Afternoon (14.00PM)	73.71	71.86	75.17	73.00
Pulse rate/per min	Morning (8.00AM)	64.86	63.33	64.33	65.14
	Afternoon (14.00PM)	71.29	68.00	68.83	69.29
Rectal temperature (°F)	Morning (8.00AM)	101.60	101.35	101.59	101.54
	Afternoon (14.00PM)	101.71	101.70	101.88	101.80
Body Weight (kg)		38.86	38.61	38.96	37.43

Table 19. Hormonal profile of animals following recuperation with ad libitum water

Items	G-I	G-II	G-III	G-IV
Cortisol (nmol/l)	32.96	47.66	44.82	46.49
Aldoestrone (pg/ml)	60.57	64.64	63.43	63.04
Progestrone (ng/ml)	3.39	2.63	2.83	3.01
Estradiol (pg/ml)	13.39	13.83	13.54	13.08

Effect on feed intake and nutrition

A metabolism trial was conducted at the end of restriction phage of experiment to assess feed and nutrient intake, nitrogen and water balances in different groups exposed to variable degree of water restriction. The results are presented in tables 9 to 12.

Table 20. Intake and digestibility of nutrients

Attributes	G-I	G-II	G-III	G-IV	SEM	P value
Intake (g/d)						
DM	1030	1025	1007	891	39.3	0.032
OM	930	926	911	806	35.4	0.032
CP	103.2	102.9	101.0	90.9	3.45	0.032
EE	18.5	18.4	17.8	16.4	0.56	0.035
TCHO	809	809	792	699	31.4	0.032
Digestibility (%)						
DM	65.8	63.1	62.5	61.9	0.79	0.021
OM	66.5	63.7	63.2	62.5	0.78	0.017
CP	64.1	63.1	63.6	63.1	0.81	0.782
EE	76.7	75.9	74.9	75.2	0.87	0.461
TCHO	66.5	63.5	62.8	62.1	0.82	0.011

Mean values with P<0.05 are significantly different

Table 21. Nutritive value and plane of nutrition

Attributes	G-I	G-II	G-III	G-IV	SEM	P
Nutritive value						
TDN (g/kg)	618	592	588	582	7.21	0.021
ME (MJ/kgDM)	9.96	9.54	9.46	9.36	0.118	0.017
Nutrient intake/d						
DOM (g)	617	611	576	502	20.8	0.005
DCP (g)	66.1	66.1	64.4	57.3	2.15	0.023
TDN (g)	635	630	592	518	21.3	0.006
ME (MJ)	10.30	10.24	9.54	8.32	0.345	0.005
Intake/kg BW						
DM(g)	26.66	27.04	24.25	24.42	1.599	0.251
CP(g)	2.67	2.73	2.43	2.49	0.152	0.283
TDN (g)	16.46	16.75	14.26	14.18	0.904	0.114
ME (kJ)	271	265	230	228	14.6	0.110
Intake/kgW$^{0.75}$						
DM(g)	66.45	68.56	61.53	59.98	3.484	0.181
CP(g)	6.66	6.82	6.17	6.11	0.325	0.210
TDN (g)	41.0	41.6	36.2	34.8	1.95	0.065
ME (J)	674	661	583	560	31.6	0.062

Mean values with P<0.05 are significantly different

Table 22. Water restriction effect on water balance

Attributes	G-I	G-II	G-III	G-IV	SEM	P value
Water intake						
Free water(L)	2.900	2.611	2.091	2.245	0.1224	0.003
Preformed water(L)	0.049	0.047	0.046	0.040	0.0018	0.031
Metabolic water(L)	0.346	0.344	0.320	0.280	0.0116	0.005
Total water intake(L)	3.295	3.002	2.456	2.565	0.0128	0.003
Excretion						
Excretion via faeces(L)	0.536	0.396	0.252	0.280	0.070	0.050
Excretion via urine(L)	0.253	0.233	0.217	0.208	0.047	0.598
Total excretion(L)	0.789	0.629	0.472	0.488	0.119	0.085
Balance (L)	2.506	2.373	1.984	2.077	0.080	0.001
Balance/Intake(%)	76.3	79.4	79.8	79.9	2.52	0.717
Balance/DMI	3.19	2.83	2.45	2.79	0.108	0.003
Balance/MEI	1.34	1.25	1.08	1.24	0.049	0.001

Mean values with P<0.05 are significantly different

Table 23. Water restriction effect on Nitrogen Balance

N balance	G-I	G-II	G-III	G-IV	SEM	P value
N intake (g/d)	16.51	16.49	16.17	14.54	0.552	0.032
Faecal N (g/d)	5.94	6.04	5.87	5.38	0.267	0.141
Urinary N (g/d)	4.19	4.13	3.93	3.59	0.201	0.199
Total N excreted (g/d)	10.13	10.47	9.80	8.97	0.408	0.109
N retained (g/d)	6.38	6.32	6.36	5.57	0.191	0.008
N retained/N intake (%)	38.8	39.0	39.4	38.3	0.78	0.813
N retained/N abs (%)	60.4	59.7	62.1	59.0	1.43	0.512

Mean values with P<0.05 are significantly different

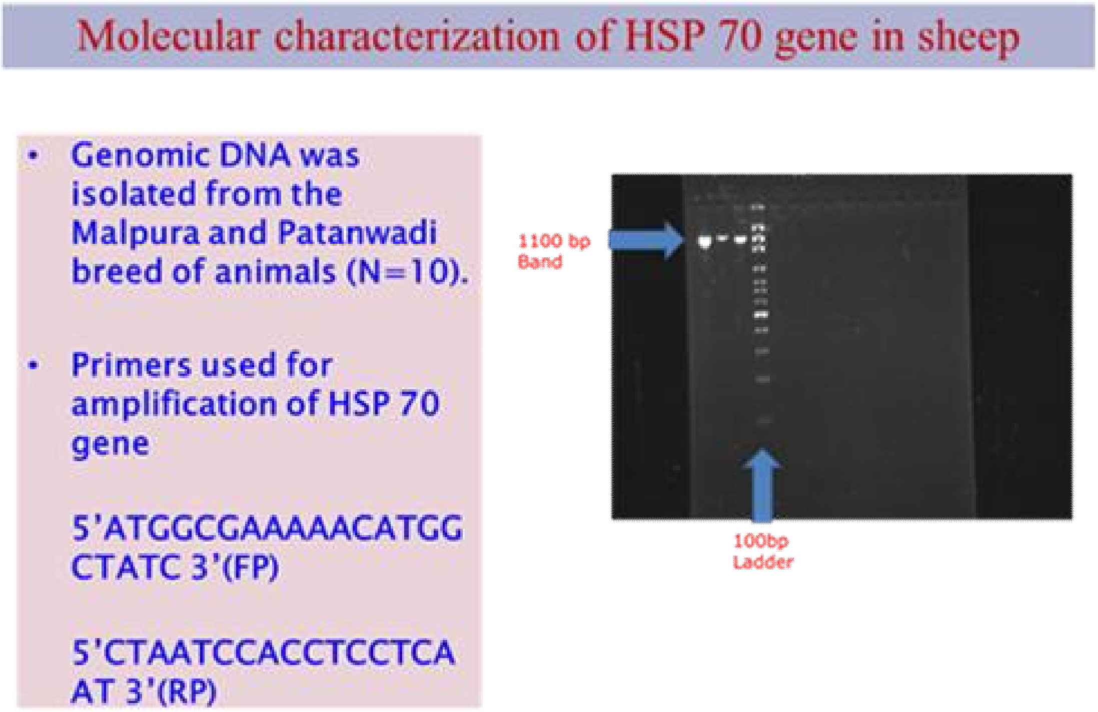
Conclusion:-

- Water restriction had significant effects on physiological response, blood biochemical, endocrine profile and feed intake
- Malpura ewes have shown capability to adapt 40% water restriction but reduction in feed intake & digestibility has concern if restriction/scarcity is prolonged
- Watering on alternate day is more adverse to production as it limited intake and digestibility besides showing more stress response

Experiment 4: *Differential expression of genes in sheep under nutritional and climatic stress conditions*

Amplification of HSP 70 gene of sheep was established (Fig) which will be helpful for deriving phylogenic relationship among different species and for determining expression and identifying new functions considering its importance in conferring thermotolerance.

Fig. 11. Molecular characterization of HSP 70 gene in sheep.



The blood samples collected form sheep exposed to different stresses are processed and RNA was isolated from WBC cells and c-DNA has been prepared. Primers for the full coding region and qPCR of HSP gene family were designed (Table 1) and synthesized. PCR conditions for the HSP family of genes were optimized for molecular characterization. The sequencing of the HSP70 and 90 is under progress.

Table 24. Primers designed for the full coding region and qPCR of HSP gene family

S. No.	**Gene ID**	**Nucleotide Sequences**	**Product Length**
1.	HSP70	F5'ATGGCGAAAAACATGGCTATC3' R5'CTAATCCACCTCCTCAATG3'	1926bp
2.	HSP70	F5'GGTGCCCCAGATCGAGGTGAC3' R5'CACCCTCTCGCGCTGGACCTC3'	199bp
3.	HSP90	F5'GATGGAGGAGAGGAGGTGGA3' R5'AACATATTGGAGGGAACGGAGAC3'	1979bp
4.	HSP90	F5'CGGAAATTGCCCAGTTGATGTCAC3' R5'AGGGTTCGATCTTGCTTGTTC3'	196bp
5.	HSP40 BT	F5'AGACGCTACCTGATGGAG3' R5'TAACCTAAAGATAAAATACAAATG3'	1063bp
6.	HSP40 BT	F5'ACCTGATGGAGCTAGAAG3' R5'TGCTGTGATAAACCAAGGAG3'	187 bp
7.	HSP40 BT	F5'CAGGCAGACAATGCAACACC3' R5'CCAGGCACTGCTTCTGCTAT3'	158 bp
8.	HSP60 BT	F5' GGAGTCGGGCGATTGTATTC3' R5'GCACTATTCTAGGAGTTAGAACATG3'	1773 bp
9.	HSP60 BT	F5' GGAGTCGGGCGATTGTATTC3'	1871 bp

		R5'CCTTTTCTTCAGTCAGCTCCTTC3'	
10.	HSP60 BT	F5' GGAGTCGGGCGATTGTATTC3' R5' CTTCCCTTTGGCCCCATAG3'	215 bp
11.	HSP60 BT	F5' TGGTCTTCAAGTTGTGGCAGTC3' R5' TGGCATCATCTTTGGTCACA 3'	188 bp
14	ACTB	F5'CCAACCGTGAGAAGATGACC3' R5'CCAGAGGCGTACAGGGACAG3'	97 bp

Experiment 5: *To assess the effect of mineral mixture supplementation on growth and physiological adaptability of Malpura ewes subject to heat stress.*

Table 25. Effect of heat stress and mineral mixture supplementation on RR (breaths/Min), PR (beats/Min), RT (°F) and SR ($g/m^2/h$) of Malpura ewes

Items	**RR (Morning)**	**RR (Afternoon)**	**PR (Morning)**	**PR (Afternoon)**	**RT (Morning)**	**RT (Afternoon)**	**SR (Afternoon)**
μ±SE	25.786 ±0.586	82.655 ±2.064	60.429 ±1.163	75.036 ±1.030	100.092 ±0.055	102.281 ±0.042	60.840 ±8.584
Group	NS	**	NS	NS	NS	**	NS
Control	26.071[a]	41.929[c]	58.500[a]	71.893[b]	100.118[a]	101.786[b]	72.443[a]
Heat Stress	26.286[a]	108.893[a]	62.214[a]	76.000[ab]	100.079[a]	102.432[a]	51.894[a]
Mineral Supplementation	25.00[a]	97.143[b]	60.571[a]	77.214[a]	100.079[a]	102.625[a]	58.182[a]
Pooled SE for treatment	±1.015	±3.575	±2.014	±1.783	±0.095	±0.73	±14.868
Day	**	**	*	**	**	**	**
0	24.095[b]	43.905[b]	53.619[c]	67.714[b]	99.929[bc]	101.481[c]	145.184[b]
7	23.429[b]	102.000[a]	58.286[cb]	77.571[a]	100.233[ab]	102.810[a]	34.035[a]
14	30.857[a]	91.190[a]	65.238[a]	75.524[a]	100.386[a]	102.457[b]	33.451[a]
21	24.762[b]	93.524[a]	64.571[ab]	79.333[a]	99.819[c]	102.376[b]	30.689[a]
Pooled SE for Day	±1.172	±4.128	±2.325	±2.059	±0.110	±0.084	±17.168
Group*Day	**NS**	**	**NS**	**NS**	**NS**	*	**NS**

RR- respiration rate; PR-pulse rate; RT-rectal temperature; SR-sweating rate

Table 26. Effect of heat stress and mineral mixture supplementation on Body Weight and BCS of Malpura ewes

Items	**Body weight Kg)**	**BCS**
μ±SE	33.462 ±0.136	3.155 ±0.036
Group	**NS**	*
Control	33.565[a]	3.143[ab]
Heat Stress	33.368[a]	3.018[b]

Mineral Supplementation	33.454[a]	3.304[a]
Pooled SE for treatment	±0.236	±0.062
Day	**	**
0	31.971[c]	2.762[c]
7	33.881[ab]	3.214 [b]
14	33.571[b]	3.190 [b]
21	34.424[a]	3.452[a]
Pooled SE for week	±0.272	±0.072
Group*Day	**NS**	**NS**

μ indicates the overall mean for the parameter. * (P<0.05), ** (P<0.01), NS- Non-Significant; Means with similar superscript do not differ significantly (P>0.05) from each other.

Table 27. Effect of heat stress and mineral mixture supplementation on feed, water intake of Malpura ewes

Items	Feed Intake (DMI gm/w^.75/day)	Water Intake (Lt/DMI Kg/day)
μ±SE	65.457 ±1.012	3.041 ±0.043
Group	**	**
Control	87.050[a]	2.429[c]
Heat Stress	46.575[c]	3.681[a]
Mineral supplementation	62.745[b]	3.014[b]
Pooled SE for treatment	±1.753	±0.074
Day	*	*
7	61.842 [b]	2.900 [b]
14	67.179[a]	3.076[ab]
21	67.349[a]	3.148[a]
Pooled SE for week	±1.753	±0.074
Group*Day	**	**

DMI: Dry Mater Intake; μ indicates the overall mean for the parameter. * (P<0.05), ** (P<0.01) andNS- Non-Significant; Means with similar superscript do not differ significantly (P>0.05) from each other.

Table 28. Effect of heat stress and mineral mixture supplementation on Glucose, Hemoglobin and Packed Cell Volume of Malpura ewes.

Items	Glucose(ml/dL)	Hb(g%)	PCV(%)
μ±SE	61.516 ±0.667	9.920 ±0.105	35.700 ±0.136
Group	**	**	**
Control	65.548[a]	9.68 [b]	34.335[b]
Heat Stress	58.181[b]	10.641[a]	38.478[a]
Mineral Supplementation	60.819[b]	9.432[b]	34.289 [b]
Pooled SE for treatment	±1.155	±0.181	±0.994
Day	**	NS	NS
0	66.607[a]	9.620[b]	33.782[a]
7	62.367[b]	9.794[a b]	35.327 [a]

14	61.843[b]	9.942[a b]	36.952 [a]
21	55.247[c]	10.321[a]	36.740 [a]
Pooled SE for week	±1.333	±0.209	±1.148
Group*Day	**	NS	*

μ indicates the overall mean for the parameter. * (P<0.05), ** (P<0.01), NS- Non-Significant; Means with similar superscript do not differ significantly (P>0.05) from each other.

Fig. 12. Effect of heat stress and mineral mixture supplementation on plasma T3 concentration of Malpura ewes.

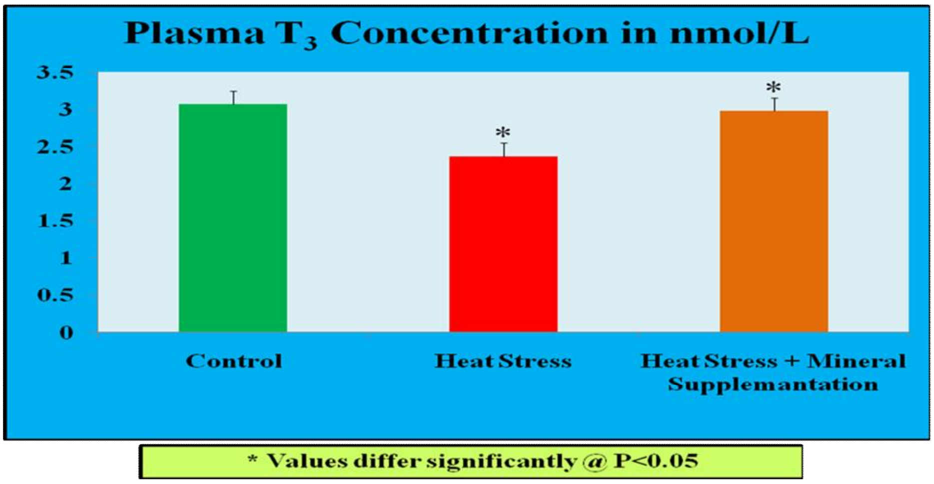


Fig. 13. Effect of heat stress and mineral mixture supplementation on plasma T4 concentration of Malpura ewes.

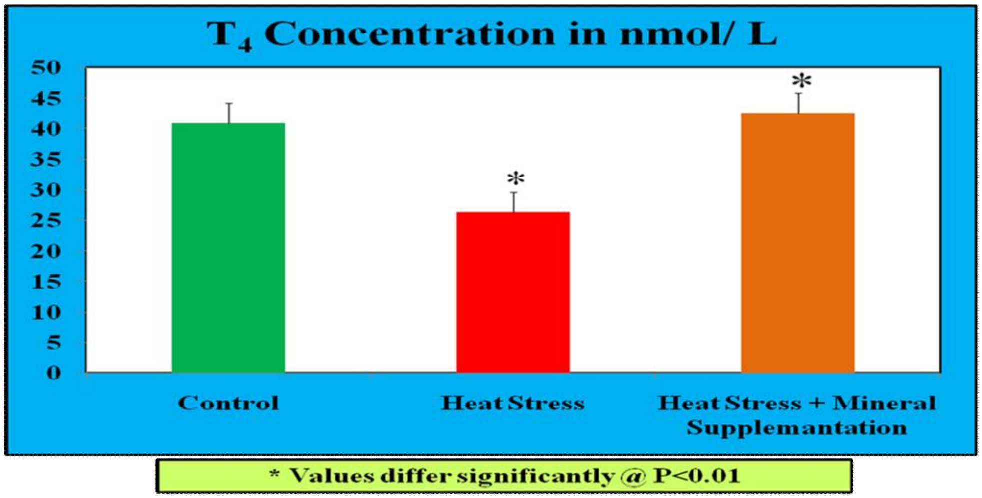


Fig. 14. Effect of heat stress and mineral mixture supplementation on plasma cortisol concentration of Malpura ewes.

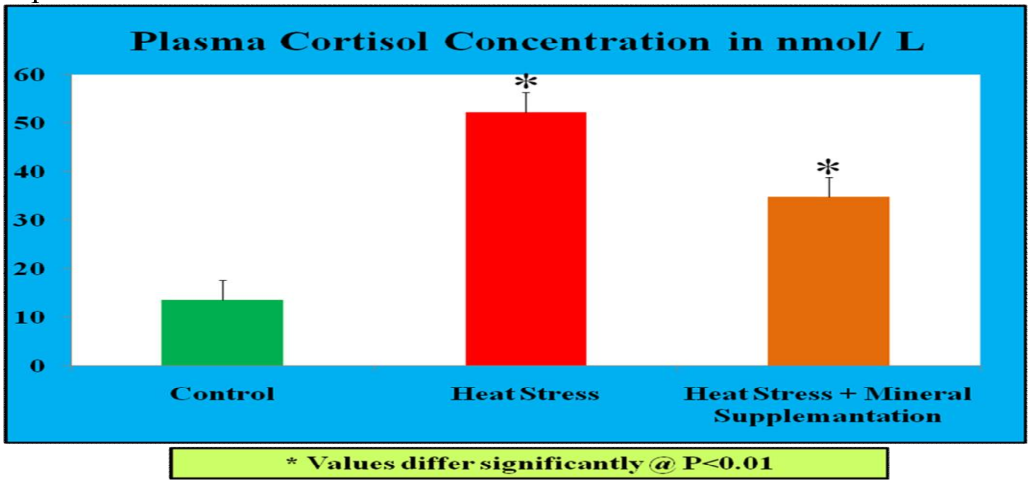


Fig. 15. Effect of heat stress and mineral mixture supplementation on plasma estradiol concentration of Malpura ewes.

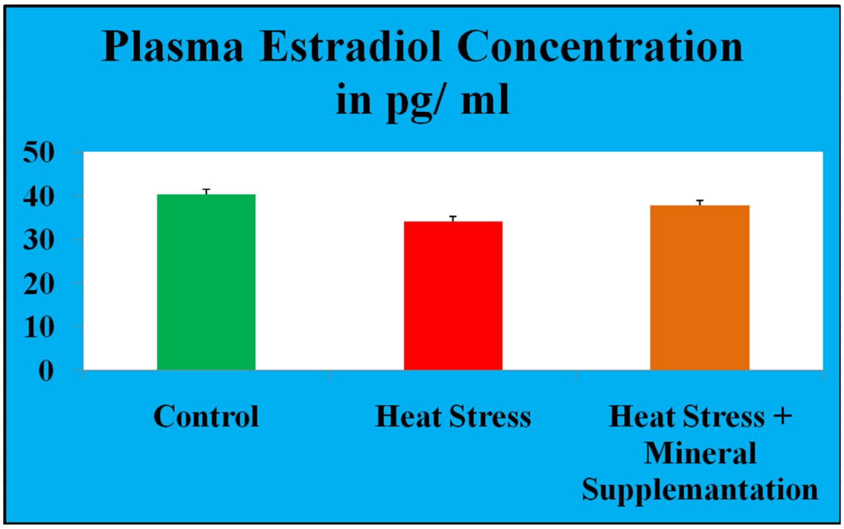
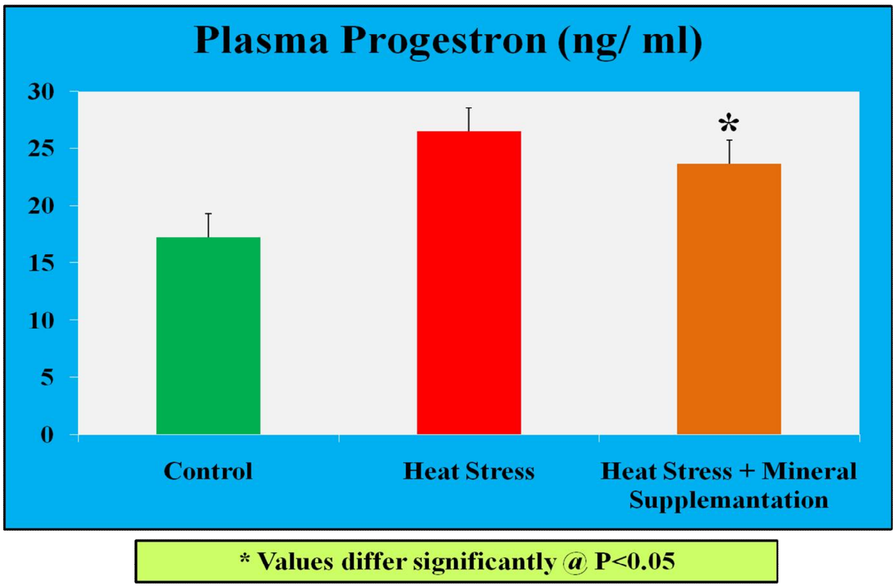


Fig. 16. Effect of heat stress and mineral mixture supplementation on plasma estradiol concentration of Malpura ewes.



Conclusion:-

- Heat stress affected the feed intake, water intake, physiological responses, blood biochemical and endocrine responses. This shows that Malpura ewes posses the capability to adapt to hot semi-arid environment. Further, the results from the study prove that the adverse effect of heat stress on the productive and reproductive efficiency of Malpura ewes was reduced considerably by mineral mixture supplementation. This shows the protective effect of mineral mixture to relieve heat stress in Malpura ewes.

Experiment 6: *Effect of selenium-yeast supplementation on growth and physiological adaptability of Malpura ewes subjected to heat stress*

Sachharomyces cerevisiae was successfully grown in Se-enriched media and was fed to ewes exposed to experimental heat stress in a climatic chamber having arrangements for thermoregulation. The effect on different response parameters was studied by exposing the animals to gradient increasing and decreasing temperature (38°C to 42°C) consecutively for 6 h starting from 10.00 AM to 4.00 PM. There was no significant difference in body weight, feed intake and water intake between the groups after 35 days of heat exposure. Physiological response was also did not differ significantly between the groups except pulse rate. It was significantly ($P<0.05$) higher in treatment group in morning. Plasma glucose level was also significantly ($P<0.05$) higher in Selenium fed animals as compared to control ewes. There was not much change in plasma glutathione reeducates activity but glutathione peroxidase activity increased in Se fed animals, where as it decreased in control groups as the experiment progressed. Cortisol level was higher in control animals as compared to control animals. Estrogen level was higher in treatment animals as compared to control animals; whereas reverse trend was found in progesterone level. Estrous response was also better in Se fed animals as compared to control (100% vs 83.3%). Estrous duration was longer in treatment group. It may thus be concluded that supplementation of *Saccharomyces cerevisiae* grown in selenium enriched media provided resilience to counter heat stress in Malpura ewes.

Table 29. Effect of Se-yeast feeding on body weight, feed intake and water intake

Parameters	Control	Treatment	SE
Initial body weight (Kg)	41.8	41.4	0.57
Final body weight (Kg)	41.6	41.5	0.51
BCS (Initial)	3.66	3.63	0.07
BCS (Final)	3.62	3.66	0.06
Feed intake (g/d)	54.46	54.61	0.88
Water intake (L/d)	4.17	4.11	0.06

Table 30. Effect of selenium-yeast feeding on physiological responses

Parameters	Control	Treatment	SE	Control	Treatment	SE
	Morning			Afternoon		
Respiration rate	35.07	34.60	2.22	97.06	95.93	2.70
Pulse rate	59.67[a]	64.33[b]	0.99	74.46	75.60	1.06
Rectal temperature	100.90	100.96	0.07	102.54	102.44	0.13

Table 31. Effect of selenium-yeast feeding on blood biochemical parameters

Parameters	Control	Treatment	SE
Hb	10.08	9.65	0.29
PCV	35.76	34.09	1.13
Glucose	50.20^{a}	56.08^{b}	1.58

Table 32. Effect of Se-yeast feeding on stress and reproductive hormones

Item	Cortisol (nmol/L)	Estradiol (pg/ml)	Progesterone (pg/ml)
Group effect	NS	NS	NS
GI	41.99	17.58	9.98
GII	32.21	19.56	7.46
Pooled SE for group	6.16	2.60	1.33
Week effect	NS	NS	NS
1st week	49.02	19.02	4.72
2nd week	50.39	15.90	11.28
3rd week	29.01	21.17	9.38
4th week	26.92	22.35	11.48
5th week	25.12	12.24	11.13
6th week	42.13	21.70	4.32
Pooled SE for week	10.23	5.14	2.30
Group*week	NS	NS	NS

Table 33. Effect of selenium-yeast feeding on glutathione peroxidase

Parameters	Control	Treatment	SE
Initial	0.165	0.114	0.04
End	0.148	0.154	0.038
Change	-0.018	0.040	0.042

Table 34. Effect of selenium-yeast feeding on glutathione reductase

Parameters	Control	Treatment	SE
Initial	0.032	0.029	0.004
End	0.031	0.027	0.004
Change	0.001	0.001	0.008

Table 35: Effect of selenium-yeast feeding on periodic changes in glutathione reductase profile in ewes exposed to heat stress

Week	Control	Treatment
1	0.018	0.031
2	0.032	0.029
3	0.031	0.011
4	0.015	0.019
5	0.031	0.027
6	0.031	0.027
Overall	**0.026**	**0.024**

Table 36: Glutathione peroxidase activity in control and Se-supplemented ewes exposed to heat stress

Week	Control	Treatment
0	0.165	0.114
1	0.143	0.133
2	0.237	0.17
3	0.124	0.132
4	0.068	0.105
6	0.15	0.154
Changes	**-0.03987**	**0.03987**

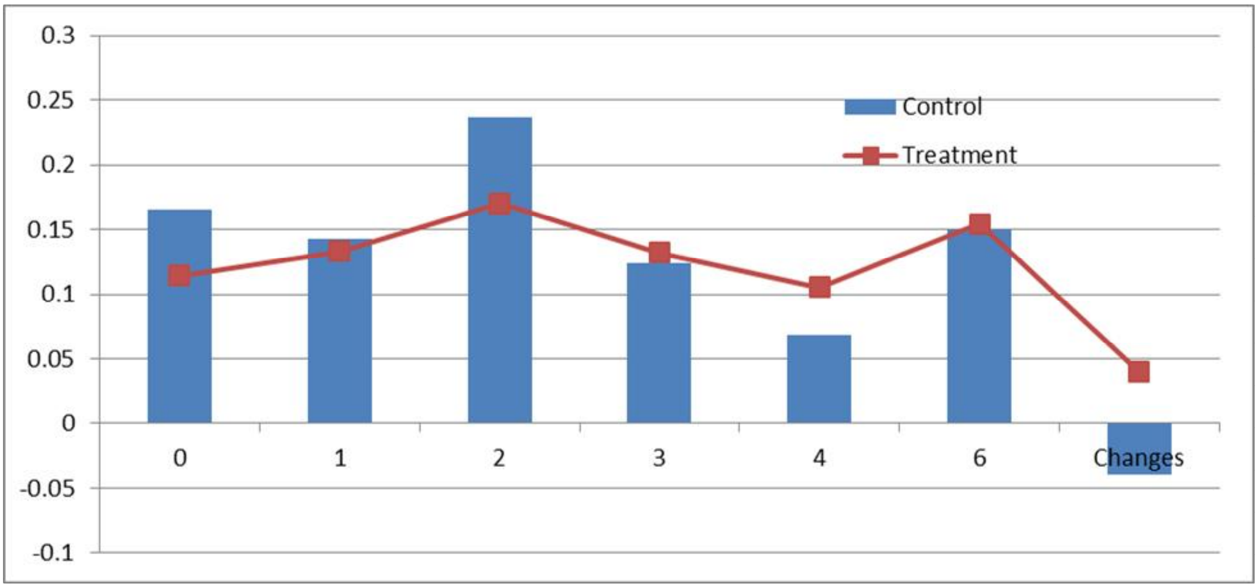


Fig. 17. Weekly Glutathione peroxidase activity in control and Se-yeast supplemented groups**.**

Table 37. Effect of selenium-yeast feeding on reproductive behavour of ewes exposed to heat stress

Attributes	**Estrous %**		**Estrous duration (h)**	
Estrous %	G-I	G-II	G-I	G-II
Ist cycle(%)	83.3% (5/6)	100% (6/6)	39.6	44
II cycle(%)	83.3%(5/6)	100(6/6)	34.8	44

Conclusion:-

- Supplementation of *Saccharomyces cerevisiae* grown in selenium enriched media provided resilience to counter heat stress in Malpura ewes.

Objective 3

Experiment 1: *Establishment of cactus field to provide biomass during hot summer*

A cactus field was developed in an area of 0.8 ha and four different types of cactus (*Opuntia ficus-indica (L.) Mill.*) propagated successfully to provide feed biomass during summer scarcity.

Fig. 18. Established cactus field

Experiment 2: *Amelioration of water deprivation stress vide feeding of prickly-pear cactus [Opuntia ficus indica (L.) Mill.] and its nutritional evaluation in the feeding of sheep during summer*

The results of the experiment are presented in tables 14 to 17. In both G2 and G3 Opuntia feeding provided 0.88 L of water. There was reduced DM intake from cenchrus due to Opuntia feeding and thus the effect on total feed intake was non-significant (P>0.05). However, the digestibility was similar between G1 and G2, but reduced in G3 that exposed to water restriction by 2L.

Table 38. Feed and nutrient intake in different treatment groups

Parameters	T1	T2	T3	Significant
Cenchrus DMI (g/d)	744b	606a	618a	*
Opuntia DMI (g/d)	0b	118a	118a	**
Concentrate DMI (g/d)	380	380	380	NS
Total DMI (g/d)	1124	1104	1116	NS
Dry matter intake (g/kgW$^{0.75}$)	72.0	72.0	74.6	NS
Crude protein intake (g/d)	111	109	110	NS
Crude protein intake (g/kgW$^{0.75}$)	7.13	7.11	7.37	NS
Digestible CPI (g/d)	84.5	89.3	82.5	NS
Digestible CPI (g/kgW$^{0.75}$)	5.40	5.82	5.52	NS
Digestible OMI (g/d)	593	577	537	NS
Digestible OMI (g/kgW$^{0.75}$)	37.9	37.7	35.9	NS
ME intake (MJ/d)	8.84	8.91	8.16	NS
ME intake (MJ/kgW$^{0.75}$)	0.566	0.582	0.546	NS
% DCP of ration	7.52	8.09	7.40	**
% TDN of ration	52.2	54.3	48.6	NS

T1-(Concentrate+Cenchrus Ad lib water); T2- (T1+Cactus+water as that in T1minus water through cactus (or 1L less); T2- (T2+Water 40% less (or 2L less)
* (P<0.05), ** (P<0.01) and NS= Non Significant

Table 39. Nutrient digestibility in different treatment groups

Parameters	T1	T2	T3	Significance
Dry matter	57.1b	56.4b	52.1a	*
Organic matter	59.0	59.5	54.5	NS
Crude protein	75.8ab	78.8b	74.9a	*
Crude fat	70.2	69.1	68.5	NS
Total carbohydrate	55.7	54.1	53.4	*
Neutral detergent fibre	48.2	48.8	42.1	NS
Acid detergent fibre	36.6	32.8	23.4	NS
Cellulose	47.5	45.4	36.9	NS

T1-(Concentrate+Cenchrus Ad lib water); T2- (T1+Cactus+water as that in T1minus water through cactus (or 1L less); T2- (T2+Water 40% less (or 2L less)
* (P<0.05), ** (P<0.01) and NS= Non Significant

Table 40. Nitrogen balance in different treatment groups

Parameters	T1	T2	T3	Significance
N intake (g/d)	17.83	17.45	17.63	NS
N outgo in faeces (g/d)	4.34	3.17a	4.42b	*
N outgo in urine (g/d)	5.65	5.8b	4.44a	*
N retention(g/d)	7.84	8.48	8.76	NS
NB/NI (%)	43.97	48.38	49.64	NS
NB/NA(%)	58.16a	59.32a	66.28b	*

T1-(Concentrate+Cenchrus Ad lib water); T2- (T1+Cactus+water as that in T1minus water through cactus (or 1L less); T2- (T2+Water 40% less (or 2L less)
* (P<0.05), ** (P<0.01) and NS= Noon Significant

Table 41. Water balance in different treatment groups

Parameters	T1	T2	T3	Significant
Water intake (mL/d)				
Free water	5056c	4032b	3000a	**
Preformed water				
Water through conc	19.8	19.8	19.8	ND
Water through Cenchrus	55.8	45.5a	46.2	NS
Water through opuntia	0.0b	851.0a	851.7a	**
Metabolic water	337	317	315	NS
Total (TWI)	5469b	5265b	3918a	**
Excretion (mL/d)				
outgo in faeces	988	1435	1247	NS
outgo in urine	555b	483ab	411a	*
Total	1543	1918	1657	NS
Balance (mL/d)	3926c	3347b	2576a	*
Balance/TWI(%)	71.8	63.6	60.9	*
Balance/DMI	3.49	3.03	2.31	*
Balance/MEI	1.06	0.90	0.75	*

T1-(Concentrate+Cenchrus Ad lib water); T2- (T1+Cactus+water as that in T1minus water through cactus (or 1L less); T2- (T2+Water 40% less (or 2L less)
* ($P<0.05$), ** ($P<0.01$) and NS= Noon Significant

Conclusion:-

- Feeding of Opuntia compensated mild water restriction up to 1 L without any significant effect on feed intake. Thus, Opuntia can be successfully fed to sheep during feed scarcity meeting water and nutrient requirement. The native sheep Malpura exhibited adaptability to conserve water in the face of deprivation/scarcity.

Experiment 3: *Propagation and cultivation of Azolla (Azolla pinnata) in semi-arid regions as a biotic and protein supplement*

An extrapolation of Azolla production output per unit area provided an estimate of biomass production to the tune of 5 Q DM/ha area and with 25% CP would promise a potential biotic and protein source for semi-arid and arid regions of the country with minimum water use to harvest good quality protein for livestock feeding

Production output at CSWRI

90-100 q/ha/week = 450-500 kg DM/ha/week = 16-18 kg CP/ha/d

(Assumptions: DM 5%, CP 25%)

Fig. 19. Low-cost pond for *Azolla pinnata* production

Experiment 4: *Incorporation of Azolla as a biotic feed source in the diet of native Malpura lambs during summer nutritional scarcity*

After harvesting from the pond with a strainer Azolla needs proper washing to get rid of offensive odour if any. Since a fresh harvest Azolla has ~95% moisture, it is required to air dry under shade for 3-4 h (preferably air dried overnight on a nylon-net bed hanged from the ceiling for drainage of washed water and air circulation). It was observed that sheep took on an average 3 days' time for adaptation to Azolla based feed compared to conventional ration. In the present experiment, another unconventional source of feed 'Vilayati babool pods' was also incorporated in the ration to evaluate palatability, intake and nutritive value. On dry matter basis Azolla had 25% CP and 12% ash. The fat and total carbohydrates content were 4% and 57%, respectively. Following adaptation to Azolla the feed and DM intake was similar between the groups. Data on nutrient digestibility and other parameters will be compiled in due course. From the available information on feed intake and phenotypic performance of animals it may be concluded that Azolla could successfully replace 10% of concentrate in the the diet of sheep and also, Vilayati babool pods showed promise as an unconventional feed source with 18% CP to be incorporated as part of concentrate.

Experiment 6: *Establishment of Senjana (Moringa oleifera) field to harvest biomass during scarcity*

Fig. 20. Moringa oleifera: A promising fodder biomass for semi-arid Rajasthan

A 0.5 ha area with Senjana (*Moringa oleifera*) implants was developed to provide biomass during scarcity. Commonly known as "Drumstick" tree, it has gained interest as a protein source for livestock. It was observed that Moringa could easily be established in the field and has good coppicing ability to promise as a potential source of forage during scarcity. With a DM content ranging from 16-28%, the foliage had average 18% CP and 11% ash. A preliminary palatability trial has been conducted in sheep on conventional ration and it was observed that none of the animals did show rejection even on day 1 and thus proved good palatability. The feeding trial with 500 g of fresh foliage over and above the conventional ration based on concentrate 1% of body weight with ad libitum dry cenchrus grass was conducted and the assessment of feed and nutrient intake and its nutritive value is under progress.

Experiment 7: *Establishment of herbal garden with plants rich in secondary metabolites and herbal properties*

Fig. 21. Field for growing herbal plants

Experiment 8: *Collection, drying and storage of monsoon herbage to feed during scarcity*

Monsoon herbage biomass is generally neglected due to availability of enough pasture during rainy season. However, a huge amount of palatable forage biomass can be harvested, shade dried and stored for future scarcity periods of the year. The two identified herbages Chaulai and Jojhru were grown soon after monsoon and at the end of monsoon period and observed to be consumed by sheep during foraging. These forage biomass was harvested and analysed for nutrient composition (Table 1)

Table 42. Nutrient composition of different monsoon herbages

Botanical name	Common name	DM	OM	CP	EE	TCHO	NDF	ADF	Lignin	HC	C	Ash
Amaranthus spp	Chaulai	14.7	88.3	17.61	4.87	65.9	61.5	32.9	6.19	28.6	26.7	11.67
Crotalaria medicaginea	Jhojhru	29.9	90.0	13.88	3.11	73.0	55.1	20.2	6.95	34.9	13.2	10.05

DM Dry matter, OM Organic matter, CP Crude protein, EE Ether extract, TCHO Total carbohydrates, NDF Neutral detergent fiber, ADF Acid detergent fiber, HC Hemicellulose, C Cellulose

Fig. 22. ***Amaranthus sps.*** ***Crotalaria medicaginea Lam*** ***Shade drying of monsoon herbage***

Objective 4

Experiment 1. *To assess the efficiency of indigenously devised bamboo dome structure as cold protection device and to observe its effects on adaptive capability of Malpura lambs during winter season.*

Table 43. Effect of cold protection on BW (kg) RR (breaths/Min), PR (beats/Min), RT (^{o}F) and ST (^{0}C) of Malpura lambs

Items	BW	RR Morning	RR Afternoon	PR Morning	PR Afternoon	RT Morning	RT Afternoon	ST Morning	ST Afternoon
μ±SE	11.372 ±0.539	48.231 ±1.189	51.938 ±1.860	87.425 ±1.989	108.550 ±1.729	102.378 ±0.116	102.860 ±0.057	31.389 ±0.388	34.562 ±0.263
Group	NS	**	*	NS	**	NS	**	NS	NS
Cold Protected	10.800	52.225	47.475	88.400	103.900	102.410	102.708	31.923	34.385
Cold Exposed	11.945	44.200	56.400	86.450	113.200	102.345	103.013	30.855	34.740
Pooled SE for treatment	±0.762	±1.681	±1.681	±2.813	±2.445	±0.163	±0.864	±0.548	±0.372
Week	NS	**	NS	NS	*	NS	**	**	**
0	9.475	49.875	51.562	78.375	114.375	102.125	103.312	29.069	37.575
1	10.494	65.250	53.875	92.625	106.500	102.694	102.881	29.225	34.963
2	11.063	38.562	43.125	87.000	98.000	102.250	102.569	33.294	35.694
3	12.300	44.500	53.750	85.000	111.250	102.488	102.731	33.212	28.050
4	13.531	42.875	57.375	93.625	112.625	102.331	102.806	32.144	36.531
Pooled SE for Week	±1.205	±2.658	±4.160	±4.448	±3.866	±0.258	±.127	±0.867	±0.588
Group*Week	NS	NS	NS	NS	NS	NS	NS	NS	NS

μ indicates the overall mean for the parameter. * (P<0.05), ** (P<0.01), NS- Non-Significant

Table 44. Effect of cold protection on cortisol (n mol/L), T_3 (n mol/L)andT_4(n mol/L) concentrations of Malpura lambs

Items	Cortisol	T3	T4
µ±SE	16.536 ±0.668	4.801 ±0.170	60.387 ±3.442
Group	**	**	*
Cold Protected	12.082	4.039	51.852
Cold Exposed	20.989	5.564	68.922
Pooled SE for treatment	±0.944	±0.241	±4.868
Week	*	NS	NS
1	12.233	4.727	59.339
2	18.306	4.713	65.542
3	16.870	5.092	65.390
4	18.239	4.773	56.803
5	17.030	4.703	54.860
Pooled SE for Week	±1.493	±0.380	±7.697
Group*Week	NS	NS	NS

µ indicates the overall mean for the parameter. * (P<0.05), ** (P<0.01), NS- Non-Significant

Table 45. Effect of cold protection on Hb and PCVconcentrationsof Malpura Lambs

Items	Glucose (g/dl)	Hb (g%)	PCV (%)
µ±SE	93.217 ±2.336	10.901 ±0.267	47.254 ±1.185
Group	NS	**	**
Cold Protected	90.883	10.189	43.924
Cold Exposed	95.551	11.613	50.583
Pooled SE for treatment	±3.304	±0.378	±1.676
Week	**	*	*
0	109.436	10.469	49.639
1	97.699	11.425	40.299
2	92.765	9.427	45.092
3	82.826	11.309	52.617
4	83.357	11.875	48.620
Pooled SE for Week	±5.223	±0.598	±2.649
Group*Week	NS	NS	NS

µ indicates the overall mean for the parameter. * (P<0.05), ** (P<0.01), NS- Non-Significant

Conclusions:-

- ❖ The results from the study proves that the indigenously developed bamboodome structurewere able to protect the lambs from the cold stress. This is evident from the significant reduction in level of stress hormone cortisol and significant lowering of metabolic hormones as compared to cold exposed group indicating that they are not relying on increasing their metabolic rate to counter cold stress.

Experiment 2. *Development of shelter to combat heat and cold stress*

Shelters to protect from cold

Fig. 23. Shelter for cold protection.

Dome-type easy to carry shed made of bamboo   House with thermocol-insulated roof

<u>Shelters to protect from summer</u>

Fig. 24. Yagya-type shed to protection against summer

Fig. 25. Integrated farming with tree-shade for protection against summer

Experiment 3: *Effect of micro environment manipulation on growth performance, physiological response, blood metabolites and endocrine profile of Malpura lambs in semi-arid region during winter*

The experiment on micro-environment impact on animal performance was studied during winter months. The meterological data is presented in table 18. The observations on physiological responses, blood metabolic and endocrine profile are depicted in tables 19, 20 and 21. Micro environment manipulation had no significant ($P<0.05$) effect on physiological response and skin temperature except morning respiration rate. The present study reveals that, Hb, PCV, total protein, albumin, T3 and cortisole level were significantly (P<0.050 influenced by microenvironment manipulation. Further, the study signifies the importance of micro environment manipulation for lambs during winter in hot semi-arid tropical region to improve their average daily gain.

Table 46. Meteorological data during the study period in different shed.

	Maximum temperature (°C)	Minimum temperature (°C)	RH(%)	THI	Wind velocity (m/s)	Day length (h)
Environmental	24.13 ± 0.44	8.76 ± 0.87	77.78 ±2.43	10.21±0.98		
GI	25.07±0.30	8.59±0.71	59.28 ±4.50	12.51±0.91	2.68 ± 0.32	8.11 ± 0.52
GII	23.91±0.41	14.59±0.54	66.44±2.02	16.12±0.62		
GIII	22.61±0.46	11.84±0.64	56.67±3.73	13.80±1.06		

GI, Control; GII, Dome; GIII, Thermocol insulated.
RH, Relative humidity, THI, Temperature humidity Index The meteorological data were recorded at morning 0700h and afternoon 1400 h. Temperature humidity index were calculated with the formula of, THI = db ◦C − {(0.31 − 0.31 RH)(db ◦C − 14.4)} given by Marai *et al*. (2007).

Table 47. Effect of micro environment manipulation on physiological response in Malpura lambs.

Item	RR morning	RR afternoon	PR morning	PR afternoon	RT morning (°F)	RT afternoon (°F)	ST (°F)
μ ± SE	42.45 ± 0.87	63.11 ± 2.48	93.57 ± 1.56	104.85 ± 1.20	102.86 ±0.09	103.31 ±0.09	95.95 ±0.57
Group effect	*	NS	NS	NS	NS	NS	NS
GI	40.33[a]	58.17	96.21	102.58	102.77	103.50	94.86
GII	46.58[b]	68.38	93.88	107.08	103.01	103.28	95.97
GIII	40.45[a]	62.17	90.63	104.88	102.79	103.15	97.00
Pooled SE	1.50	4.31	2.70	2.08	0.16	0.15	0.95
Week effect	**	**	**	**	NS	*	**
1st week	27.72[a]	41.88[c]	94.61[a]	110.83[a]	102.74	103.22[bc]	92.00[b]
2nd week	47.330[b]	60.55[bc]	88.00[b]	107.22[a]	102.66	102.63[c]	95.46[b]
3rd week	46.00[b]	70.67[ab]	101.78[ab]	107.56[a]	102.77	103.37[ab]	95.66[b]
4th week	48.77[b]	79.33[a]	89.89[b]	93.78[b]	103.26	104.03[a]	100.68[a]
Pooled SE	1.73	4.94	3.11	2.40	0.19	0.18	0.99
Group×week	NS	NS	*	NS	NS	NS	*

GI:- Control, GII:- Dome, GIII:- Thermocol insulated, ST:-Skin temperature. [a,b] Values within a column with different superscripts differ significantly at $P<0.05$.

Table 48. Effect of micro environment manipulation on blood metabolites in Malpura lambs**.**

Item	Hb (g/dL)	PCV (%)	Glucose (mg/dL)	Total Protein (g/dL)	Albumin (g/dL)	Globulin (g/dL)	Cholesterol (mg/dL)	Urea (mg/dL)
μ ± SE	12.50 ± 0.26	48.67 ± 1.28	103.05 ± 2.20	6.90 ± 0.15	5.50 ± 0.06	2.49 ± 0.12	116.91 ± 3.81	36.01 ± 1.68
Group effect	*	*	NS	*	*	NS	NS	NS
GI	11.52[a]	44.24[a]	100.78	6.49[a]	4.27[a]	2.22	109.82	38.68
GII	12.96[ab]	51.42[b]	101.51	6.76[ab]	4.43[a]	2.59	128.60	30.61
GIII	13.03[b]	50.36[ab]	106.85	7.46[b]	4.79[b]	2.66	112.32	38.76
Pooled SE	0.44	2.21	3.81	0.26	0.10	0.20	6.61	2.90

Week effect	**	**	**	NS	*	NS	NS	**
1st week	19.28[c]	59.17[c]	121.41[b]	6.73	4.27[a]	2.46	107.39	40.02[b]
2nd week	10.29[ab]	50.87[b]	93.10[a]	6.55	4.52[ab]	2.37	114.47	41.48[b]
3rd week	11.25[b]	47.68[b]	112.08[b]	7.36	4.79[b]	2.57	124.75	39.86[b]
4th week	9.19[a]	36.96[a]	85.60[a]	6.96	4.41[ab]	2.55	121.05	22.71[a]
Pooled SE	0.51	2.05	4.40	0.30	0.12	0.23	7.63	3.35
Group*week	NS	NS	NS	NS	NS	NS	NS	NS

GI:- Control, GII:- Dome, GIII:- Thermocol insulated, ST:-Skin temperature.
[a,b] Values within a column with different superscripts differ significantly at $P<0.05$.

Table 49. Effect of microenvironment manipulation on endocrine parameters in Malpura lambs

Item	GH (mlU/L)	IGF-1 (ng/mL)	T4 (nmol/l)	T3 (nmol/l)	Cortisol (nmol/l)
µ ± SE	**0.070±0.006**	**353.26±16.00**	**175.42±8.81**	**5.83±2.82**	**30.03±2.81**
Group effect	**NS**	**NS**	**NS**	*	*
GI	0.071	335.08	183.00	6.11[ab]	29.85[ab]
GII	0.067	344.77	173.52	6.62[b]	35.64[b]
GIII	0.072	379.94	169.77	4.78[a]	22.78[a]
Pooled SE	0.010	27.72	15.25	0.49	4.76
Week effect	**NS**	**NS**	**NS**	**NS**	*
1st week	0.079	348.31	176.87	6.46	16.90
2nd week	0.065	383.03	184.34	6.31	44.39
3rd week	0.082	340.26	189.75	5.34	31.49
4th week	0.054	341.46	150.76	5.24	25.98
Pooled SE	**0.01**	**32.00**	**17.31**	**0.56**	**5.89**
Group×week	**NS**	**NS**	**NS**	**NS**	*

GI:- Control, GII:- Dome, GIII:- Thermocol insulated, ST:-Skin temperature.
[a,b] Values within a column with different superscripts differ significantly at $P<0.05$

Table 50. Effect of microenvironment manipulation on body weight gain in different type of housing

	Initial weight (kg)	Final body weight (kg)	Weekly body weight gain (kg)
Control	9.97	13.17	1.072
Dome	9.97	13.9	1.294
Thermocol insulated	9.88	13.97	1.339
SE	0.55	0.60	0.135

Conclusion:

Bamboo-make dome-type shed and thermocol-insulated shed provided warmth by raising the minimum temperature by 6.0 and 3.3 °C compared to conventional asbestos roof shed. This provided comfort to young lambs by minimizing cold stress which was reflected with relatively lower stress (lower cortisol) in animals kept in thermocol-insulated shelter. The animals kept inside bamboo-dome structure showed more stress as against better thermo-insulation, probably due to restricted floor space.

Experiment 4: *Effect of different type shelters on physiological response, growth performance, blood biochemical and endocrine profile of lambs under hot semi-arid environment*

To ameliorate heat stress, open area **silvi-pasture system with fodder trees to provide shade** was developed with an objective to protect animals from solar radiation during extreme summer as well as to provide fodder during scarcity period in semi-arid region.

Yagya-type shed was constructed to protect the animal from extreme summer. This concept was taken from The Hindu rituals, where they used to construct special type of structure to perform Havan (yagya). That structure used to keep the shed comfortable inspite of continuous fire and burning of woods inside the shed. Similarly here we have constructed a modified shed that can provide comfort during summer. The shed was made up of bamboo. The side walls were double walled. The empty space between two walls was filled with sand. The sand was kept in moist condition through continuous drip water system. This provide evaporative cooling inside the shed, that kept the inside micro environment comfortable.

The open area tree-shade had higher THI (table 1) than the other two housing types (asbestos and Yagya type) and animals exhibited more discomfort (high respiration rate, pulse rate). The animals showed higher metabolic rate as exhibited from their high T3 values (fig.3). Amongst the three housing types, Yagya-type shed provided maximum comfort with lower physiological responses (table 3). The animals kept in this shed also had relatively balanced haemato-biochemical (fig. 1) and hormonal profile (fig. 2) with better growth response (table 2).

Table 51. Environmental data for Yagga type shed during summer

	Max T (°C)	Min T (°C)	RH (°C)	THI at 1400 h
Environmental	43.46±0.44	26.19±0.56	23.61±1.91	37.60±0.38
Asbestos roof	45.48±0.51	27.09±0.52	18.95±1.96	33.73±1.23
Yagya	41.42±0.47	27.92±0.91	21.16±1.6	32.42±1.26

*Max T-Maximum Temperature, Min T- Minimum Temperature, RH- Relative Humidity, THI-Temperature Humidity Index. (Marai et al. 2007)

Table 52. Effect of different type of shelters on growth performance

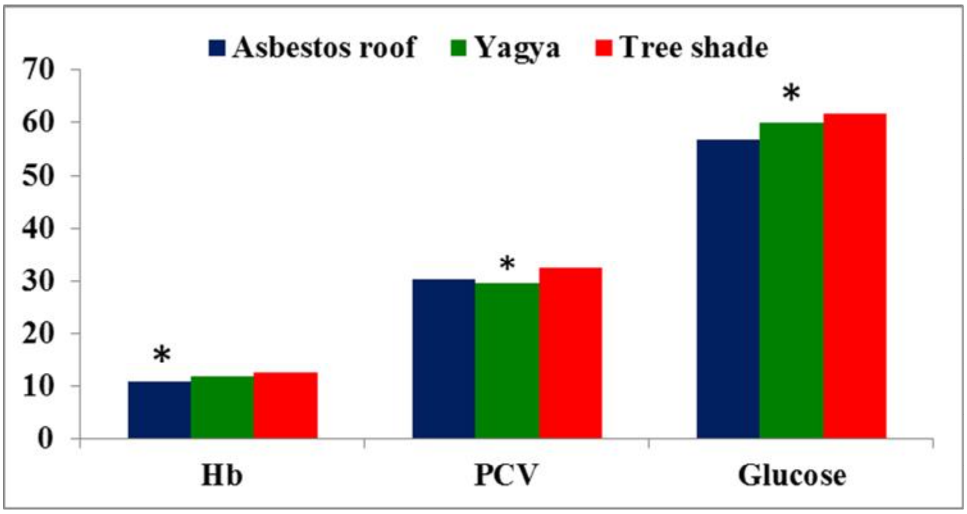
	Initial weight (kg)	End weight (kg)	Weight gain (kg)	ADG (gm)
Asbestos roofed	19.49±0.74	25.19±1.40	5.70±1.31	94.99±21.74
Yagya Type	19.44±0.74	26.19±1.40	6.75±1.31	112.57±21.74
Tree Shed	19.64±0.70	25.30±1.34	5.67±1.24	94.45±20.73

Table 53. Effect of different type of shelters on Physiological response

Item	RR Morning	RR Afternoon	PR Morning	PR Afternoon	RT Morning	RT Afternoon
μ ± SE	20.30±0.41	54.47±1.14	54.92±0.69	61.90±1.01	101.49±0.06	102.09±0.06
Treatment	*	**	*	*	NS	*
Asbestos roof	22.28[a]	46.05[b]	56.61[a]	65.97[a]	101.44	102.13[ab]
Yagya	18.57[b]	33.62[c]	51.85[b]	57.42[b]	101.43	101.90[b]
Tree shed	20.06[ab]	83.73[a]	56.30[a]	62.31[a]	101.60	102.24[a]
Pooled SE for treatment	±0.70	± 1.97	± 1.19	± 1.75	± 0.10	± 0.10
Week	**	**	**	**	**	NS
1^{st}	23.20[a]	39.64[b]	61.67[a]	74.60[a]	102.03[a]	102.27
2^{nd}	21.50[a]	56.23[a]	58.28[a]	60.49[b]	101.49[b]	102.16
3^{rd}	15.95[b]	59.01[a]	49.33[b]	57.13[b]	100.95[c]	102.06
4^{th}	20.56[a]	62.99[a]	50.40[b]	55.38[b]	101.49[b]	101.86
Pooled SE for day	± 080	± 2.26	± 1.37	± 2.01	± 0.12	± 0.11
Treatment*week	*	**	*	*	**	*

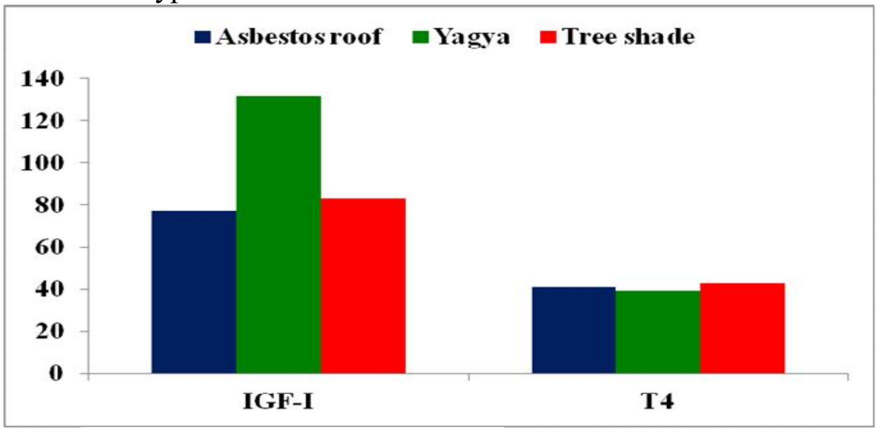
RR; Respiration rate (breath/ Minute), PR; Pulse rate (beat/Minute) and RT; Rectal temperature (°F), μ indicating overall mean, **(p<0.01) differ significantly * (p<0.05) differ significantly

Fig 26. Effect of Shelter on Blood Biochemical's of lambs under hot semi arid environment



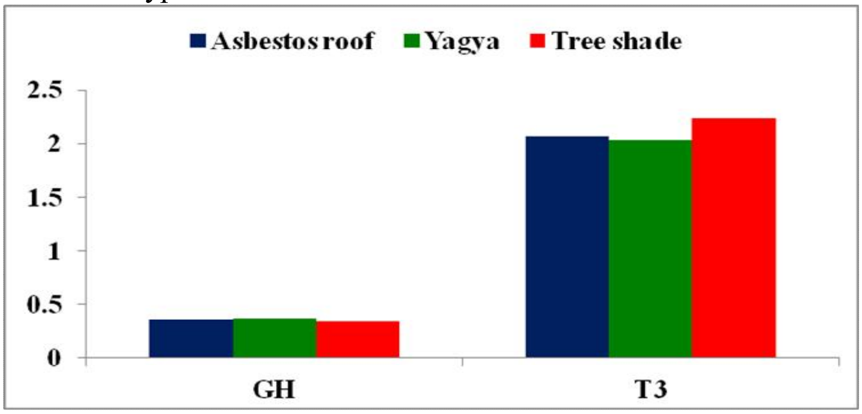
Hb; Haemoglobin (g/dl), PCV, Packed cell volume (%), Glucose(mg/dl) and * (p<0.05) differ significantly

Fig 27. Effect of different types shelter on IGF-1 and T4.



IGF-I; Insulin-like growth factor-1(ng/mL) and T-4; thyroxine (nmol/L)

Fig 28. Effect of different types shelter on GH and T3.



GH; Growth Harmone and T3 triiodothyronine (nmol/L)

Conclusion:-

- The open area tree-shade had higher THI than the other two housing types (asbestos and Yagya type). The animals sheltered in Yagya-type shed experienced maximum comfort with lower physiological responses, and relatively balanced haemato-biochemical and hormonal profile with better growth response.

Experiment 5: *Development of low-cost shed to protect lambs from cold stress*

Establishment of low cost shed for protection of lambs during winter. The shade was constructed with locally available material (*Panipuli*). The material is having insulation property.

Fig 29. Low cost Hut- type shed for cold protection

Experiment 6: *Establishment of Climate-resilient all-weather shed to protect from winter as well as summer*

Fig. 30: Climate resilient all weather shed is under construction

9. Results of Significant value

- The water samples from different sources available for livestock were analyzed from five districts (water dark zone) of Rajasthan and found that specific conductivity, chloride magnesium, sodium, silica and total solids were above the range of maximum permissible limits, while calcium was lower
- Despite significant effects of water restriction on physiological response, blood biochemical, endocrine profile and feed intake, Malpura ewes showed capability to adapt and tolerate up to 40% water restriction during summer season under semi-arid tropical environmental conditions, but comparatively less to alternate day water restriction. A reduction in feed and nutrient intake may have more detrimental effect, if water scarcity prolonged
- Sheep under field conditions of semi-arid region try to tolerate high temperature and solar radiation by increasing physiological responses and by hiding under trees near the source of water during peak hours (44.3 ºC during 13.00 h to 14.00 h) of summer season.
- Malpura ewes showed signs of recovery from heat stress (adaptability to heat stress) within a period of one week from severity of heat stress (Solar radiation: 42- 46^{0}C) as assessed from productive and reproductive parameters. **Amplification of HSP 70 gene** of sheep was established and PCR conditions for the HSP family of genes were optimized for molecular characterization.
- Effect of heat stress on the productive and reproductive efficiency of Malpura ewes was reduced considerably by mineral mixture supplementation (Mineral Mixture Composition per Kg diet: Zinc Sulphate 164.0 mg, Colbalt sulphate 0.95 mg, Chromium acetate 1.2g, Selenium chloride 0.1mg, and Vitamin E 40.0 mg. Dose: 20gm/Kg body weight). This shows the protective effect of mineral mixture to relieve heat stress in Malpura ewes.
- **Amelioration of heat stress through selenium-yeast supplementation:** Supplementation of *Saccharomyces cerevisiae* grown in selenium enriched media provided resilience to counter heat stress in Malpura ewes.
- **Cactus: resilient against feed and water scarcity:** With 88% moisture, consumption of 2.0 kg cactus biomass could provide 240 g feed DM with and 1.76 L water.
- **Azolla as biotic and protein supplement**: 10% replacement of concentrate with Azolla provided additional protein besides as a source of green
- **Harvesting monsoon herbage to cater summer feed scarcity**: Promising plant species (e.g. Chaulai, Jojhru) that erupts during monsoon could be harvested, dried under shade and stored to feed during summer scarcity
- The indigenously developed **bamboo dome structure** could able to provide better protection from cold stress (inside temp. 19.33°C vs outside: 9.25°C; a difference of 10.08°C) to lambs but relatively more stress due to restricted floor space. Thermocol-insulated shelter was found to be the best to protect lambs against extreme winter and would be useful for commercial sheep farmers.
- **Yagya-type shed to provide more comfort during summer**: The microenvironment inside the yaga type shed provide better comfort then asbestos roofed shed and open-area tree shade (THI reduction by 5 unit).
- **Low cost shed for protection of lambs during winter:** The shade was constructed with locally available material (*Panipuli*) that can be easily made by farmers in their field or during temporary

stay en-route migration. The material is having insulation property because of its sharp blade leafs and is not usually consumed by the animals due to its tough plant structure and unpalatability.

10. Procurement of Equipment

SN	Name of the Equipment	Status of Procurement	Estimated Cost/ Budget allocated (Rs. in lakhs)	Actual Cost
1	Laparoscope	Installed	13,00,000/=	15,39,429/=
2	Blood Chemistry Auto-analyser	Installed	8,10,000/=	6,62,720/=
3	ELISA Reader	Installed	7,00,000/-	6,47,806/-
4	Water Purification System*	Installed	6,00,000/-	6,00,000/-
5	Hematology Analyzer	Installed	6,00,000/-	6,42,750/-
6	Milk Analyzer	Not Purchased	6,00,000/-	-
7	Deep -Freezer	Not Purchased	1,90,000/-	-
	Total=			**40,74,705/-**

11. Status of works, if any:

Name of the Work	Actual expenditure incurred
1. 1.8 ha Cactus farm	79,452/-
2. Establishment of a herbal garden (approx.. 2.0 ha)	45,500/-
3. Climate-resilient All-weather shed	1, 98,000/-
4. Boundary Wall around cactus and Senjana farm	1,99,000/-
Total	**5,21,952/-**

12. Budget details:

Year (2011-12)

Head	1st Release		2nd Release		Cumulative		
A. Recurring Contingency	**Released**	**Expend.**	**Released**	**Expend.**	**Released**	**Expend.**	**%**
I. Operational expenses (Labour, skilled staff, POL, Supplies etc.,) Contractual services etc.,	0.02	-	19.0	14,35,313	19.02	14,35,313	-
II. TA	0	0	4.0	1,31,008	4.0	1,31,008	-
III. HRD	0	0					
Total (A)	**2000**	**-**	**23,00,000**	**15,66,321**	**23,02,000**	**15,66,321**	**68.04%**
B. Non Recurring Contingency			-	-			-
I. Equipment	46,10,000	22,02,150	-	-	46,10,000	22,02,150	-
II. Equipment costing less than Rs. 5 Lakhs	1,90,000	0	-	-	1,90,000	0	-
III. Information Technology	1,50,000	1,40,250	-	**-**	1,50,000	1,40,250	**-**
C. Inst. Charge		-	-	-		-	-
Total (B)	**49,50,000**	**23,42,400**	**0**	**0**	**49,50,000**	**23,42,400**	**47.32%**
D. Total (A+B)	**49,52,000**	**23,42,400**	**23,00,000**	**15,66,321**	**72,52,000**	**39,08,721**	**53.9**

Year (2012-13)

Head	2012-13			Cumulative		
	Release	Exp.	%	Release	Exp.	%
I. RC	**7,35,679**			**16,64,321/-**	**19,74,663/-**	**82.28**
i.	4,66,687			17,33,313/-	19,34,977/-	87.95
ii.	2,68,992			(-)68,992/-	39,686/-	19.84
iii.	-	-	-	-	-	-
II. NRC	**26,07,600/-**			**(-)76,00/-**	**18,72,556/-**	
i.	24,07,850			2150	18,72,556/-	77.7
ii.	1,90,000				-	-
iii.	9,750			(-)9,750	-	-
III. Inst Charges						
IV. Total	**33,43,279/-**			**48,00,130/-**	**69,90,628/-**	**85.84**

Year (2013-14)

Head	Opening balance (Rs) (01-04-13)	2013-14	Cumulative (2013-14)		
		Release	Received	Exp.	%
I. RC	**-**				
i. Operational		**1447219***	**2500000**	2378889	95.16
ii. TA		-	100000	58948	58.95
iii. HRD		- -	-	-	
II. NRC	**-**	**-**			
i.		-	-		
ii.		-	-		
iii.		-	-		
III. Inst Charges			**-**		
IV. Total	**1152781**	**1447219***	**2600000**	**2437837**	**93.76**

*NB. Total amount received including CIRG Rs 3053967/-; Amount credited to CIRG Rs 1000000/- and amount to be transferred to CRIDA (meant for CIRG) Rs 606748/-; So, **Balance released for CSWRI for the year 2013-14 = Rs 3053967 – 1000000 - 606748 = Rs 1447219**

13. HRD Program conducted, if any:

Name of the programme	Venue	Dates (DD/MM/YYYY)	No. of participants
One day workshop on "Climate resilient shelter and stress management in small ruminants in hot arid and semi-arid regions of india"	CSWRI, Avikanagar	02-05-2013	Delegates- 03 Scientists-19 Farmers-65
Field Day	CSWRI, Avikanagar	24-03-2014	Technical Off. 10 Scientists-30 Farmers-61

- One day workshop on "Climate resilient and stress management in small ruminant in hot arid and semi-arid region of India" was held at CSWI, Avikanagar on 2nd May, 2013. Three delegates, nineteen scientists and sixty five farmers attended this workshop.
- Farmers under training programme at CSWRI, Avikanagar were exposed to different shelter management strategies under NICRA.
- Visit of farmers under training programme at CSWRI to Cactus field area and exposure to its importance during summer food and water scarcity
- Exposure of resource persons and dignitaries to different shelter and nutritional management activities carried out under NICRA project at CSWRI, Avikanagar
- Trainees under different programme at CSWRI, Avikanagar were exposed to different shelter management strategies under NICRA.
- Farmers involved in training programme at CSWRI were visited to Cactus field area and given knowledge regarding its importance during summer food and water scarcity.
- Resource persons and dignitaries visited to CSWRI, were introduced the different shelter and nutritional management activities carried out and going on under NICRA project at CSWRI, Avikanagar




NICRA
National Initiative on Climate Resilient Agriculture
ONE DAY WORKSHOP
on
CLIMATE RESILIENT SHELTER AND STRESS MANAGEMENT
IN SMALL RUMINANTS IN HOT ARID AND SEMI-ARID REGIONS OF INDIA
02-05-2013
Dr A. Sahoo

14. Publication/ patents

A. Research papers

1. Sejian, V, Naqvi, S.M.K., Sahoo, A. 2013. Effect of mineral mixture and antioxidant supplementation on growth, reproductive performance and adaptive capability of Malpura ewes subjected to heat stress. *Journal of Animal Nutrition and Animal Physiology,* 98, 72-83.
2. De K., Kumar D., Singh A.K., Sahoo, A. and Naqvi, S.M.K. 2013. Seasonal variation of physiological response in ewes of farmers' flocks under semiarid tropical environment, Biological Rhythm Research, DOI: 10.1080/09291016.2013.830509.
3. Chaturvedi, OH, Bhatt RS, Sahoo A. 2014. Nutrient utilization in grazing ewes supplemented with complete feed blocks during scarcity in semi-arid region. *Indian Journal of Small Ruminants*, 20, 114-117.

B. Books

Sahoo A, Ror D, Naqvi SMK. 2013. Climate Resilient Small Ruminant Production. NICRA Publication, CSWRI, Avikanagar. Pp 1-106

C. Book Chapters

1. Sahoo A. 2012. Feeding and nutrition of animals at high altitude. In: Animal Nutrition-Advances and Developments, U.R. Mehra, P.Singh and A.K. Verma (eds). Satish Serial Publishing House, Delhi. pp 329-350.

D. Scientific/Teaching Reviews/Lead Paper

1. Sahoo, A. 2013. Nutritional issues in grazing and migratory sheep and goats. Centre of Advanced Faculty Training in Animal Nutrition is organizing an advanced Short Course on "Clinical Nutrition Approaches for Health and Productivity of Farm Animals", February 06-26, 2013, IVRI, Izatnagar. pp 174-181.
2. Naqvi S.M.K., Davendra Kumar and Sahoo A. 2013. Strategies for sustainable small ruminant production in arid regions under changing climate. In: Proc. Workshop on "Strategies for sustainable small ruminant production in arid regions under changing climate", 14-15, March, 2013, CAZRI, Jodhpur.
3. Naqvi, S.M.K. and Kumar, D. 2012. Environmental stresses and sheep production under changing climatic scenario. In: National Symposium on "Physiological research in changing environmental scenario for sustainable livestock and poultry production'', Navsari, 6-8 November, Invited paper, pp 15

E. Folders:

1. Chaturvedi, O.H., Sahoo, A., Bhatt, R.S., Sankhyan, S.K., Shinde A.K. and Meena, M.C. 2013. Akal Men PashudhanKaBharanPoshan. Published By NICRA, CSWRI, Avikanagar.
2. Sahoo, A. Chaturvedi, O.H., Sharma, S.C., Meena, M.C., Naqvi, S.M.K. 2014. "Ok'kkZdkyhu "kkdh; & tM+h cwVh;ksa dk i"kqvksa ds pkjs esa mi;ksx"Published By NICRA, CSWRI, Avikanagar
3. Sahoo, A. Chaturvedi, O.H., Sharma, R.B., Meena, M.C., Naqvi, S.M.K. 2014. "Monsoon herbage and weeds: Could be an answer to feed scarcity" Published By NICRA, CSWRI, Avikanagar.

F. Abstract papers

1. Singh, A.K., Sejian, V and Naqvi, S.M.K (2011). Effect of mineral mixture supplementation on growth and physiological adaptability of Malpura ewes subjected to heat stress. In: Prospects and retrospect of small ruminants and rabbit production: contribution to socio-economic security" organized by Indian Society for Sheep and Goat Production and Utilization in association with Central Wool development Board at Jaipur between 7-9 December 2011, pp 98-99.
2. Rajni, C., Sejian, V and Naqvi, S.M.K (2011). Comparative study on the endocrine responses during pre-exposure, exposure and post-exposure period of heat stress under hot semi-arid environment. In: Prospects and retrospect of small ruminants and rabbit production: contribution to socio-economic security" organized by Indian Society for Sheep and Goat Production and Utilization in association with Central Wool development Board at Jaipur between 7-9 December 2011, pp 100.
3. Rajni, C., Sejian, V and Naqvi, S.M.K (2011).Effect of summer season on the growth and reproductive performance of Malpura ewes under semi-arid tropical environment. In: XX Annual conference of Society of Animal Physiologist of India (SAPI) and International Symposium on "Advances in Physiologic Research for Sustainable Development of Livestock and Poultry Production" organized by Department of Veterinary Physiology, WBUAFS, 37, Kshudiram Bose Sarani, Belgachia, Kolkata between 2-4 November 2011, pp 134.
4. Singh, A.K., Rajni, C., Sejian, V and Naqvi, S.M.K (2011). Effect of summer season on the adaptive capability of Malpura ewes under semi-arid tropical environment. In: XX Annual conference of Society of Animal Physiologist of India (SAPI) and International Symposium on "Advances in Physiologic Research for Sustainable Development of Livestock and Poultry Production" organized by Department of Veterinary Physiology, WBUAFS, 37, Kshudiram Bose Sarani, Belgachia, Kolkata between 2-4 November 2011, pp 156.
5. Chaturvedi, O. H. and Sahoo, A. 2012. Intake and utilization of nutrients in grazing ewes supplemented with complete feed block during scarcity in semi-arid region. In Souvenir cum Abstracts of National Seminar on Future Challenges and Opportunities to Improve Health and Production of Small Ruminants. December 22-23, Makhdoom, Farah (Mathura), India. Pp.95.
6. Singh, A.K., Kumar, D., and Naqvi, S.M.K. 2012. Physiological adaptability of sheep in farmer's flock during peak summer season in semi-arid region of Rajasthan. In: XXI Annual conference of Society of Animal Physiologist of India (SAPI) and National Symposium on "Physiologic Research in Changing Environment Scenario for Sustainable Livestock and Poultry Production" organized by Department of Veterinary Physiology and Biochemistry, Vanbandhu College of Veterinary Science & Animal Husbandry, Navsari Agriculture University, Navsari- 396 450 (Gujarat) between 6-8 November 2012, pp 47.
7. Kumar, K., Singh, A.K., Kumar, D., and Naqvi, S.M.K. 2012. Effect of water restriction on the adaptability of Malpura ewes under semi-arid tropical environment. In: XXI Annual conference of Society of Animal Physiologist of India (SAPI) and National Symposium on "Physiologic Research in Changing Environment Scenario for Sustainable Livestock and Poultry Production" organized by Department of Veterinary Physiology and Biochemistry, Vanbandhu College of Veterinary Science & Animal Husbandry, Navsari Agriculture University, Navsari- 396 450 (Gujarat) between 6-8 November 2012, pp 48.
8. Singh, A.K., Kumar, K., Kumar, D., Naqvi, S.M.K. 2012. Effect of water restriction on the endocrine response of Malpura ewes under semi-arid tropical environment In: Souvenir cum abstracts, National Seminar on Future Challenges and Opportunities to Improve Health and Production of Small Ruminants and Annual Conference of ISSGPU organized by Indian Society for Sheep and Goat Production and Utilization, Avikanagar (ISSGPU) in association with Central Institute for Research on Gotas, Makhdoom at CIRG Makhdoom, - 281122 (Mathura, U.P) pp 148.
9. Chaturvedi, O.H. and Sahoo, A. 2013. Opuntia (prickly pear cactus) feeding in sheep to evaluate water and nutrient metabolism during summer. *In Souvenir Cum Compandium of Intractive*

Meeting on Prospects in Improving Production, Marketing and Value Addition of Carpet Wool. December 31, ARC (CSWRI) Bikaner, India. Pp. 58.

10. De K., Kumar D., Singh A.K., Sahoo, A. and Naqvi, S.M.K. 2014. Effect of microenvironment manipulation on physiological response, blood biochemical, behaviour and growth of Malpura lambs during winter in semiiarid tropical condition. In: XXI Annual convention of Indian Society of Animal Production and Management and national seminar on "New Dimensional Approaches for Livestock Production and management, January 28-30, 2014, pp 20.

15. Any other information:

- Participated in National Stakeholders consultation on climate change platform at CRIDA, Hyderabad between 18-21 September 2011 (V. Sejian and S.M.K. Naqvi).
- Participated in XX Annual conference of Society of Animal Physiologist of India (SAPI) and International Symposium on "Advances in Physiologic Research for Sustainable Development of Livestock and Poultry Production" organized by Department of Veterinary Physiology, WBUAFS, 37, Kshudiram Bose Sarani, Belgachia, Kolkata between 2-4 November 2011 (V.Sejian and Anoop Kumar Singh).
- Participated in National seminar on "Prospects and retrospect of small ruminants and rabbit production: contribution to socio-economic security" organized by Indian Society for Sheep and Goat Production and Utilization (ISSGPU) in association with Central Wool development Board at Jaipur between 7-9 December 2011 (S.M.K.Naqvi, V.Sejian, Anoop Kumar Singh and Rajni Chhetri).
- Dr A. Sahoo attended workshop on "Strategies for sustainable small ruminant production in arid regions under changing climate", 14-15, March, 2013, at CAZRI, Jodhpur.
- Dr Davendra Kumar attended XXI Annual conference of Society of Animal Physiologist of India (SAPI) and National Symposium on "Physiologic Research in Changing Environment Scenario for Sustainable Livestock and Poultry Production" organized by Department of Veterinary Physiology and Biochemistry, Vanbandhu College of Veterinary Science & Animal Husbandry, Navsari Agriculture University, Navsari- 396 450 (Gujarat) between 6-8 November 2012
- A total of four abstract papers were presented, two at CIRG, Makhdoom and two at NAU, Navsari
- Dr A. Sahoo chaired a technical session in the Workshop at CAZRI, Jodhpur
- Dr A. Sahoo presented an invited paper on "Environmental Stresses and Sheep Production under Changing Climatic Scenario" in the Workshop at CAZRI, Jodhpur.
- Dr Kalyan Dey attended workshop on NICRA activities at CAZRI, Jodhpur.
- Dr A. Sahoo and Dr Davendra Kumar attended an Intractive Meeting on "Prospects in Improving Production, Marketing and Value Addition of Carpet Wool". December 31, 2013 ARC (CSWRI) Bikaner,
- A 'Field Day' under the project on National Initiative on Climate Resilient Agriculture (NICRA) was organized on 24th March, 2014 at Central Sheep and Wool Research Institute, Avikanagar. Professor M.P. Yadav, Secretary, NAAS presided the meeting as Chief Guest. Two folders, one in Hindi "Ok'kkZdkyhu "kkdh; & tM+h cwVh;ksa dk i"kqvksa ds pkjs esa mi;ksx" and one in English "Monsoon herbage and weeds: Could be an answer to feed scarcity" were released in this occasion.
- About fifteen farmers visited Azolla production unit under NICRA at CSWRI, Avikanagar in March, 2014.
- The scientist delegation from Bangladesh namely, Dr. Md. Nazrul Islam, Director General, Bangladesh Livestock Research Institute, (BLRI), Mrs. Delwora Begum, Deputy Secretary, Ministry of Fishery & Livestock (MOFL), Dr. Md. Ershaduzzaman, Project Director (Sheep Project), BLRI,

Pulakash Mondal, Senior Assistant Chief, Ministry of Fisheries and Livestock and Md. Tanjim, Assitant Chief Planinig Commission have visited NICRA activities during their study tour to CSWRI, Avikanagar on 06.04.14.

- Dr Fisal Hassan Ibrahim, Minister of Animal Resource, Republic of Sudan and H.E. Hon. visited NICRA activities during their study tour to Central Sheep and Wool Research Institute, Avikanagar on 6th March 2014.

Signature of PI & Associates

Davendra Kumar **Kalyan De** **Satish Kumar** **O.H. Chaturvedi**

S.M.K. Naqvi **A. Sahoo**