

MATERIALS FOR **SHADE** NETS

a guideline to select the most performant materials to enhance the living conditions inside emergency shelters



Sahel Shelter Solution implemented in Burkina and Niger
with the international support of the Luxembourg Red Cross and IFRCRU

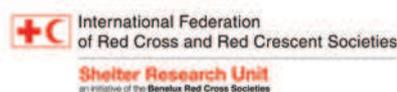
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Layout

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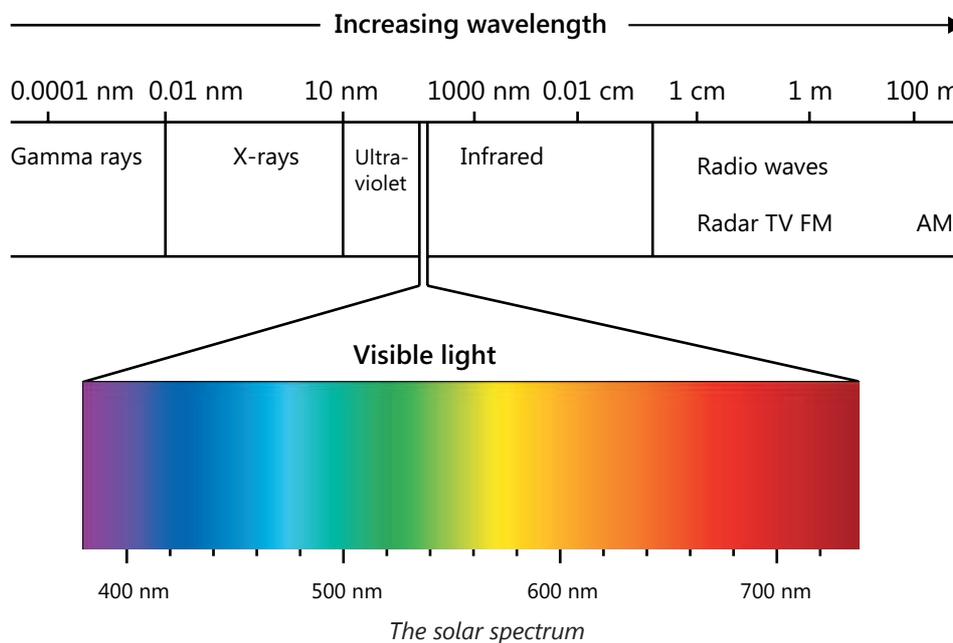


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GLOSSARY

INFRARED (IR) LIGHT is the invisible radiation emitted by the sun (and objects) with longer wavelengths than those of visible light, extending from the red edge of the visible spectrum at 700 nanometers up to 1 mm. This IR light is responsible for heating phenomena.



ULTRAVIOLET (UV) LIGHT has shorter wavelengths than visible light, extending from the violet edge of the visible spectrum. This invisible radiation contains more energy than the visible light and is responsible for the degradation of materials.

INCIDENT RADIATION is the radiation originating from the sun and reaching the shade net. This not only includes the visible light (43%), but also a large part of the infrared (53%) and some ultraviolet light (4%).

REFLECTION is the amount of the radiation reflected by the surface of the shade net.

TRANSMISSION is the amount of radiation passing through the shade net.

ABSORPTION is the amount of radiation absorbed by the shade net and that will heat the shade net itself.

One part of the incident radiation will be reflected by the surface of the shade net, a second part will be absorbed by the shade net, and a third part will pass through it.

Optical reflection, transmission and absorption take place in wavelengths in the range between 380 nm and 780 nm.

Heat reflection, transmission and absorption are measured in the range of the visible light and in a large part of the infrared light (up to 2500 nm).

LIGHT TRANSMITTANCE is the amount of visible light passing through the shade net.

TEAR STRENGTH measures the force needed to tear the fabric in a specific direction.

TENSILE STRENGTH measures the force needed to pull the fabric in one direction to the point where it breaks.

INTRODUCTION

Emergency situations often occur in hot climates. To provide comfortable living conditions inside the shelters of refugees or homeless people, it must be prevented that the inner shelter temperature rises significantly above the outside temperature. The inner temperature can easily be lowered by using shade nets.

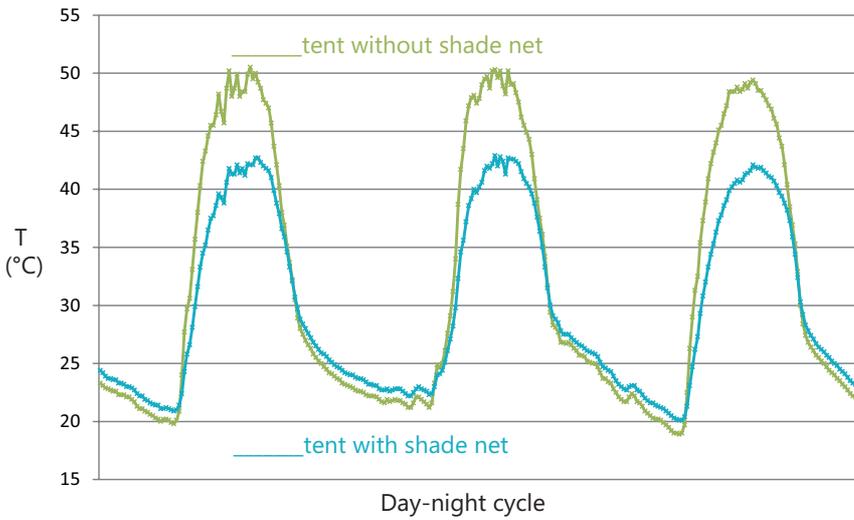


Figure 1. Field tests performed in November 2014 in a refugee camp in Burkina Faso provided evidence that shade nets effectively lowered the inner shelter temperature. Temperature differences of nearly 10°C between the two structures were registered.

The use of shade nets is a universal solution and can be implemented in almost any situation. The market offers many types of materials with different properties. This guideline intends to provide an tool to select the most appropriate material (colour, shading factor, strength,...).

In order to have an overview of the available shading materials, over one hundred materials were collected from different suppliers. Although most of these materials were developed for the agricultural sector, they can be used as shade nets in emergency situations.

24 samples have been selected, with different colours and/or constructions to cover a diverse range of materials. The results of this study are therefore based on the findings of the tests performed on this very selection. However, it was never the intention of the researchers to provide an exhaustive survey of all available shade nets on the market.

1. SHADING PERFORMANCE

1.1 Thermal performance of shade nets - explanation

The main goal of this study is to investigate the thermal performances of the different shade nets and to determine which kind of shade net will create the most comfortable living conditions in the shelter underneath.

The incident radiation from the sun is partially reflected by the shade net and partially absorbed by it. The radiation that is not reflected or absorbed is transmitted through the shade net (Figure 2).

What will be the effect of the combined actions of these phenomena on the temperature rise inside a volume (e.g. a shelter) underneath the shade net?

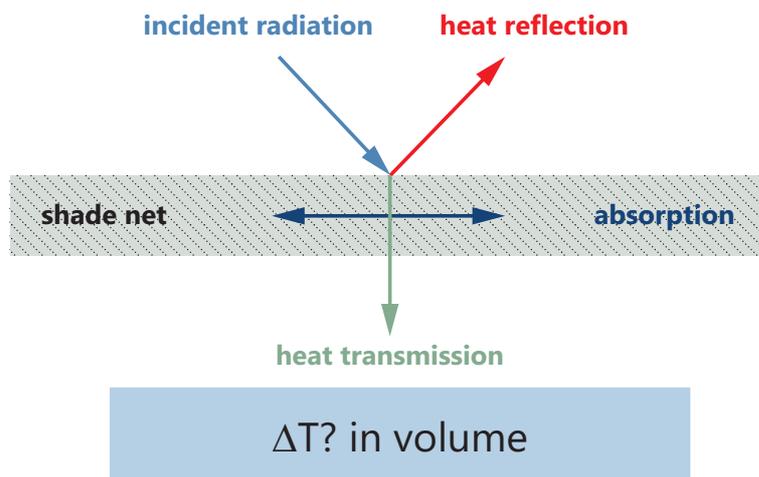


Figure 2: Physics of radiation

At first, the optical and heat reflection/transmission of each shade net have been determined according to the European standard EN 410.

Good correlations are observed between the heat and optical transmission characteristics.

Similarly, the optical and heat reflections are in line with each other. The optical transmission (380 nm - 780 nm) can also be correlated with the measured light transmittance (480 nm - 670 nm, determined according to AATCC 148-1989) (Figure 3).

The absorption of the shade net can be calculated (absorption (%) = 100 - reflection - transmission).

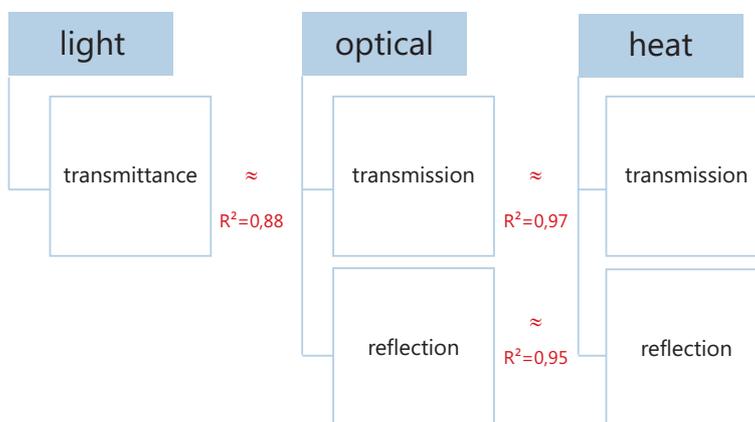


Figure 3: Correlations of reflections and transmissions

1.2 Light transmittance and shade factor

In most cases, a correlation can be observed between the measured light transmittance and the shade factor indicated by the manufacturer. This is logical as the shade factor (%) added to the light transmittance (%) should equal 100%. So, the higher the shade factor, the less light will penetrate, resulting in a lower light transmittance value.

Only within a series of similarly constructed shade nets, it is possible to find a correlation between the weight of the shade net and the light transmittance (Figure 4, red squares). The higher the weight, the denser the shade net becomes, resulting in a decreasing light transmittance. But this rule of thumb does not apply when different types of shade nets are being compared. For example, in the weight category of 100 g/m², one will find shade nets with light transmittances widely varying from ca. 15% to ca. 70%.

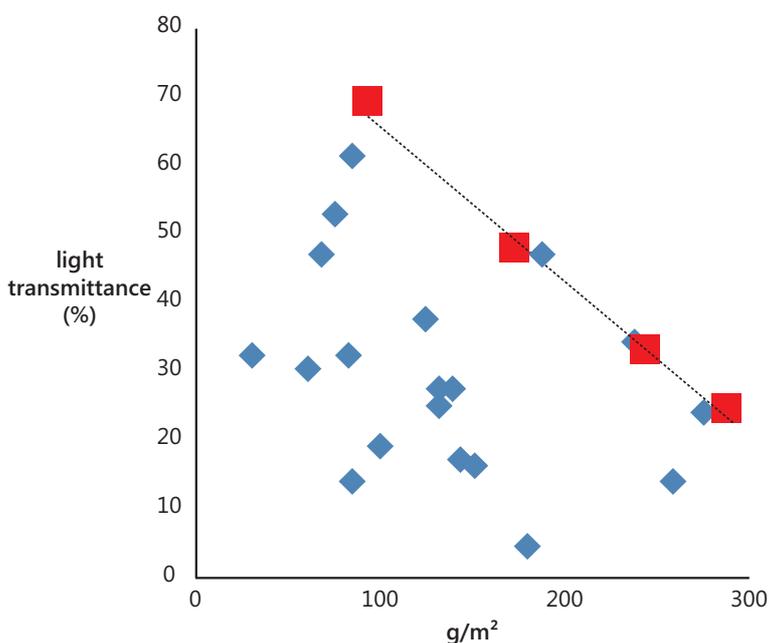
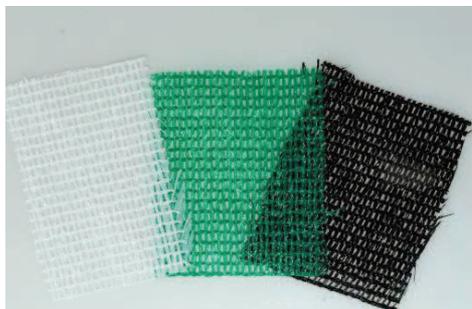


Figure 4: Correlation between light transmittance and the weight of a shade net

1.3 Influence of colour and shade factor on thermal performance

The temperature rise in a closed volume is measured according to a Centexbel in-house testing method. The different shade nets are mounted between the volume (a closed box) and the infrared light (i.e. the part of the sunlight that is responsible for creating heat). The recorded temperature rise (ΔT) in the box will give an indication of the performance of the shade net. Although it is not possible to correlate the lab measurements with the actual temperature rise in a shelter, it allows ranking the shade nets according to their thermal performance.

1.3.1 Colour influence



In order to measure the effect of differently coloured shade nets on the inner temperature rise, three shade nets with an identical structure but with a different colour (white, green, black) have been purchased. Their performance was evaluated according to the Centexbel in-house testing method.

Figure 5 shows that the black shade net offers the best thermal insulation. The inner temperature rise significantly decreased from 6.5°C to 2°C. The insulating effects of the white and green shade net are only half as important as the effect of the black one: temperature rises around 4.5°C are recorded.

Intuitively one would presume that a shade net with a high reflectivity has a better thermal performance. However, this is not generally true, because the effect of heat absorption has been neglected in this reasoning. It is shown that there is a good correlation between heat transmission and temperature rise: all the heat that is able to pass through the shade net will augment the inner temperature of the box.

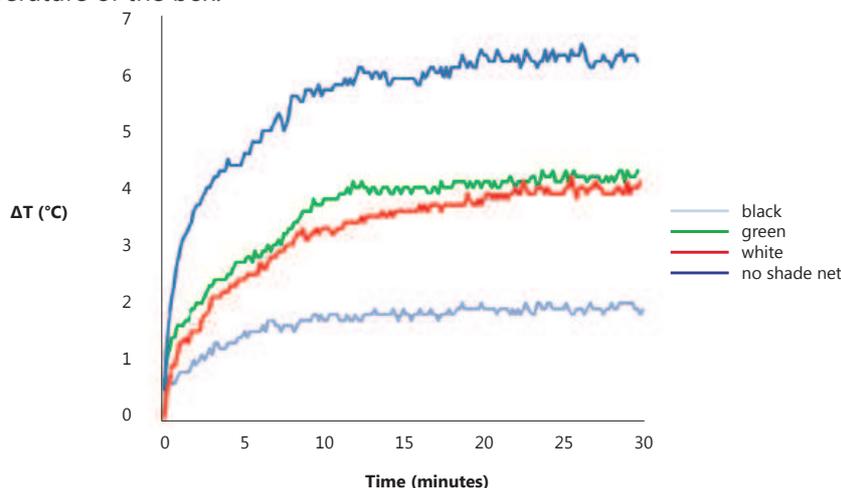


Figure 5: Influence of colour on internal temperature rise

MAIN FINDINGS

- A white shade net will reflect a larger part of the infrared light (~43%) but will absorb less heat in its structure, so a major part of the infrared light will pass through the shade net (~55%). A black shade net, on the other hand, will have a very poor reflectivity (~4%) but will retain a great amount of heat in its structure (~73%). The amount of heat that actually passes through the net (~23%) is therefore smaller than in the case of the white shade net.
- Darker coloured shade nets are thermally better performing. Because they will absorb the majority of the heat, the shade net itself will become warm. A ventilation gap between the shade net and the shelter is therefore indispensable. One should keep the ventilation gap as big as possible in order to guarantee maximal ventilation. Enlarging the ventilation gap will mean that additional attention should be paid to the anchoring and fixing of the shade net since it should not be blown away by the wind. Also allowing ventilation in both longitudinal as transversal direction is an advantage. According to the Shelter Centre¹ a minimal distance of 50 cm is advisable.
- An aluminium shade net with a high shade factor is also a good option to control the inner shelter temperature. This material is able to reflect around 75% of the sunlight and will not retain much heat in its structure (~11%). A disadvantage is the higher cost price of the aluminium net compared to a black shade net.
- Camouflage nets and dark green colours should be avoided since they are referring to the military and are not performing better than the black ones.

¹ Shade nets - use, deployment and procurement of shade nets in humanitarian relief environments, first edition 2006, Shelter Centre and Médecin sans Frontières

1.3.2 Shading factor influence

In general, the heat transmission of a shade net is unknown to the manufacturer/end user. The manufacturer usually indicates the shade factor of the material based on visible light.

However, the wavelength of visible light (380 nm – 780 nm) differs from the one of infrared light (780 nm – 1 mm) that is causing the heating phenomenon.

Therefore, measurements of the visible light transmittance will give lead to different results than measurements of the heat transmission. In addition, no perfect correlation can be found between the light transmittance and the heat transmittance ($R^2 = 0.85$) of a shade net.

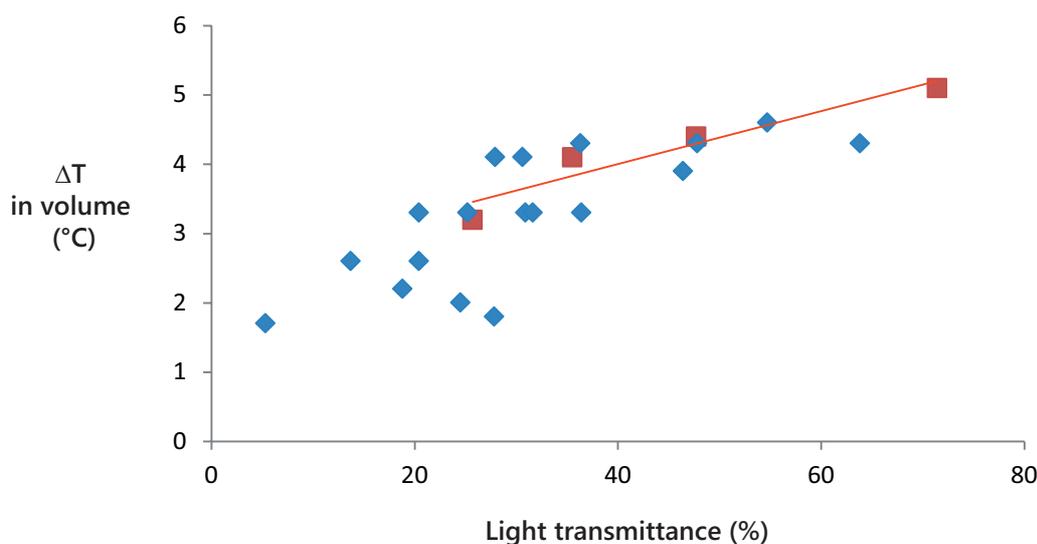


Figure 6: Correlation between temperature rise and light transmission of the shade net

MAIN FINDINGS

- The shade factor (which is linked to the light transmittance) gives only an indication of the thermal performance (see Figure 6). Two shade nets with exactly the same shade factor, but made from different materials, can result in a different temperature rise, because of the differences in heat absorption of the materials.
- For shade nets with an identical construction and colour, the shading factor can be linked to the temperature rise (see red trendline in Figure 6). Higher shading factors result in better thermal performances. Since all shade nets of the same series are made from the same material, the used filaments or tapes show a similar heat absorbing behaviour.
- Figure 6 also shows that, the denser the structure of a shade net, the more it will block the visible and infrared light. Blocking the infrared light has a positive effect on the inner temperature.
- A minimum shade factor of 50 should be used, as this has already a significant effect. A higher shade factor is of course more effective, but adds weight to the shade net. For example, the weight of a shade net with a shading factor of 73% can be 60% higher than the weight of the one with a shading factor of 50%.

2. MECHANICAL ASPECTS

2.1 Weight of the shade nets

The weight of the tested shade nets strongly varies between 43 g/m² and 275 g/m². A higher shade factor within a similar series of shade nets increases the weight of the shade net since a denser fabric will need more material. A lower weight is more favourable during transport, while a denser shade net has a better performance; therefore, a compromise must be found.

Shade nets based on round filaments are generally heavier than shade nets made of flat tapes (for the same shade factor).

2.2 Tear strength

According to the IFRC specifications, shade nets should withstand tear strengths of 100 N. Only 5 out of the 24 tested shade nets (ISO 4674-1B (2003)) comply with the specs and all 5 nets have a weight that is superior to 160 g/m².

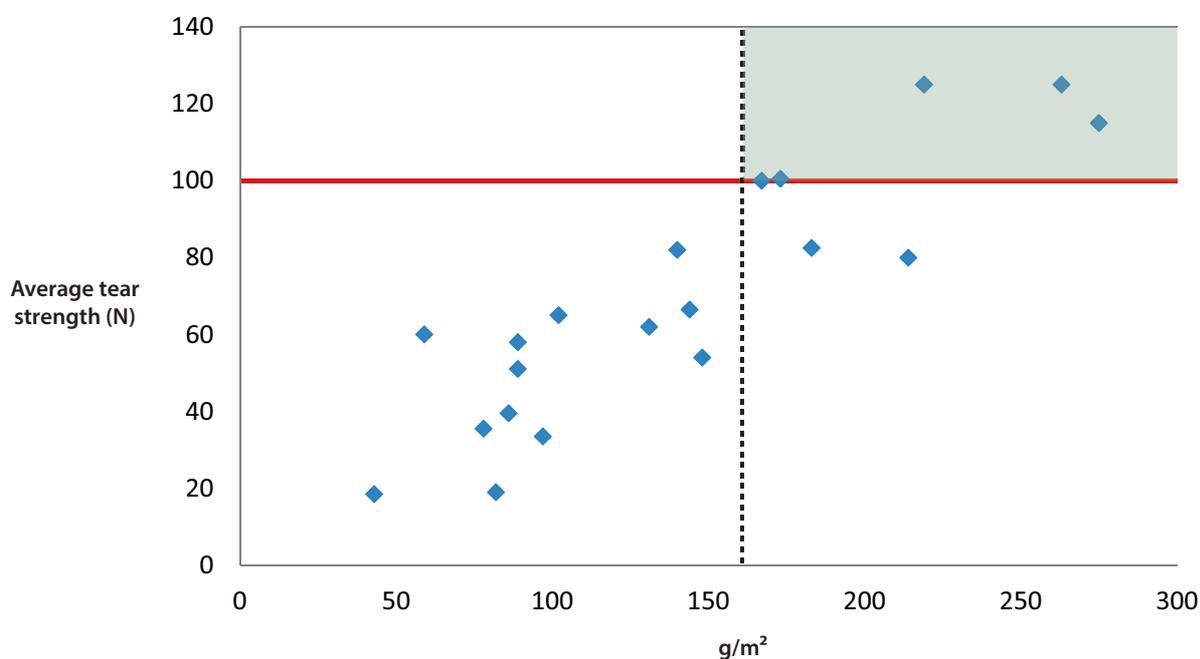


Figure 7: Correlation between the weight of the shade net and tear strength

Shade nets are manufactured in different ways (see pictures of the examined shade nets on page 14). Four major classes can be distinguished:

- round filament structure
- flat tape structure
- flat tapes held together by a knit of round filaments
- woven mesh structure

The influence of the structure is shown in Figure 8. The woven mesh structure has the highest tear resistance. For the other shade nets the correlation between the structure and tear strength is less obvious. If no technical data is available, it is advisable to select round filament shade nets, for they are most likely to have the best tear strengths.

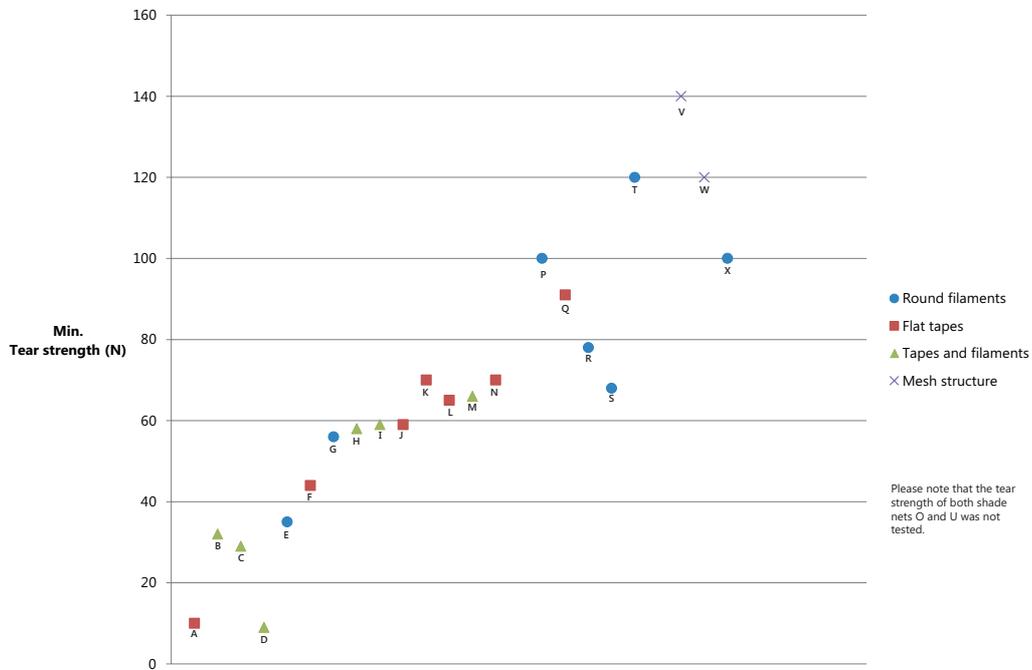


Figure 8: Correlation between shade net structure and tear strength (A-X see page 14: overview all 24 tested shade nets)

MAIN FINDINGS

- In general, the tear strength of most shade nets differs but slightly in length and width directions. Only one of the tested shade nets is equally strong in both directions. WARNING: some shade nets can only withstand 1/3 (!) of the strength in the width direction compared to the length direction.
- Shade nets with a weight superior to 160 g/m² typically comply with the minimal tear strength requirement of 100N. Lighter weight shade nets usually have a poor tear strength in at least one direction. As a rule of thumb, it can be stated that the higher the weight of the shade net, the less it is prone to tearing. This correlation is depicted in Figure 7.
- Shade nets with a woven mesh structure (e.g. shade nets 'V' and 'W') are more resistant to tearing and show a rather comparable behaviour in both directions.

2.3 Tensile strength

The tensile strength of the shade nets is evaluated according to ISO 1421-1 (1998-). Figure 9 depicts the minimal tensile strength measured in one of both pulling directions (length - width). Half of the investigated shade nets do not comply with the IFRC requirement of 450N.

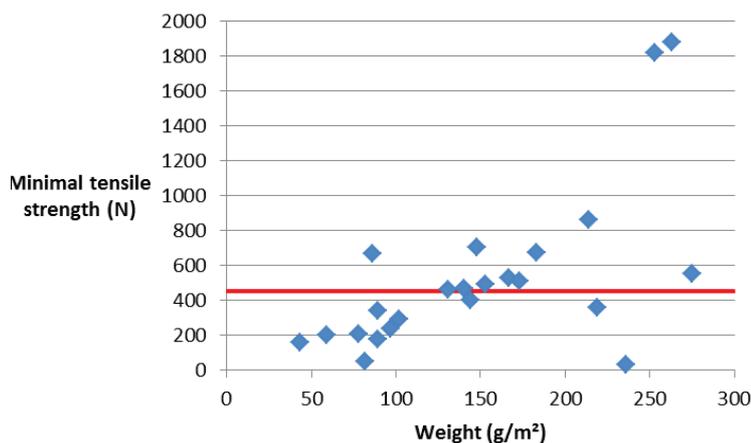


Figure 9: Correlation between the weight of the shade net and tensile strength

Round filament shade nets are in general stronger than flat tape ones. Woven mesh shade nets are by far superior to the other structures.

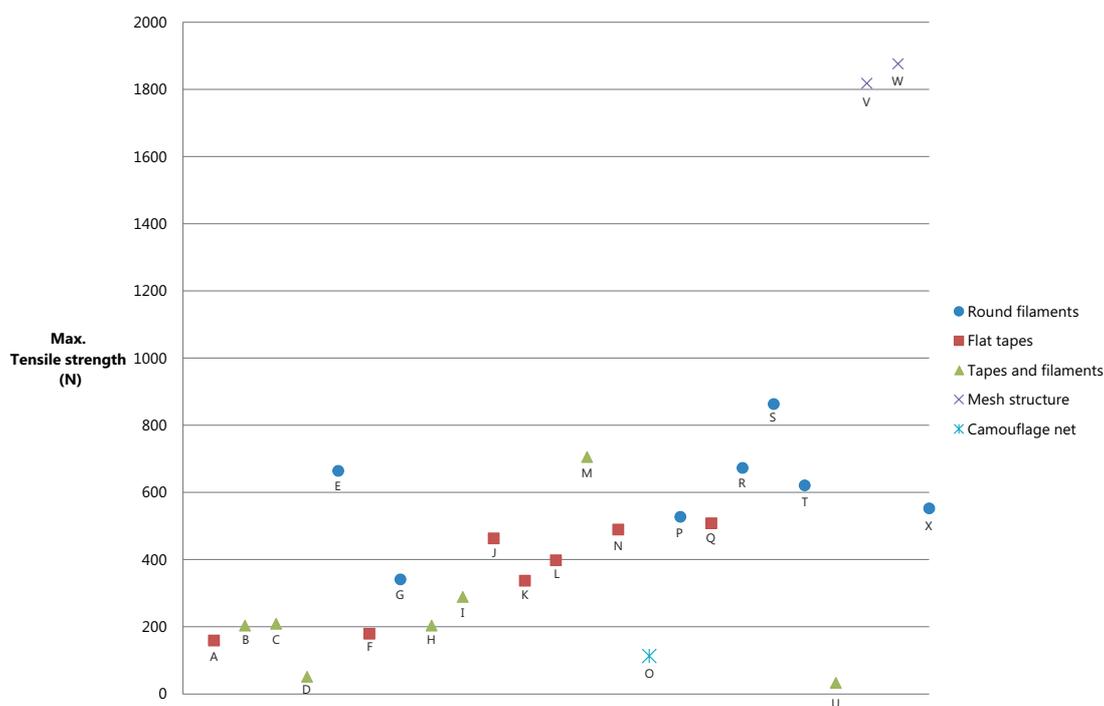


Figure 10: Influence of the construction of the shade net on the tensile strength (A-X see page 14: overview all 24 tested shade nets)

MAIN FINDINGS

- As a rule of thumb, higher weight shade nets are stronger and have a higher tensile strength. Nevertheless, great strength differences can be found in the direction of pulling.
- In many cases, the tensile strength in one or both directions is insufficient to pass the IFRC requirement of 450N (see Figure 9). When the shade net is made of round filaments only, the length direction is the weakest one. In the case of higher weight shade nets of this type, additional strength is obtained only in the width direction. These findings must be taken into account in the field when the shade net is attached to a structure.
- Shade nets with a woven mesh structure (e.g. shade nets 'V' and 'W') are the strongest ones and show quite comparable strengths in both directions. Shade nets from round filaments are generally slightly stronger than the flat tape ones.

2.4 Resistance to ageing

The shade nets are aged by means of heat, light and humidity (ISO 4892-3 (2006)). UV-light, which is part of the solar spectrum, is the most damaging for materials. During the test procedure, the samples are irradiated with 1500 hours of UVB-light which should give an estimation of the deterioration of the fabric during a 6 months use in the field. This deterioration is assessed by performing the tensile strength test following the ageing process.

The lifespan of a shade net can be prolonged by adding UV-stabilisers in the polyethylene filaments and tapes during the production process. The more additives are added, the longer the material will last. UV-stabilisers have no real impact on the weight of the shade net since they are imbedded in the fibre itself and neither will they have a negative influence on the recycling of the material. However, the more UV-stabilisers are added, the more expensive the shade nets will be.

Half of the tested shade nets fail the ageing criterion. They all lose more than 50% of their original strength after exposure to UV-light. Whether the stabilisers are added or not cannot be seen or felt. Most likely, the cheapest materials will contain less UV-stabilising additives. Therefore, at the procurement stage one should pay attention to (and get proof of) the expected lifespan of the shade net.

2.5 Burning behaviour

Because shelters in a refugee camp tend to be placed in close vicinity to each other, fire safety is an important issue. Therefore the burning behaviour of the shade nets is assessed (ISO 15025). It is important that the shade net does not catch fire, and if it does, that no molten or flaming debris is formed that will spread the fire.

For safety reasons, the best choice is a flame retardant fabric. These shade nets do not ignite in the presence of a flame. The non-flame retardant treated shade nets ignite mostly at the edges. Once the shade net does ignite, it is accompanied by molten and flaming debris. None of the shade nets has an afterglow.

It is impossible to see or feel whether FR additives have been added since they are imbedded in the polymer matrix of the tapes or yarns. As a result, the weight of the shade net will not be negatively influenced. Normally, a flame retardant quality will be more expensive than the non-flame retardant version. Therefore, at the procurement stage one should pay attention to (and get proof of) the FR properties.

2.6 Conclusions on shade nets

The study of the different shade nets pointed out that there is a **great variety in physical properties** between the tested shading materials. Large differences in the tensile/tear strengths and burning behaviour are shown. **In general, the higher weight shade nets are the ones with the best tear resistance and tensile strength. To prevent fire spread in the refugee camp, it is important to purchase a flame retardant quality.**

The **life span** of the different shade nets also varies to a great extent and corresponds with the purchased quality (the more UV-stabilisers are added, the longer the life span will be).

In general it can be stated that the best thermal performing shade nets (creating the lowest temperature rise in a shelter) are the ones allowing only a low transmission of heat through the shade net. No correlation is found with the reflective properties of the net.

Black shade nets (high absorption of heat) and dense aluminised ones (high reflectivity) have a low heat transmission and are therefore the best options to use. It must be mentioned that a ventilation gap between the shade net and the shelter is especially important when a black shade net is chosen since it absorbs a lot of heat!

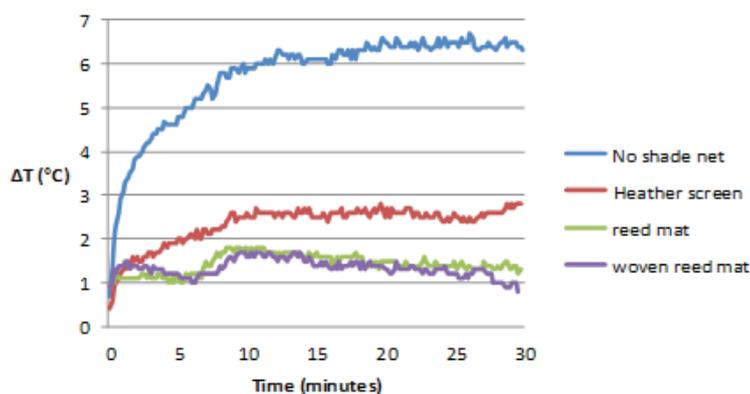
Within the same series of shade nets (made from the same material) a good correlation can be found between the light transmittance and the recorded temperature rise. The more the light passes through the shade net, the more the heat will pass through as well. To have a good shading effect, a shading factor of at least 50%, but preferably higher (70% - 80%), should be used.



3. EVALUATION OF VEGETAL MATS

In the field, a lot of locally available material is used to cover the shelters as an alternative to shade nets.

A woven reed mat blocks all light and therefore has the best thermal performance. This shading effect is at the same level as the one of synthetic shade nets. The thermal performance of the reed mat is quite similar and it also has a very low light transmittance (6%). Although a heather screen is more advantageous to light transmission (32%), it has a poorer thermal behaviour.



Heather screen



Palm leaves



Reed mat



Woven reed mat

To evaluate the palm leaves, 2 branches were put on top of each other, in a 90° angle. The more branches are stacked, the lower the light transmittance will be. This results in a higher thermal performance. Fresh leaves will also have a better light blocking effect as the leaves will tend to shrivel up in time.

The thermal performance of locally available vegetal materials is as good as the best shade nets and they can thus be used as an alternative. The higher light blocking effect of some materials, such as the woven reed mat, must be taken into account when light is needed in the shelter/shade area. Furthermore, the ventilation will decrease when using a more closely structured mat.

The burning behaviour was determined according to ISO 15025. The heather screen and the reed mat ignite easily and are completely burned after the test. The woven reed mat, on the other hand, shows another burning profile: it has a reduced burning time (flame formation) but it has a very long afterglow effect. All these natural materials have this afterglow time, which is not the case with synthetic shade nets.

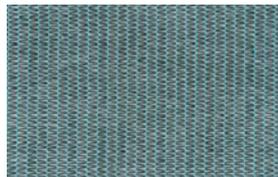
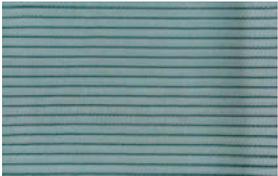
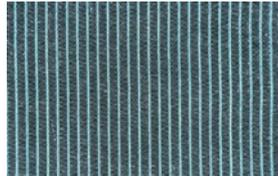
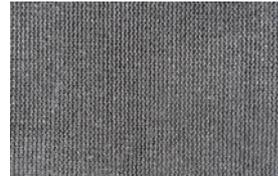
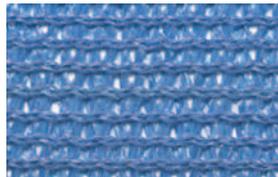
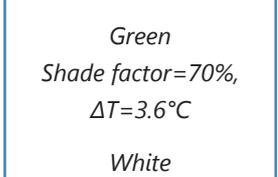
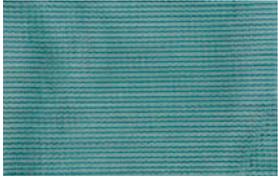
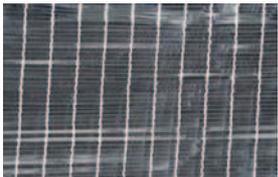
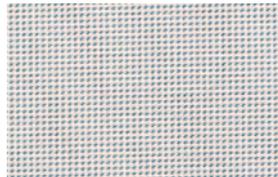
Experience from the field reveals that vegetal mats must be replaced after every rainy season, so their life span is quite limited. Vegetal mats are also much heavier than synthetic shade nets, so attention has to be paid to the fixation of the materials.

Since these materials will only be purchased locally, their origins should be checked since frequent use of specific materials could lead to deforestation or interfere with the needs of local inhabitants.

Conclusions on vegetal mats

Although the vegetal materials will provide the same shade/cooling factor, the synthetic materials are superior because they weigh less, block the light to a lesser degree, have a longer life span and because they can be made fire retardant.

4. OVERVIEW OF ALL 24 TESTED SHADING NETS

				
A) 43 g/m ² Shade factor=70% $\Delta T = 3.3^{\circ}\text{C}$	B) 59 g/m ² Shade factor=70% $\Delta T = 4.1^{\circ}\text{C}$	C) 78 g/m ² Shade factor=50% $\Delta T = 4.1^{\circ}\text{C}$	D) 82 g/m ² Shade factor=50% $\Delta T = 4.4^{\circ}\text{C}$	E) 86 g/m ² Shade factor=40% $\Delta T = 4.3^{\circ}\text{C}$
				
F) 89 g/m ² Shade factor=70% $\Delta T = 3.3^{\circ}\text{C}$	G) 89 g/m ² Shade factor=30% $\Delta T = 5.3^{\circ}\text{C}$	H) 97 g/m ² Shade factor=75% $\Delta T = 2.5^{\circ}\text{C}$	I) 102 g/m ² Shade factor=70% $\Delta T = 3.4^{\circ}\text{C}$	J) 131 g/m ² Shade factor=80% $\Delta T = 2.6^{\circ}\text{C}$
				
K) 140 g/m ² Black Shade factor=80%, $\Delta T=2.1^{\circ}\text{C}$ Green Shade factor=70%, $\Delta T=3.6^{\circ}\text{C}$ White Shade factor=65%, ΔT =4.0 ^o C	L) 144 g/m ² Shade factor=70% $\Delta T = 3.5^{\circ}\text{C}$	M) 148 g/m ² Shade factor=65% $\Delta T = 1.8^{\circ}\text{C}$	N) 153 g/m ² Shade factor=80% $\Delta T = 3.5^{\circ}\text{C}$	O) 166 g/m ² Shade factor=60% $\Delta T = 4.1^{\circ}\text{C}$
				
P) 167 g/m ² Shade factor=50% $\Delta T = 4.4^{\circ}\text{C}$	Q) 173 g/m ² Shade factor=95% $\Delta T = 1.7^{\circ}\text{C}$	R) 183 g/m ² Shade factor=50% $\Delta T = 3.9^{\circ}\text{C}$	S) 214 g/m ² Shade factor=65% $\Delta T = 3.3^{\circ}\text{C}$	
				
T) 219 g/m ² Shade factor=65% $\Delta T = 4.1^{\circ}\text{C}$	U) 236 g/m ² Shade factor=70% $\Delta T = 1.3^{\circ}\text{C}$	V) 253 g/m ² Shade factor=80% $\Delta T = 4.0^{\circ}\text{C}$	W) 263 g/m ² Shade factor=75% $\Delta T = 2.0^{\circ}\text{C}$	X) 273 g/m ² Shade factor=75% $\Delta T = 3.2^{\circ}\text{C}$

ΔT : recorded temperature rise inside a closed volume covered by the shade net (Centexbel inhouse method)



SPEEDKITS



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Shade net comparison on Standard Family Tent

More information on the evaluation of shade net performances in real conditions: see annex to this document.

More information on the project: <http://www.speedkits.eu>

General project information:

The project started in March 2012 for the duration of 4 years.

The S(P)EEDKITS project has received funding from the European Union's Seventh Framework Programme (FP7) under grant agreement n° 284931.



Het Nederlandse  Rode Kruis

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ANNEX

Shade net comparison on Standard Family Tent in Burkina Faso

Context

In the spring of 2012, Burkina Faso was confronted with a massive influx of refugees from Mali.

At the beginning of 2013, the Burkina Faso Red Cross (BFRC) and the Luxembourg Red Cross (LRC) identified a large need of shelters in the Sag Nionio refugee camp. A first assessment in the spring of 2013 highlighted extremely high temperatures in the standard family tents that had been distributed. The LRC operational department charged IFRC-SRU to assess, with the support of the Speedkits project, the value of adding a shade net on the tents.

The refugees are not only confronted with shelter and food problems, but they are also exposed to climate related hazards. According to the regular weather patterns, they will face heavy rains hitting an almost impermeable ground, as well as extreme heat.

In addition, the "Harmattan", a hot, dry and dusty wind coming from the Sahara affects Burkina between late November and early January.

The first observations revealed that the distributed tents were not very suited to the local weather conditions. The material the tents are made from and the lack of ventilation, caused the inside temperature to rise beyond the tolerable maximum and failed to provide a minimum of thermal comfort.

Research

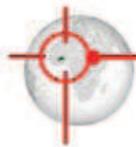
In November 2013, the efficiency of a "shade net kit" proposed by a standard family tent supplier is measured and compared with an alternative shade net solution, based on an agricultural net. Both approaches will be installed on a standard tent to observe the shade net impact.



*Burkina Faso
20km north of Ouagadougou in Sag Nionio
camp*



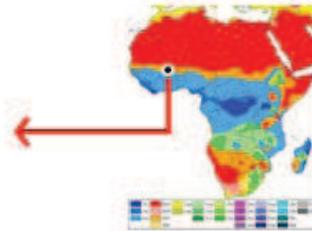
*1- Refugee camp
Lat: 12°32'23.22" N
Long: 01°27'40.61" O
Alt: 287m
2- IFRC-SRU test site*



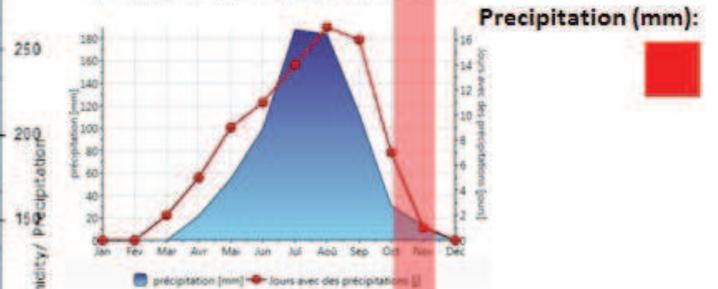
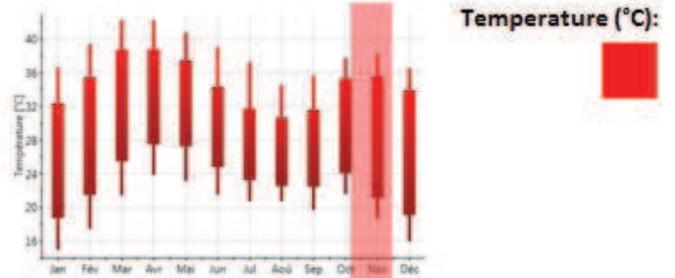
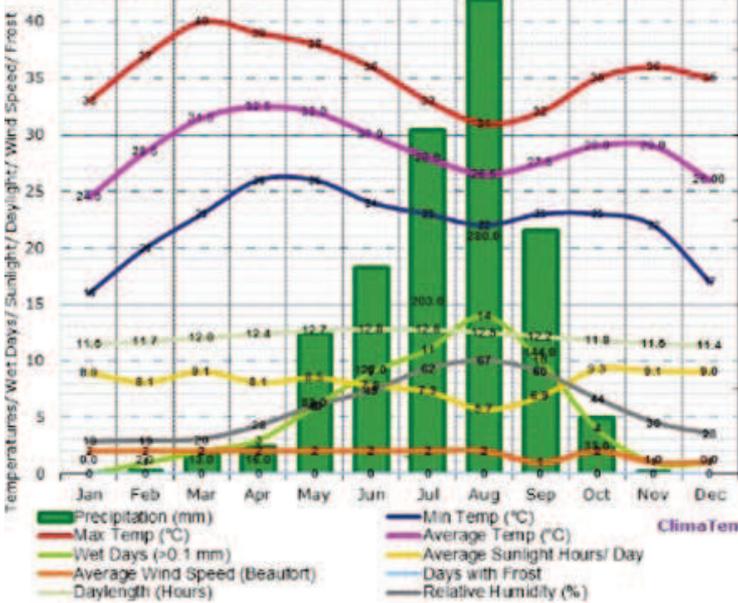
Burkina Faso
Ouagadougou
Weather data station

12°21'N
01°31'W
316m

Koppen-Geiger = **Aw**
Tropical very dry climate
(with a wet season)
Savanna Climate



average annual temperature	29 °C
Average monthly temperature vary by	8 °C
Annual precipitation average	897mm (897 litr./m2)
Sunshine average per year	3031 h



Nov.



Shade net investigations - Temperatures observed



Note: all the tents were completely closed and the loggers were fixed at the same height (1m) in each tent

1



SFT Model following the EIC specifications



2



Shade net option:

- HDPE monofilament
- Weight = 185 gr/sm
- Shade factor = 70 to 80 %
- Color = Black

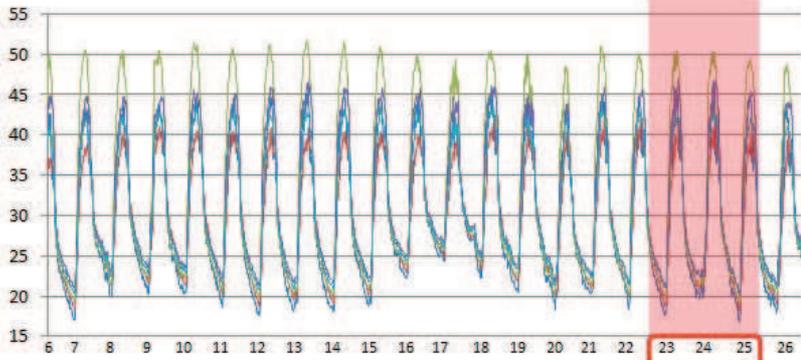


3

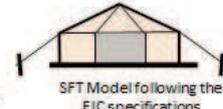


Shade net option:

- HDPE flat filament
- Weight = 85 gr/sm
- Shade factor = 80 %
- Color = strong green



- temp ext non protégée (°C)
- temp ext protégée (°C)
- standard tent / without shade net
- standard tent / with shade net 1
- standard tent / with shade net 2



SFT Model following the EIC specifications

1



1 Shade net option:

- HDPE monofilament
- Weight = 185 gr/sm
- Shade factor = 70 to 80 %
- Color = Black

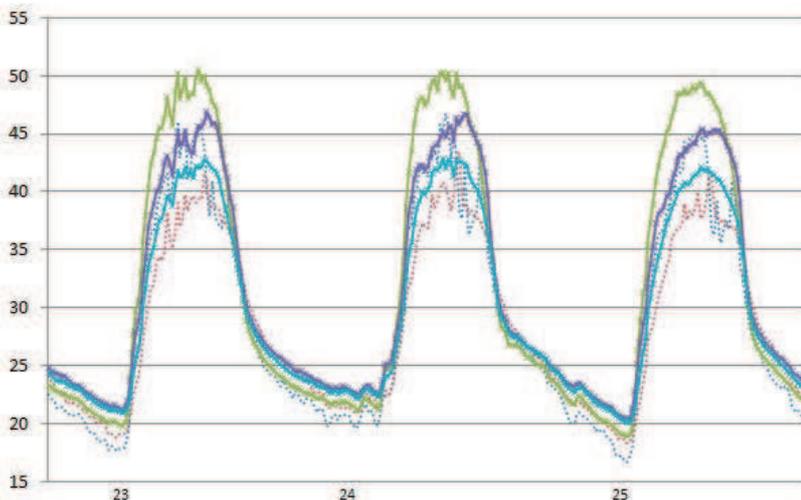
2



2 Shade net option:

- HDPE flat filament
- Weight = 85 gr/sm
- Shade factor = 80 %
- Color = strong green

3



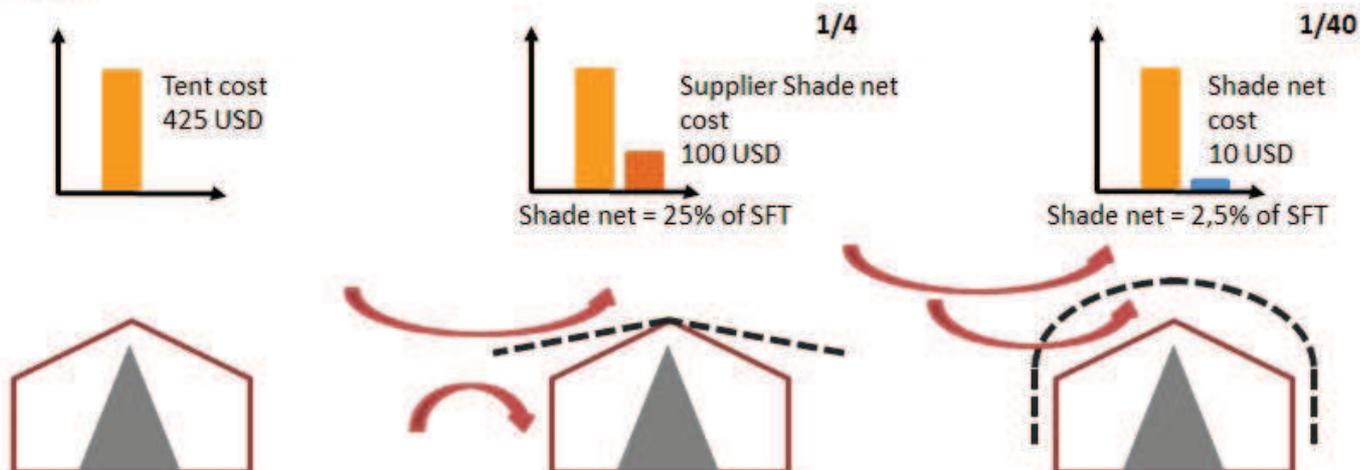
Comments:

- Max. temp. = 24 Nov. at 12am with 46,8 °C
- External loggers
- * daytime: non protected loggers is always higher
- * nighttime: protected loggers always lower
- The highest temp from a tent record is corresponding to the highest temp in SFT
- The SFT without shade net is cooling faster than the tents with shade nets
- at mid night a difference of ± 3,5°C
- Shade nets are really effective with a better impact for the field made option (higher and more ventilated)

Relation between efficiency and prize



Prize impact



This field test highlighted the efficiency of shade nets in drastically improving the thermal behaviour of the standard tent structures.

MAIN OBSERVATIONS & RECOMMANDATIONS FOR USE

- Shade nets improve the thermal behaviour of tents by significantly decreasing the inside temperature.
- It is necessary to maintain a ventilation gap between the tent and shade net. Ventilation has a high influence on the heat stress reduction in covered spaces in general which is also noticeable underneath shade nets. The experiment was carried out on two identical family tents covered by a shade net (with identical orientation and wind interaction) but with a different configuration (1: shade net on top of the ridge with a small air gap; 2: shade net configuration with a large ventilation gap). Temperature measurements showed that the inside temperature is drastically lowered by implementing a larger air gap between the tent structure and the shade net.
- The alternative solution is much cheaper and offers better results.

The positive effect of the shade nets on the inside temperature has been clearly demonstrated. Although the materials that have been examined differ in price (from 0.23 euro to 3.65 euro/m²), a higher cost price does not necessarily mean that the material has a better thermal performance. The shade nets that are commonly used by humanitarian organizations cost 0.70 euro/m². The present study has proved that the thermal performance of this material is good and can therefore be used as a reference value. Moreover, additional materials to anchor and stabilize the shade nets needed in function of the climatological circumstances represent the major cost.
- The shade net accumulates heat during the day and slows down the cooling off in the evening.
- Good anchorage and wind stability are necessary.

The implementation of shade nets is a cost effective strategy to reduce the inside temperature, creating a more comfortable micro-climate underneath the covered space.

SPEEDKITS!



Sahel Shelter Solution implemented in Burkina and Niger
with the international support of the Luxembourg Red Cross and IFRCRU