DEVELOPMENT AND EVALUATION OF A TRAY TYPE PROTECTED CULTIVATION SYSTEM FOR FODDER CROPS

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PROJECT REPORT

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DECLARATION

We hereby declare that this project entitled "**Development and Evaluation of a Tray Type Protected Cultivation System for Fodder Crops**" is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship or other similar title of any other University or society.

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CERTIFICATE

Certified that this project entitled "**Development and Evaluation of a Tray Type Protected Cultivation System for Fodder Crops"** is a bonafide record of project work jointly done by Linsha C.P., Riyola George and Sreeduth S. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship to them.

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Riyola George

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Dedicated To All Passionate Farmers...

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SYMBOLS AND ABBREVIATIONS

cm	Centimetres
cm/cm^3	Centimetre per cube centimetre
°C	Degree Celsius
et al	and others
E	Evening
Fig.	Figure
g	Gram(s)
GI	Galvanised iron
hrs	Hours
i.e.	That is
inch	Inches
j.	Journal
KCAET	Kelappaji College of Agricultural Engineering and Technology
m	Meter

M	morning
m^2	Square meter
mm	Millimetre
ml	Millilitre
lph	Litres per hour
M.C	Moisture content
MS	Mild steel
N	Noon
No	Number
PVC	Poly vinyl chloride
RH	Relative humidity
sec	Second
Sl No	Serial number
T1	Top tray
T2	Middle tray
T3	Bottom tray
UV	Ultra violet

°	Degree
/	per
%	Percentage
′	Minute(s)
″	Second

INTRODUCTION

CHAPTER 1

INTRODUCTION

Agriculture plays a vital role in the lives of human and reasonably interspersed with the livestock production. It is regarded as the backbone of the economic system of a given country, especially in developing countries. In supplement to providing food and raw material, agriculture also provides employment opportunities to very large percentage of the population.

Currently our population has grown to seven billons and we are expected to be around 9.5 billion by 2050(UN, 2004, Gerber *et al*, 2011). By that time, the UN estimates that 80% of the world's population will be living in urban areas. More water, energy, land and food are needed to feed this growing population. If this situation is to be realistic in future, due to industrialization and urbanization increasing day by day around the world and population explosion, people will not have enough space, labour, arable land and time for cultivation of crops, especially fodder for livestock, which is required in bulk.

1.1 Urban agriculture

As a solution for the hazardous growth of population and human encroachment into the land resources, urban agriculture has been introduced. Urban agriculture can be elucidated as the growing, processing and distribution of food and non-food plant and raising of livestock, directly for the urban market both within and on the fringe of an urban area. These agriculture activities take many forms and occur at multiple scales in cities throughout the world, responding to the need and preferences of the urban residence. Growing evidence suggest that incorporating different types of agriculture technologies into the urban environment will greatly improve the sustainability of cities, particularly if these systems are designed to take advantage of the resources and markets available there.

1.2 Tray type cultivation system

Among the different urban agricultural systems, the evolution of the prodigious method of tray cultivation, which consumes less landscape and provides with a high yield per area, is widely chosen. The system includes the cultivation in trays, vertically stacked one above the other with a certain space between them.

- Tray cultivation enables marginal farmers and common man to cultivate food crops to suffice them and green fodder for their live stocks in their premises. The space is widely diminishing, that could be effectively used for cultivation. Therefore, tray cultivation, adopting the idea of vertical farming can be a potent system.
- Homestead cultivation would be widely encouraged by the effective method of tray cultivation.
- The method uses the same area for several harvestings thus eliminating the inputs such as crop, land preparation (tillage) and addition of precise amount of irrigational water is made possible. Hence, reduction of several losses of irrigational water and the cost can be achieved. The perception of tray cultivation can also be checked that the system is either worthwhile in protected cultivation structures.

1.3 Relevance in cultivation of fodder crops

The prominent sector, agriculture, in India has witnessed different phases of growth exponentially since independence. It was characterized by decrease in productivity and stagnant output during 1950s and early 1960s. New invention in agriculture technology introduced in the form of improved seed, fertilizer efficiently combined with irrigation has brought significant changes in the sector during 1970s, and 1980s.The level of crop production and input uses has increased tremendously. This has helped India to move from the state of food deficit to food secure country. Among remarkable changes that have taken place during these periods, India had reached a mature green revolution stage registering a respectable growth in crop production across regions and achieved white revolution by recording a significant growth in milk production. Crop economy continues to be a dominant sector contributing about three fourth of total agricultural income. Although animal husbandry and dairying are considered supplementary to crop production, they play important role in total agricultural economy. It is argued that the recent high growth in agricultural sector is mainly contributed by a respectable growth from the livestock sector.

Agriculture and animal husbandry in India are interlaced with the intricate fabric of the society in cultural, religious and economical ways as mixed farming and livestock rearing forms an integral part of rural living. The agriculture and livestock sector provide employment to 52% of the work force. India supports nearly 20% of the world livestock and 16.8% human population on a land area of only 2.3%. Therefore, the need of fodder cultivation is primary and supreme than other grain crops. The tremendous livestock population, the huge gap between the supply and demand for all types of animal food, the pre-occupation of a high percentage of land for food, fibre and cash crops leaving only about 4 per cent of the total cultivated area for fodder production, the highly deteriorated conditions of the natural grasslands due to overgrazing and faulty management for ages and general lack of interest on forage and fodder crops from farmers arising out of necessity for human food -all constituted a formidable and challenging situation. The need to work out the possibility of improving the fodder situation from a deficit to that of a required status and of improving the nutritional value is therefore an urgent need of the hour.

Table 1.1Supply and demand scenario of forage (in million tonnes)

Year	Supply		Demand		Deficit as% of demand (as actual)	
	Green	Dry	Green	Dry	Green	Dry
1995	379.3	421	984	526	568(59.95)	105(19.95)
2000	384.5	428	988	549	604(61.10)	121(21.93)
2005	389.9	443	1,025	569	635(61.96)	126(22.08)
2010	395.2	451	1,061	589	666(62.76)	138(23.46)
2015	400.6	466	1,097	609	696(63.50)	143(23.56)
2020	405.9	473	1,134	630	728(64.21)	157(24.81)

2025	411.3	488	1,170	650	759(64.87)	162(24.92)

Source: X Five-Year Plan Document, Govt. of India

Several hydroponic techniques in trays, placed vertically have already established by different dairies that had proved to be a revolt in the production of green fodder. A single area could be utilised to give yield for several seasons, in a confined, closed or open chamber. Hydroponic technique also favours the increase in feed quantity by including the consumable root mass. The crops of fast growth rate like maize, wheatgrass, barley, is allowed to grow particular height and then either the cutting is done for number of times or it is fed as a whole.

1.4 Why the wheatgrass is chosen?

By the after effects of urbanisation, followed by the environmental pollution has increased the rate of several acute and chronic diseases. The green sprouts and edible grasses can be admired for the solution of the effect. Cereal sprouts are believed to have a greater nutritive value than cereal grains and their products. Wheatgrass (*triticum aestivum*) is a good option selected for the cultivated crop as food and as the fodder. Wheatgrass is a tender small plant grown from wheat seed. It contains a powerful cocktail of antioxidants molecules and acts as anti-microbial agent. Its increased growth rate, and thus number of harvestings taken from a single input of crop, in addition to its nutritive quality made wheatgrass worthwhile.

1.5 Problems related with harvesting

Various harvesting method of fodder has been designed to take out the production but the cutting made using cutters in the case of vertical stacked trays is still an undetermined problem. Burdened process of its collection, individually from the tray requires the adoption of some cutting mechanism from the trays and collecting the demanded product.

Based on all the above facts this study has been undertaken to proceed and evaluate, the following objective:

- To develop a tray type protected cultivation system for fodder (wheatgrass).
- To compare the fodder growth in the developed protected tray type cultivation system to that from tray type cultivation system without protective covering.
- To fabricate a cutting mechanism for the tray type protected cultivation system.

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Agricultural science presently faces the most challenging objective to ensure continuous and enough supply of food for the growing human civilisation. Urban centres and cities, throughout the world have experienced substantial increase in population; this growth is accompanied with the change in food habits and rising concern for food quality and its quantity. Thus, steep increase in global trade and easy access to chemicals such as weedicides, pesticides etc. and technology has contributed to undesirable changes in agricultural system. Recent trend in agriculture has seen rise in organic agriculture due to the health consideration. Vertical farming shall help in meeting the food and other demands of rapidly growing urban population. Vertical farming will be worthwhile project because it replaces the thousands of crop fields by simple buildings structure, conserves water, and protects the food from weather anomalies.

2.1 Urban Agriculture

Hynes and Patricia (1996) analysed that urban agriculture can contribute significantly to the development of social connections, capacity building, and community empowerment in urban neighbourhood, most commonly through community gardening.

Brown and Bailkey (2000) concluded that the urban agriculture can contribute to environmental management and the productive reuse of contaminated land, including brown fields. Because of increased plant foliage, urban agriculture can reduce storm water runoff and air pollution, and can increase urban biodiversity and species preservation.

Kaufman and Bailkey (2000) conducted a study and reported that the urban agriculture can contribute to environmental management and the productive reuse of contaminated land, including brown fields. Because of increased plant foliage, urban agriculture can reduce storm water runoff and air pollution; can increase urban biodiversity and species preservation.

Gilhooley (2002) reported that the participants of who worked in an environment with plants 12% more productive was stressed than those who worked in an environment with no plants.

Bellows *et al.* (2004) conducted a study on health benefits of urban agriculture presents many economic opportunities for public health programming to improve nutrition knowledge, attitudes, and dietary intake.

Teig *et al.* (2009) suggested that urban agriculture can foster community building mutual trust sharing, feelings of safety and comfort and friends his that translate into a collective investment in the common good of a neighbourhood. It can also serve as an alternative vacant property reuse strategy to decrease or prevent crime, trash accumulation, illegal dumping, littering, juvenile delinquency, and fires, and as a catalyst for additional community development activities and positive place-based programs.

2.2 Protected cultivation

Nelson (1991) studied on issues involved in operating greenhouses for flower production. Following an introduction to the flower market in the USA, chapters cover greenhouse construction, heating, cooling, growing media, growing media pasteurization, watering, fertilization, alternative cropping systems, the role of carbon dioxide, light and temperature, chemical growth regulation, insect control, disease control, post-production handling, marketing and business management.

Mastalerz (1977) incorporated a vast amount of knowledge drawn from the USA and Europe and was of interest to growers and research workers who need to have an intimate knowledge of plants and their requirements. The interdependence of many factors is rightly stressed and the optimum characteristics of many components are given. The effect of environmental factors on flower crop including the greenhouse environment, temperature, solar and luminous radiant energy, gases, growing media, water, nutrient requirements and fertilization programs and growth regulating chemicals was examined.

Takakura (1988) reported that the area of protected cultivation in Japan is more due to reasons such as less sophisticated types of cultivation, better thermal insulation against long wave radiation. Plastic nets or films permeable to water vapour is becoming popular to protect against wind and rain damage, thereby improving the thermal environment.

Polat *et al.* (2010) examined the cultivation of grape cultivars in the open field and under protected cultivation and compared the studies. In protected cultivation, the effect of production sites on shoot development was greater than it was in the open field.

2.3Tray cultivation

B.E. Spencer *et al*. (1976) studied the seasonal growth and survival of experimental batches of European oyster and the Pacific oyster was followed in North Wales Survival was significantly better in tray nursery system for both species of oyster.

Nesmith and Duval (1997) had the research on the effect of container cell size (volume)on transplant growth and development, and concluded that by increasing transplant cell volume a potential yield increase often resulted. Plants raised in larger cells result in earlier yield; yield that favours extra-large size fruit, and often-greater overall yield. Studies reported that if the size of the container cell can affect crop yield, perhaps the construction of the transplant tray itself might be instrumental in affecting crop yield as well.

2.4 Mist irrigation system

Sanders *et al*. (1972) had a study on the influence of mist irrigation on potato growth and development and showed that during a high and moderate stress season misting maintained the haulm later into the season and increased the proportion of small and medium size tubers.

North and Brown (1983) reported that minimization of surface soil erosion can be achieved with mist nozzles enabling continuous high infiltration rates to be sustained, without premature ponding, over the period leading to saturation.

Sivanappan (1994) conducted research studies in India by various institutions and have indicated that water saving is about 40-80%. The yield increase is up to 100% for different crops by using micro-irrigation. Minimization of surface soil erosion can be achieved with mist nozzles enabling continuous high infiltration rates to be sustained, without premature ponding, over the period leading to saturation.

Burt (1997) reported that micro had an advantage of requiring less stringent filtration than drip because of the large and short paths of micro nozzles.

2.5 UV sheet

Carlos (2000) explained the functional significance and induction by solar radiation of ultraviolet-absorbing sunscreens in field grown soya bean crops. They found significant difference in UV penetration among cultivars with different levels of phenolic sunscreens in soybean is highly responsive to the wavelengths that are most affected by variations in ozone levels, and that they play an important.

Betriaz and Alberto (2007) found that ultraviolet-blocking materials act as a physical barrier to control insect pests and plant pathogens in materials in protected crops. UV –blocking materials have properties to filter the UV radiation (280-400) interfering with vision of insects and in consequence, their behaviour related with movement, host location ability and their population parameters. The exclusion of part of the UV radiation within the greenhouse environment has a dramatically incidence on insect orientation, movement and on the spread of insect –transmitted viral diseases. In the same way, the impact of UV-absorbing materials on population dynamics of natural enemies, pollinators and crop yields needs further investigation.

2.6 Wheatgrass as a food

Rajesh and Ramesh (2011) conducted studies on Triticum aestivum, freshly juiced or dried into powder for animal and human consumption and suggested that it provides chlorophyll, amino acids, minerals, vitamins, and enzymes. It neutralizes infections, heals wounds, overcomes inflammations and gets rid of parasitic infections. The three most important effects of wheatgrass on the human body are: blood purification, liver detoxification and colon cleansing. Wheat grass therapy is recommended for patients suffering from chronic diseases like asthma, atherosclerosis, Parkinson's disease, joint pains, TB, constipation, hypertension, diabetes, bronchitis, insomnia, eczema, sterility, haemorrhage, obesity and flatulence. It is also useful in the treatment of cancer.

Chakraborty *et al*. (2012) studied the anti-microbial effect of water extracts of fresh wheatgrass (triticum aestivum) at on the growth of bacterial strains (gram positive strains and gram-negative strains) and fungus, mostly food borne including pathogens. It was found to be effective against all the test organisms, and especially with gram-positive strains, being more sensitive than gram-negative strains. Significant differences were found among the microorganisms. The minimal inhibitory concentration (MIC) of the extract for each bacterial strain was studied by a gradient plate method.

Chauhan (2014) studied on wheat grass juice and found that it possesses anti-cancer activity, anti-ulcer activity, anti-inflammatory, antioxidant activity, anti-arthritic activity, and blood building activity. It has been argued that wheat grass helps blood flow, digestion, and general detoxification of the body. The presence of biologically active compounds and minerals with their antioxidant potential which is (derived from apigenin, quercetin etc.) is the reason for its quality. Wheat grass makes it more useful in various clinical conditions, involving haemoglobin deficiency and other chronic disorders ultimately considered as green blood.

Khan GM *et al*. (2013) reported that the antioxidant enzymes present in wheat grass helps rid of free radicals thus improving memory. Wheat grass containing antioxidant properties is anticipated to exert neuroprotective effects via the regulation of cellular homeostasis.

2.7 Need of fodder

The interactions between crop and livestock sectors are so complex that it would be difficult to separate out the contributions from each sector. The crop sector mainly provides fodder to livestock, while livestock supplies manure and draught power to crop sector. However, the interactions between crop and livestock sector has been weakening over time with the advent of new technologies, which has prompted mechanization of most of the agricultural operations. Change in cropping pattern from cereal to non-cereals-based crops has affected the availability of fodder. A few studies have attempted to analyse these relationships under the changing context of crop and animal management practices, and its implications for rural livelihood (Erenstein *et al,* 2007).

With the increase in per capita income and urbanization, the consumption of livestock products will continue to rise in the foreseeable future. Consequently, the demand for feed and fodder for feeding and fattening of livestock will also increase. There are already evidences of intensification of livestock production taking place, although at varied pace across different regions in India. Among others, human population density, urbanization, small size farms have positive and significant effect on the intensification of livestock production. Rise in intensification of livestock production may put pressure on the existing resource base. According to Dikshit and Birthal (2010), India’s livestock sector requires 855Mt of green fodder by the year 2020.

2.8 Wheatgrass as a fodder

Mckell (1972) showed that probably no single characteristic can be used as a measure of seedling vigour in grasses, a rapid germination rate, fast rates of root and top growth, a robust growth habit, and resistant to stress may be important indicators.

Khan *et al.* (2000) proposed that the antioxidant enzymes present in wheat grass helps rid of free radicals thus improving memory. Wheat grass containing antioxidant properties is anticipated to exert neuroprotective effects via the regulation of cellular homeostasis

Davis and Beacon (2003) reported that reduced water availability would reduce turgor and therefore growth rate. While resources such as water, carbon and nutrients are hardly consumed, they certainly have the potential to influence the growth rate of a plant.

Hendrickson *et al*. (2004) investigated on intermediate wheatgrass that provides high quality forage for hay and pasture in the Great Plains of North America but lacks persistence under grazing. They found the effect of grazing at early vegetative, mid-culm elongation, and boot stages on tiller persistence of three cultivars and five experimental lines of intermediate and pubescent wheatgrass.

Jim Kern (2012) pointed out that when a cow eats fresh sprouted fodder, it is eating digestive enzymes that are not present in dry hay or in grain. It is highly digestible and nutritious and stated out the main benefit of sprouted fodder in comparison to feeding grain, which comprises of improved protein, starch and sugar. Nearly all of the starch present in the grain is converted to sugar by sprouting, which is better utilized by the rumen than the dry grain.

Gupta *et al*. (2015) showed that forages with high field yields are important to sustain a profitable milk production system and found that wheat can be grown as a dual-purpose crop to mitigate the gap of fodder scarcity with little loss in grain production, but with overall maximum yield from total biomass. Also, by a digestion trial study, they showed that wheat fodder was very good in terms of nutritive value and intake point of view.

Peer (2017) had an investigation on forage production and feed quality of perennial wheat derivatives. Perennial cereals may offer a novel forage source in mixed farming enterprises while improving the sustainability of grain farming. Dry matter digestibility and energy content of all forages tested were high. All cereals had very high potassium to sodium and low calcium to phosphorus ratios, which indicated the need to provide mineral supplements to grazing animals to maintain growth rates and manage animal health disorders, similar to conventional grazing cereals. This paper discusses the role; perennial cereals could play in a sustainable expansion of the cropping zone in south-eastern Australia.

Ghazi *et al.* (2011) conducted studies to evaluate different forage crops for green fodder production and water use efficiency under hydroponic conditions. The experiment has been conducted under temperature-controlled conditions (24 ± 1°C) and natural window illumination at growth room of soilless culture laboratory, Arabian Gulf University, Manama, Bahrain. Values for green fresh yields were recorded for the wheatgrass produced was about, 552kg fresh matter/m^3.

2.9 Vertical farming concept

Doernach (1979) found that building protection is primarily by vertical gardens by reducing temperature fluctuation of the building envelope. Decreased temperature fluctuations reduce the expansion and contraction of building materials and extend the buildings life span.

Minke (1982) found that without greening, flat roofs were 50% more susceptible to damage after five years than slightly sloped roofs (5% slope). This was because water tends to cool instead of running off. If the drainage layer is not sufficient or if drainage roots become blocked, green roofs can cause some flat roofs to leak due to continuous contact with water or wet soil with insufficient drainage, the plants will also be susceptible to the impact of wide degrees of variability in the moisture content of the soil. For example, with too much water, the soil goes sour and the plants can drown or rot.

Baumann (1986) found that green walls could reduce wall temperature as much as 15ºF that results in significant air conditioning savings.

Mitchell (1994) conducted a study on bio regenerative life support system. The study found that an estimated $28m^2$ areas of intensively farmed indoor space is enough to produce food to support a single individual in an extra-terrestrial environment like space station or space colony supplying with about 3000Kcal of energy per day.

Fjeld *et al.* (1998) conducted a study on the effect of indoor foliage plants on health and discomfort symptom among office workers. The study showed that the plant reduces wind speed also they prevent dust with wet environments which created with their roots and leaves. By means of this event, plants bring about extinction to harmful microorganism with onsite sap and juice. Air quality improvement from plants has been shown to reduce coughs by 30% and dry throat and irrigation by 24% also; the plants clean the office air by absorbing pollutants in to their leaves and transmitting the toxin to their roots where they turned into food for the plant.

Evan (2004) suggested that the urban vertical farming is an application of controlled environment agriculture with ramification even beyond helping feed the world's projected nine billion in 2050. This is because how much better, it is than industrial agriculture, especially in these three ways: production efficiency, economic resilience and ecological sustainability. There are clear efficiency, resilience and environmental advantages of vertical farming over traditional agriculture. There are even more advantages like supplying vegetables with species- specific nutrients and environmental conditions; something only the precise controls of vertical farming allow. This means that no access compound will contaminate the plant and that nothing is wasted.

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2.9 Necessity in mechanization

Dogherty *et al.* (1986) carried out studies by employing static elements to support stems during cutting, using a relatively large clearance with a moving blade or blades and examined whether cutting speeds could be significantly reduced below velocity used in practice. Work was done to determine the effect of cutting speed, blade arrangement, clearance between static and moving elements, blade rake angle and blade sharpness. In addition, studies were made of restraint at the tops of stems, cutting of groups of stems and stem inclination and concluded that for stems rigidly clamped at the top, the specific cutting energy was markedly reduced. A group of stems required significantly greater specific energy and peak force than a single stem and highly inclined stems (at 70° to the vertical) that required critical speeds greater than 40 m/s.

Lian *et al.* (2001) had a study on improving grassland and grassland production. Therefore, the mechanical technology on grassland fencing, reseeding, and shallow ploughing and grassland improvement multi-purpose implements was to be made with great development. In the Ninth-five Year Plan period, the emphasis put on the development and mechanization on the field of the technology of the intensive artificial grassland and establishing grassland agriculture ecological system, improvement and reestablishment of degenerated grassland.

Schilling (2010) reported that cutting energy is related to the plant stems' physical and mechanical properties, type of cutting element and blade edge sharpness.

Arvind *et al*. (2012) analysed the work cutting of weeds in hill orchards is labour and time intensive. When performed with grass slasher or traditional dao through impact cutting, it consumed approximately 50% of total labour requirement for cultivation and thus a simple and low-cost reciprocating weed cutter was designed with a cutter bar width of specific dimension which only required a handle, frame, reciprocating cutter bar, tension wire, spring and two wheels.

Venkatesh *et al.* (2015) fabricated the grass cutting machine for the use of agricultural field, to cut the crops in the field with simple construction and its working unit was designed as follows: below the gear arrangement cutting blade is fixed. When the motor starts running by the use of power supply, it operates the sickle bar which tends to cut the plants or crops. The sickle bar has one is fixed cutter and another one is movable cutter which is placed on it.

MATERIALS AND METHODS

CHAPTER 3
MATERIALS AND METHODS

This chapter deals with the materials used and methods adopted for the project under the title "Development and evaluation of a tray type protected cultivation system for fodder crops" conducted in Kelappaji College of Agricultural Engineering and Technology, Tavanur, Malappuram, Kerala.

3.1 Location of study

The experiment was held in KCAET Tavanur in Malappuram district Kerala, situated at 10º52′ 30″ North latitude and 76º East longitude. The total area of KCAET is 40.99ha out of which total cropped area are 29.65ha. Agro-climatically the area falls within the borderline of northern zone and central zone of Kerala. Major part of the rainfall in this region is obtained from southwest monsoon. The area is having relative humidity is about 80%. The mean maximum temperature of the area is about 22ºC. The experimental study was conducted during November 2017 to January 2018.

3.2 Fabrication of tray cultivation structure

For the construction of the structure, mild steel tube of dimension of ¾inch ×3/4 inch was used. MS flat of ¾×1/8 were used as a seating for tray. UV polythene sheet of 200 micron were used as a covering material for the roof along with the sides of this structure. To supply the adequate quantity of irrigation water with minimum losses mist irrigation was chosen. The material required for fabrication of structure is shown in the table.

Plate 3.1 Square tube **Plate 3.2 Plug tray**

Table 3.1. Materials used for fabrication of tray cultivation structure

Material	Quantity
¾ inch square tube	24m
Velcro	1.6m
½ inch MS flat	3.24m
Metal primer	500 ml
UV sheet (200 micron)	5.5m^2

Table 3.2Materials required for irrigation system

Materials	Quantity
PVC pipe	4m
Laterals	3m
Micro tube	1m

Micro tube connector	6 no.s
Mist	6 no.s
Tap (16mm)	2 no.s
T connector	7 no.s
End caps	6 no.s

Table3. 3. Materials used for fodder cutting mechanism

Materials	**Quantity**
GI sheet	$0.07m^2$
Bush	1
8mm Thread rod	0.60m
3/4 ×1/8 MS flat	1m
Split pin	2
Rotating handle	2

Table3.4 Materials used for planting

Materials	**Quantity**
Tray (53cm×27cm)	6 no.s
Seed	140g
Soil cow dung mixture	3:1

The structure was built upon consideration of certain criteria such as height of the crop which is expected to be attained by the plant (say 15cm), density of vegetation after the growth, average height comfortable for the man to harvest, size of the tray used, etc.

3.3 Experimental setup

The tray cultivation structure was built in a dimension of 56cm×30cm. This structure consists of three tiers in which trays (propagation trays) are placed on the MS flat laid breadth wise. Each platform can admit 3 trays of size 53cm×27cm160×cm. The figure shows the fabricated tray farming structure with specified dimension. The height of each platform was designed according to height that may be attained by the crop used. The average height approximated for the fabrication of the levels of tiers is 50cm from the adjacent tray vertically.

Plate 3.3 **Plate 3.4**

Plate 3.3 Fabricated protected tray cultivation structure

Plate 3.4 Fabricated outdoor tray cultivation structure

Another structure with same dimensions was constructed by enclosing it using a UV stabilised polythene sheet. Suitable ventilation is also provided at the top of the structure. The Velcro, attached length wise to the front side of the structure, ensures opening and closing.

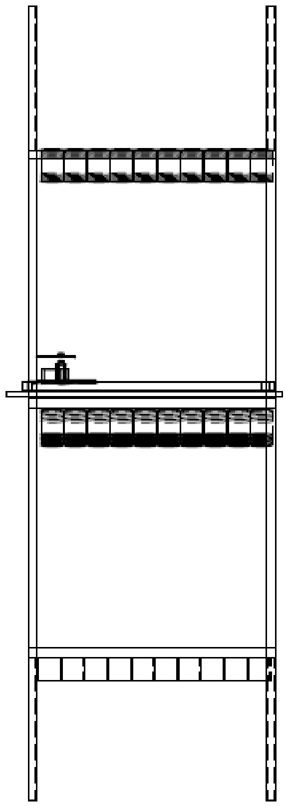


Fig 3.1.(a) Outdoor cultivation structure

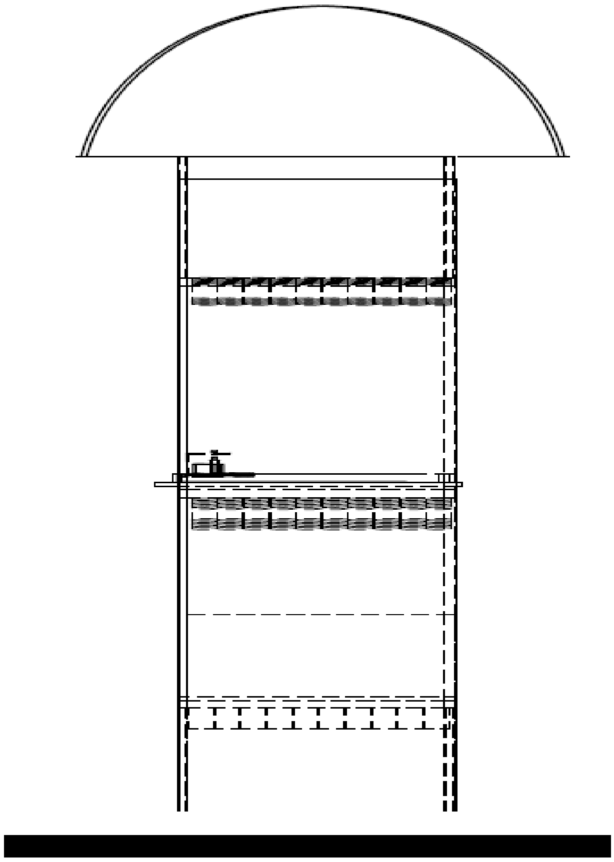


Fig3.1 (b) Protected cultivation structure

3.4 Cutter working mechanism

3.4.1 Cutting system

It consists of simple mechanism using the components such as rotating rod, cutter (blades). Arrangement works as the follows, and two cutters -one movable cutter and another fixed cutter. Movable cutter is operated by a slider crank mechanism, which is rotated by a handle. Here the handle works with the help of manual power. Rotation of handle initiates the rotation of driving beam, thereby enhancing reciprocating motion of the cutter. The cutter is moved forward, along the lengthwise of the tray with the help of rotating threaded screw. The threaded screw movement is commenced using another handle. The cutting system is placed 3cm above the tray and adjoined with the system. It is removable and a replaceable type system.

Plate 3.5 Fabricated fodder cutting mechanism suitable for tray cultivation

Fig 3. 2 (a) Fodder cutting mechanism (side view)

Major specifications considered in the design of cutting system are angle of the blade, thickness of the blade, length of screw thread and diameter of screw thread.

- Angle of the blade is 30°
- Thickness of blade is 0.5 mm
- Length of screw thread is 53 cm
- Diameter of screw thread for forward motion -9mm

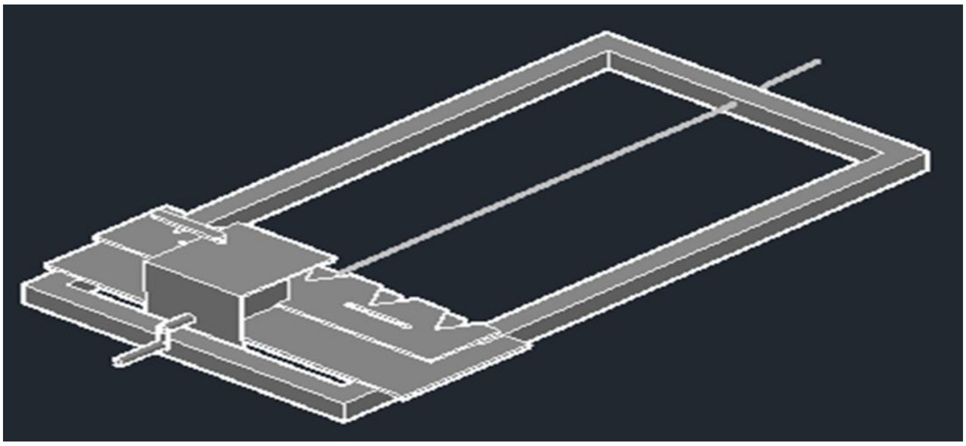


Fig 3. 2 (b) Fodder cutting mechanism (isometric view)

3.4.2 Collecting mechanism

The broadened bordered cutter bar mechanism made up of stainless steel sheet, placed along the three edges vertically, was used to collect the trimmed wheatgrass from the arrangement**.**

3.5 Installation of fabricated tray cultivation structure

Installation of the fabricated structures with and without polythene sheet enclosure was done on the north side of LH KCAET, oriented in the east west direction. Each structure had three trays placed individually on the platforms. The tray consists of 50 cells with a hole for draining purpose. The total weight of140g germinated wheat was equally distributed into 70g, which was used for planting in each structure. Individual tray contained one –third of the 70g. The trays were filled with soil and cow dung in the ratio 3:1.

3.6 Setup for irrigation

The mist irrigation system was chosen to irrigate the plants. The system only required light showers of irrigation water for its betterment and to reduce the water wastage. The water tank of LH KCAET was the major source of water, which existed at a height of about 10m from the ground level. The system worked under the force of gravity. The ball valve regulated the supply of water from the tank. This valve assembly supports the discharge through the PVC pipe of 5cm diameter. The water was applied to the plant by using the laterals and finally through micro tube. Each end of laterals was closed with the end cap for providing flushing of the line. The mists of 80 lph were installed above each tray.

Plate 3.6 Irrigation setup

3.7 Planting method

Selection of the crop was based on certain characteristics such as rate of growth, easiness in availability, nutritive benefits and fodder characteristics. Wheatgrass (Tritium aestivum) was thus selected for this study. Seed was allowed to remain in soaked position for 48hrs and left for sprouting. The arrival of tiny root and shoot indicated the stage of planting it in the tray. 70g individually in both systems were equally distributed by placing 5 seed per cell.

3.8 Irrigation application

Daily irrigation was given by mist irrigation method for 0.5min/day. The mist had a discharge rate of 80lph and the irrigation was given two times a day. This is to ensure uniform moistening of the soil. Enough drainage is made possible using the drain holes in the tray.

Plate 3.7Mist irrigation

3.9 Observation of climatic parameters

Climatic parameters such as temperature, relative humidity and light intensity were observed for morning, afternoon and evening for a period of 4 weeks during the month of November and December after the sowing of germinated seed.

The daily observations were collected and tabulated. The average values of observation of each climatic parameter were noted, and these values were used for plotting the graph.

3.10 Biometric observation

For determining growth parameters of the crops, crops from each tier of the stand were randomly selected from both stands. Biometric observations such as plant root density and weight were made after harvesting and plant height data once in a week.

3.10.1 Plant root length density (RLD)

RLD comprises the total length of all collected roots in a soil layer. The RLD is an important parameter to model water and nutrient movement in the vadose zone and to analyse the root-shoot interaction.

For the calculation of RLD, five different samples were randomly collected from each tray. After gathering the samples from the different trays, roots were separated from the soil. Plant root length density can be then calculated after measuring the length of root and determining the volume of the container holding the root. Root length density was calculated as follows:

RLD (cm/cm^3) =Root Length /volume of the container

3.10.2 Plant height

The height of randomly selected plants was measured from the surface of the rooting media to the tip of the plant in both the tray cultivation structure

3.10.3 Plant weight

The grass was trimmed from 3cm above the rooting surface and this was then weighed using a weighing balance.

3.11 Soil characteristics

3.11.1 Soil moisture content

Soil moisture was measured by collecting the soils from random cells of individual trays. The samples were placed in labelled cans and weighed straight away. It was then oven dried at 105˚C for at least 24 hours and then reweighed. Using the data, moisture content is determined, using the equation,

$$M.C\ (\%) = (W_2-W_3)/\ (W_3-W_1)$$

Where,

W_1= Weight of tin (g)

W_2=Weight of moist soil + tin (g)

W_3=Weight of dried soil +tin (g)

3.12Yield data

Harvesting of the wheatgrass was done twice with an interval of 15 days maturation after attaining a particular height. The first yield was taken about two weeks after planting.

RESULT AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

The study has been undertaken with the objective of fabricating a tray cultivation structure for homestead and to evaluate the performance of wheatgrass under protected cultivation and out door. The study was conducted from November 2017 to December 2017. The climatological data and biometric observations were taken from both structures. The results of the study are briefly discussed in this chapter.

4.1 Comparison of climatic data

Climatic parameters such as air temperature, light intensity and relative humidity were observed in the protected structure and the one without it. The daily observations were noted at 8:00am, 1:30pm and 5:00pm for a period of six weeks from November 2017 to December 2018 for the study.

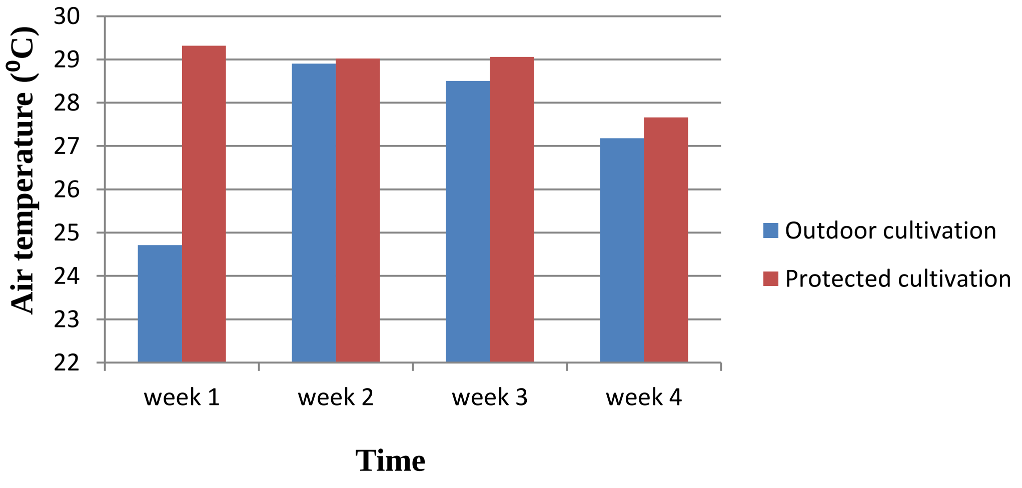
4.1.1 Air temperature

The weekly average values for air temperature was calculated for 8:00am, 1:30pm and 5:00pm from the daily data taken. Observations were taken using thermometer. The variations of air temperature at 8:00am in the two structures are shown in the fig.4.1. In the first week temperature of outdoor and protected cultivation seems to have wide variation and the rest of the weeks it varied reasonably. The maximum temperature measured in protected cultivation was about 29.32ºC and 28.9ºC in outdoor cultivation.

Table 4.1 Variation of air temperature in outdoor and protected cultivation at 8:00am

Time (week)	1st week	2nd week	3rd week	4th week
Outdoor cultivation	24.71	28.9	28.5	27.18
Protected cultivation	29.32	29.02	29.06	27.66

Fig 4.1. Variation of air temperature in outdoor and protected cultivation at 8.00am



Observations of air temperature at 1:30 pm are shown in fig.4.2. The variation was more during the first week than in the second third and fourth week. The minimum temperature in protected cultivation structure was found to be 34.59ºC and 33.53ºC in outdoor cultivation. The graph also indicated that maximum temperature in protected cultivation was 36.08ºC and in the case of outdoor cultivation was 35.6ºC.

Table 4.2 Variation of air temperature in outdoor and protected cultivation at 1:30pm

Time (week)	1st week	2nd week	3rd week	4th week
Outdoor cultivation	35.60	35.37	35.26	33.53
Protected cultivation	35.38	36.08	36.6	34.59

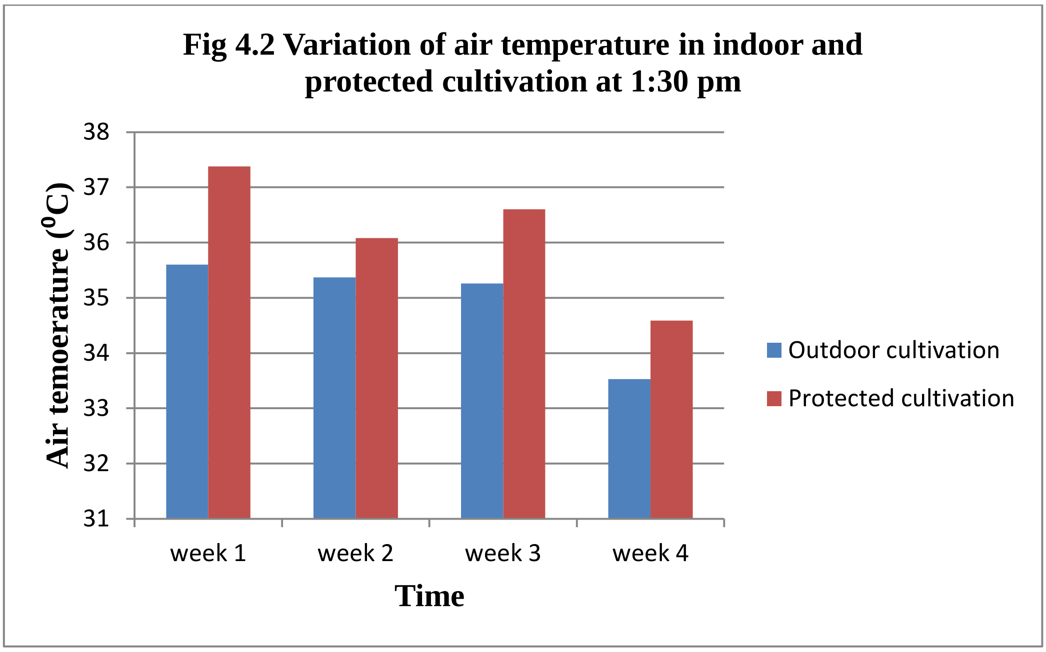
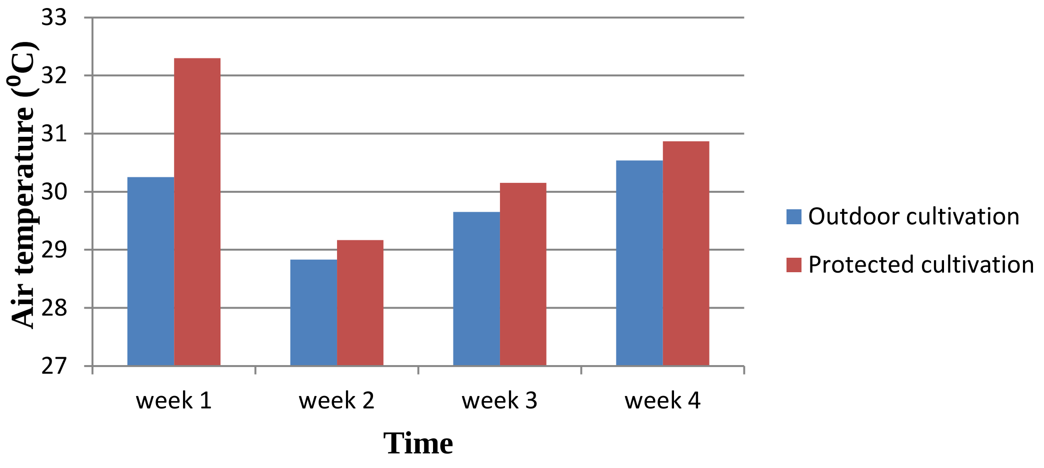


Fig.4.3 shows the air temperature of protected cultivation and outdoor cultivation structure at 5:00 pm, which denotes the difference in temperature in week 1 to be more than other weeks. The maximum temperature in protected cultivation structure was found to be 32.3ºC and 30.54ºC in outdoor cultivation. The minimum temperature in outdoor cultivation was 28.83ºC and 29.17ºC in protected cultivation.

Table 4.3 Variation of air temperature in outdoor and protected cultivation at 5:00pm

Time (week)	1st week	2nd week	3rd week	4th week
Outdoor cultivation	30.25	28.83	29.65	30.54
Protected cultivation	32.3	29.17	30.15	30.87

Fig 4.3 Variation of air temperature in indoor and protected cultivation at 5:00 pm

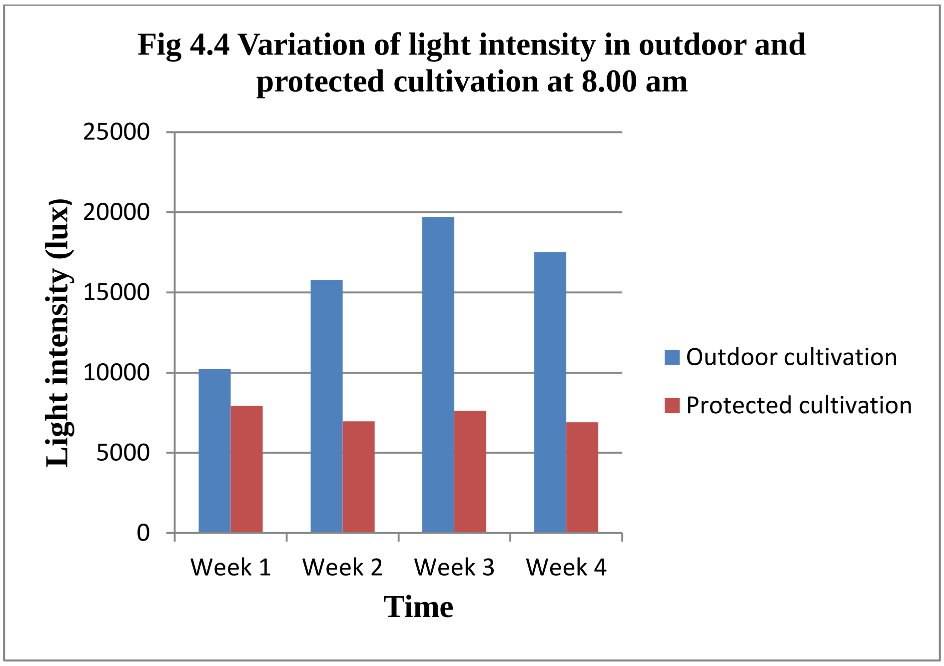


4.1.2 Light intensity

The weekly average values for light intensity was calculated for 8:00am, 1:30pm and 5:00pm from the daily data taken. Observations were taken using lux meter. The maximum light intensity was obtained in the outdoor cultivation. The variations of light intensity at 8:00am in the two structures are shown in the fig.4.4 The maximum light intensity in protected cultivation was found to be 7928.5 lux and 19701 lux in outdoor cultivation. The minimum light intensity was 6912 lux in protected cultivation and 10212.85 lux in outdoor cultivation.

Table 4.4 Variation of light intensity in outdoor and protected cultivation at 8:00am

Time (week)	1st week	2nd week	3rd week	4th week
Outdoor cultivation	10212.85	15787.14	19701	17503.3
Protected cultivation	7928.5	6960	7624.28	6912

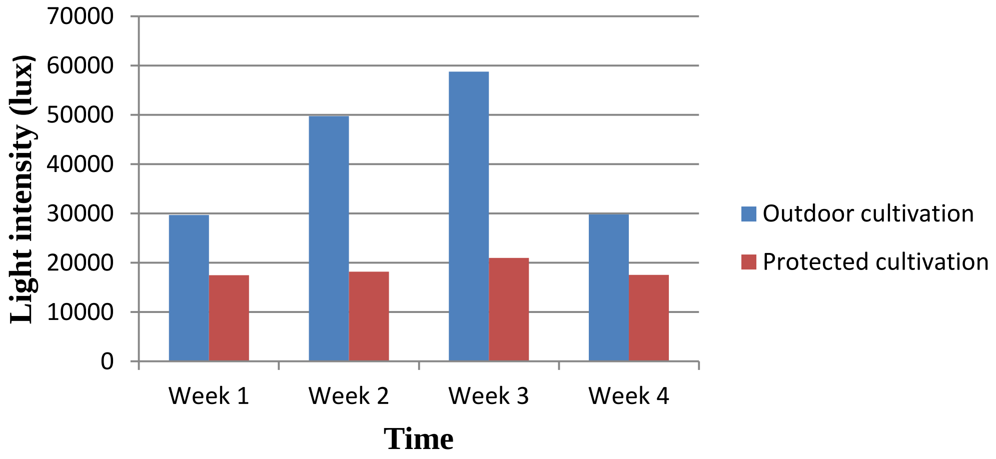


The variations of light intensity at 1:30 pm in outdoor and protected cultivation structures are shown in the fig.4.5. The maximum light intensity was observed during the third week. And it was 58744.28lux in outdoor cultivation and 20948.57lux in protected cultivation. The minimum light intensity in the outdoor cultivation was 29685.7 lux and 17444.28 lux in protected cultivation.

Table 4.5Variation of light intensity in outdoor and protected cultivation at 1:30pm

Time (week)	1st week	2nd week	3rd week	4th week
Outdoor cultivation	29685.7	49714.28	58744.28	29774.4
Protected cultivation	17444.28	18167.14	20948.57	17535.5

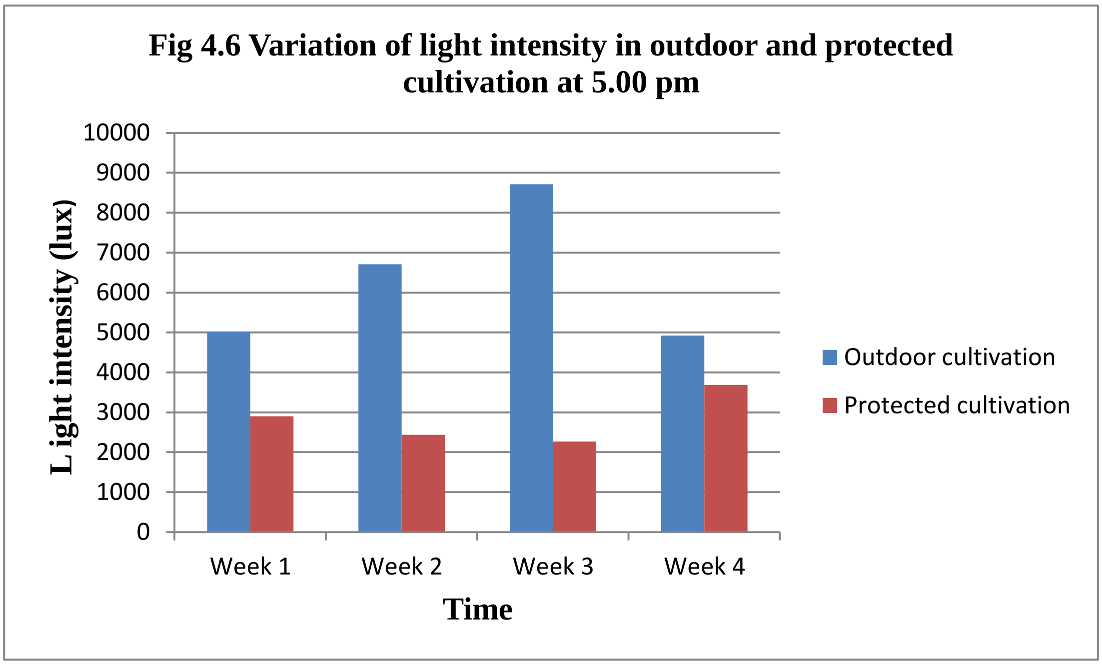
Fig 4.5 Variation of light intensity in outdoor and protected cultivation at 1:30 pm



Observations of light intensity at 5.00 pm are shown in figure 4.6. The maximum light intensity measured in protected cultivation was about 3688.8 lux and 8710 lux in outdoor cultivation. The minimum light intensity in protected cultivation was found to be about 2267.85 lux and 4924.4 in outdoor cultivation.

Table 4.6 Variation of light intensity in outdoor and protected cultivation at 5:00pm

Time (week)	1st week	2nd week	3rd week	4th week
Outdoor cultivation	5021.42	6705.71	8710	4924.4
Protected cultivation	2901.42	2434.4	2267.85	3688.8



4.1.3 Relative humidity

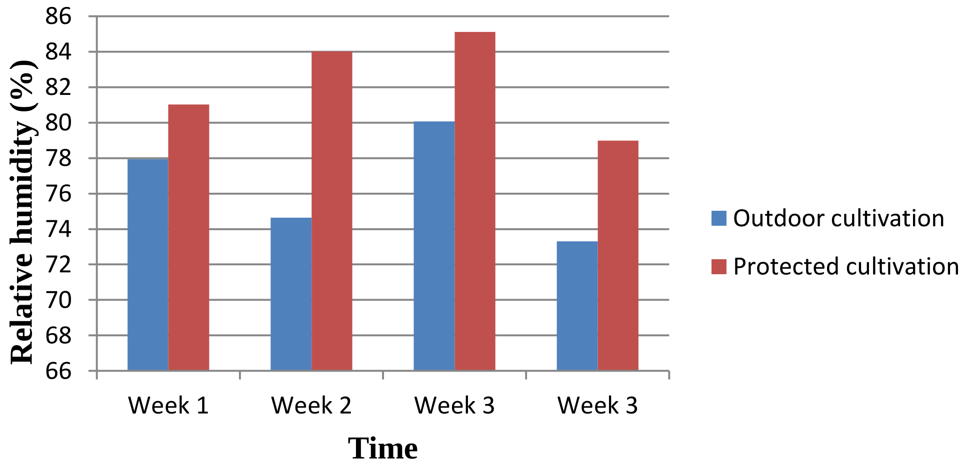
The relative humidity was recorded weekly for 8:00 am, 1:30 pm and 5:00 pm. And the average values are plotted in the graph. Observations were taken using temperature- humidity meter.

The maximum RH was obtained in the protected cultivation. The RH in the first week had comparatively less variation than in the other weeks the maximum RH obtained in the protected cultivation was 85.11% and the minimum RH was 78.98% during 8:00 am. The maximum RH obtained in the outdoor cultivation was 80.06 % and minimum RH was found to be 73.31%.

Table 4.7 Variation of relative humidity in outdoor and protected cultivation at 8:00am

Time (week)	1st week	2nd week	3rd week	4th week
Outdoor cultivation	77.94	74.64	80.06	73.31
Protected cultivation	81.01	84.01	85.11	78.98

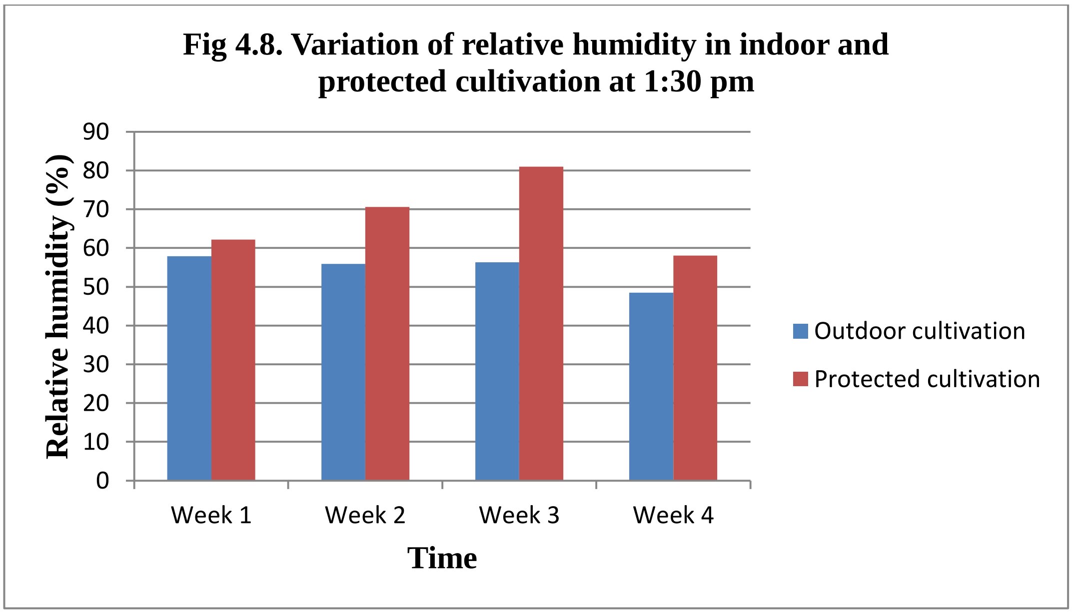
Fig 4.7 Variation of relative humidity in indoor and protected cultivation at 8:00 am



Among the observations taken, the first week indicated only a slight difference in RH as per the fig.4.8. shown. The maximum RH in protected cultivation was 81% and minimum RH was 58.05%. The minimum RH observed in the outdoor cultivation was 48.47% and maximum RH was 57.86%.

Table 4.8Variation of relative humidity in outdoor and protected cultivation at 1:30pm

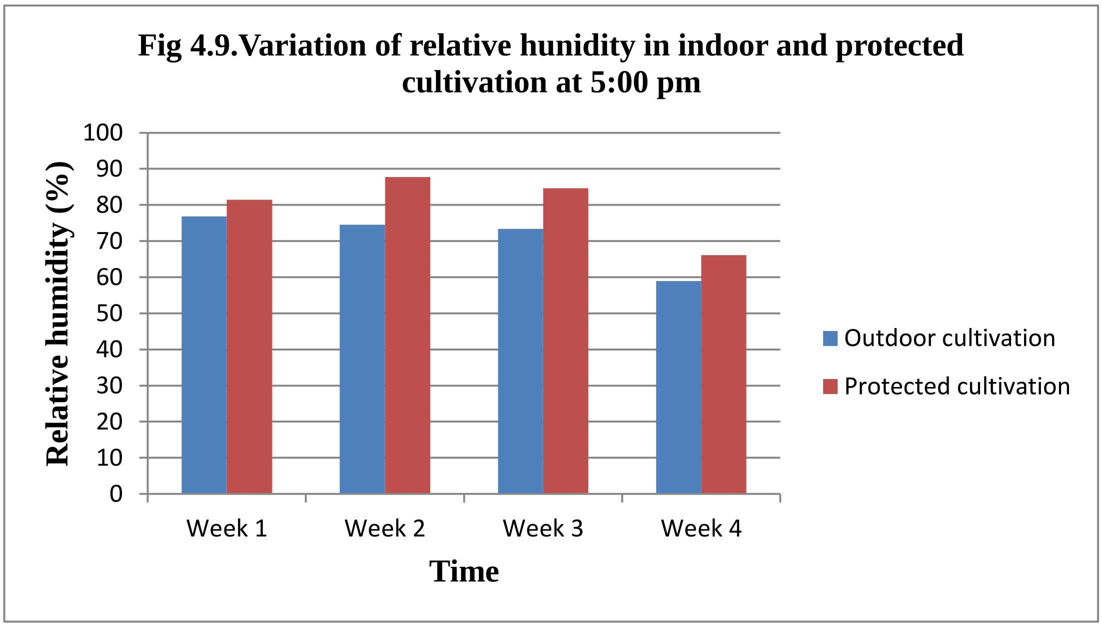
Time (week)	1st week	2nd week	3rd week	4th week
Outdoor cultivation	57.86	55.92	56.30	48.47
Protected cultivation	62.2	70.58	81	58.05



The fig.4.9 shows that the first week had a small difference in RH at 5:00pm than another week's observation. The maximum RH in protected cultivation was 87.7% and minimum was 66.15%. The maximum RH in outdoor cultivation was 76.8% and minimum was 58.96%.

Table 4.9 Variation of relative humidity in outdoor and protected cultivation at 5:00pm

Time (week)	1st week	2nd week	3rd week	4th week
Outdoor cultivation	57.86	55.92	56.30	48.47
Protected cultivation	62.2	70.58	81	58.05

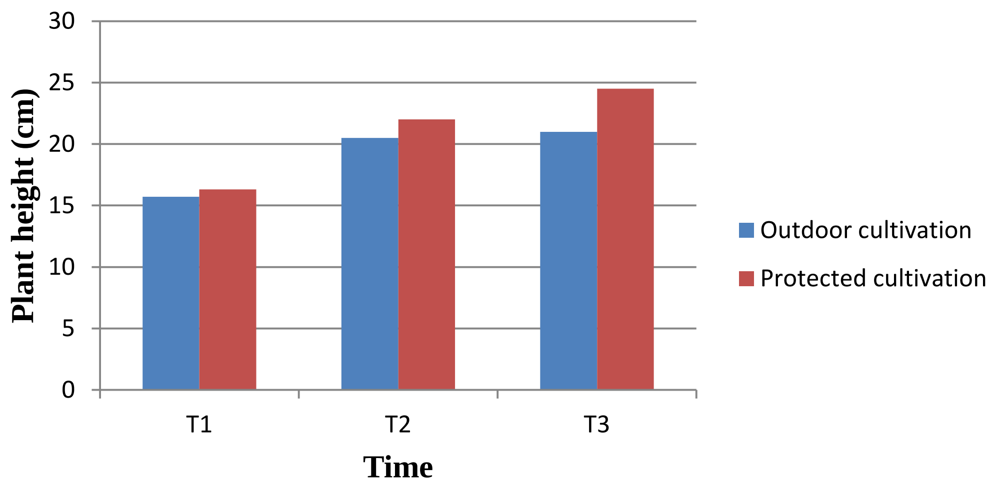


4.2 Biometric observation

4.2.1 Plant height

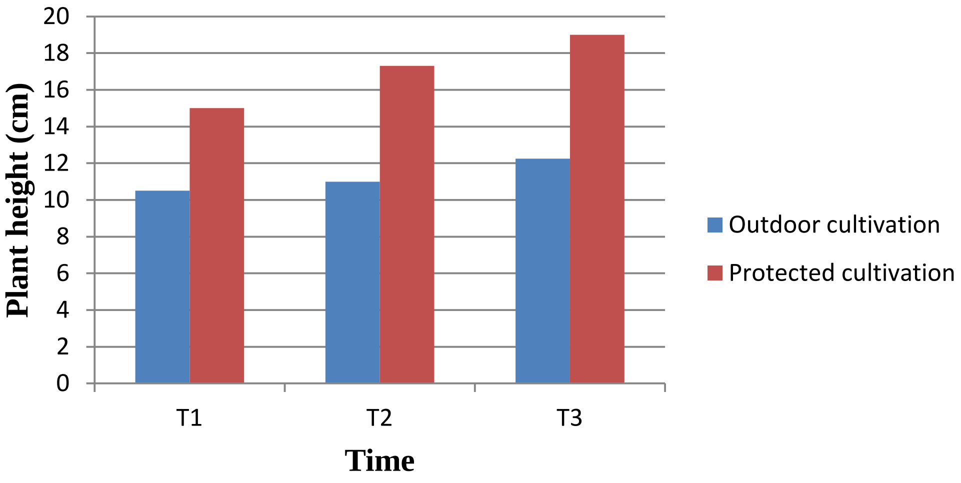
The observations on height of the plants were taken at the time of harvesting. The height of selected plants from each tier was observed for 15 days and correspondingly plotted in the graph. Considering the graph shown below the growth of wheatgrass in protected cultivation was found to be increased. Among the protected cultivation, the T_3 yielded with maximum height, 24.5cm and T_1 included in the outdoor cultivation seemed to have minimum height of 15.7cm.

Fig 4.10. Variation of plant height in protected and outdoor cultivation during first harvest



After another interval of 15 days, the plant height was again measured both in outdoor cultivation and in protected cultivation. The studies revealed that there was a decrement in the overall average heights after the first cutting. At the end of second harvesting, the measurement of wheatgrass is taken once more and the values are plotted on the graph.

Fig 4.11 Variation of plant height in protected and outdoor cultivation during second harvest



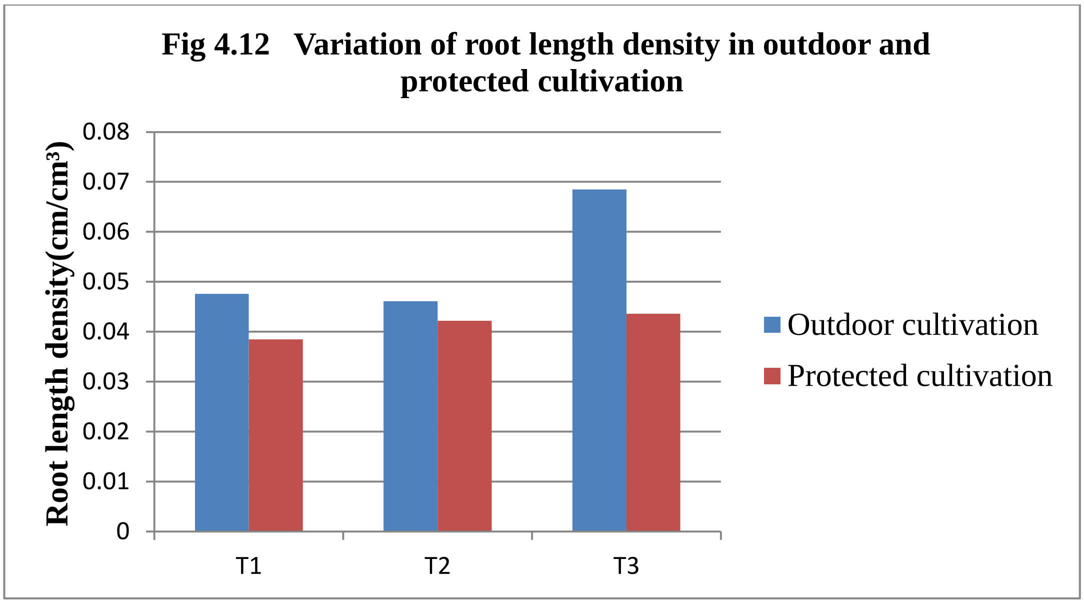
The data in the graph reveals that the height of wheat grass is maximum in the T_3 protected cultivation.

4.2.2 Plant root length density

The root samples collected from the three different tiers of either structure was measured. The length seemed to be more in the one without protected structure. This may be due to the reason that always-required moisture is remained within the accessible region in the protected structure. Therefore; the roots of the grass need not distribute well in the soil and establish enough.

Table 4.10 Comparison of plant root length density

Position of tray	**Root length density(cm/cm^3)**	
	Outdoor cultivation	Protected cultivation
Top tray	0.04766	0.0385
Middle tray	0.04608	0.0422
Bottom tray	0.06846	0.0436



4.3 Performance of cutting mechanism

4.31 Width and average height of cut

The wheatgrass cutter, which was fabricated for the tray cultivation had an operational width of 27cm.The trimming, was done at a height of 3 cm from the rooting media. A uniform cutting was obtained in the cutting process along the lengthwise movement of the mechanism.

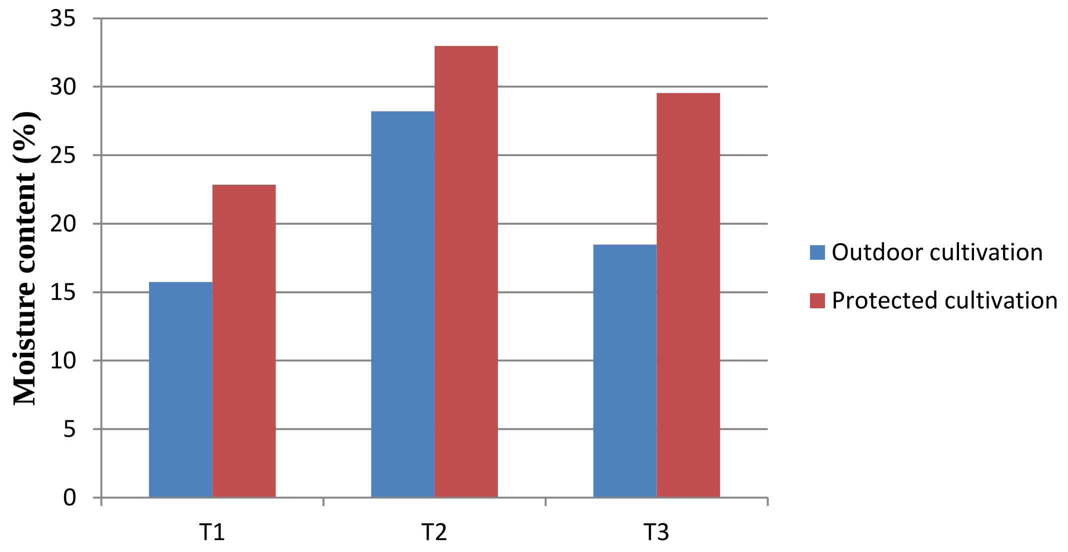
4.4 Soil moisture determination

The sample of 5g was, initially weighed along with the soil moisture can. Weight after the oven drying was taken. Using the available data soil moisture for the outdoor and protected cultivation was calculated. Data pretended that the soil moisture content remained high in the protected cultivation.

Table 4.11 Comparison of moisture content in protected and outdoor cultivation

Moisture content (%)				
Treatment		Position of the tray		
		Top	Middle	Bottom
Moisture content (%)	Outdoor cultivation	22.85	28.2	18.48
	Protected cultivation	15.74	32.97	29.53

Fig 4.13 Variation of M.C in outdoor and protected cultivation



4.5 Yield data

The observation on yield for wheatgrass was recorded after each days of interval, and thus two harvesting was done on the same crop's vegetative growth. The weight taken after the first trim from 3cm above the soil surface was 95.8g in protected cultivation and 73.7g in outdoor cultivation. Increment of growth in second harvest also revealed that the maximum yield was in protected cultivation, i.e., 52.7g and 42.7 in the outdoor cultivation. Tray at bottom gave the better yield than other trays placed at middle and top.

Table 4.12 comparison of yield obtained from both cultivation

Harvest	Protected cultivation	Outdoor cultivation
First	95.8g	73.7g
Second	52.7g	42.7g

4.6 Performance of cutting mechanism

The cutting system was incorporated above the tray, inside the fabricated structure. The forward movement was made possible by the screw threaded rod rotated by a handle, and the cutting action by another handle. Operational width of the system is 27cm (width of plug tray). Trimming was done uniformly at a height of 3 cm from the rooting media. Sheared fodder was allowed to retain for a regrowth and cutting was again done using the cutting system.

SUMMARY AND CONCLUSION

CHAPTER 5

SUMMARY AND CONCLUSION

The study entitled as “Development and evaluation of tray type protected cultivation system for fodder crops” mainly aimed at fabricating a protected cultivation and outdoor cultivation structure, best suited for homestead and compares the growth rate.

The north side of LH KCAET was selected to install both the structures. The two structures were placed at the same area so that the external temperature persisting around the structures are almost same. The wheat weighing about 140g was equally distributed among the two structures. Two structures were vertically stacked up by the propagation trays in it. The trays were filled with the rooting media composed of soil and cow dung.

The irrigation water was supplied by the LH KCAET tank which was placed 10m above the ground level. The mist irrigation was preferred in order to spread the fine droplets of water and retain the moisture inside the arrangement. The discharge rate of the mist was 80lph.

The wheatgrass (triticum aestivum) was selected for the experiment. The grass was allowed to grow for 15 days and the regrowth after another 15 days. The climatic observation and biometric observation details were recorded. This provided with the sufficient data to compare the growth between the protected and outdoor cultivation. The faster growth rate was the peculiarity visible in wheatgrass made it a crop suitable for tray cultivation system

The variations of air temperature at 8:00am in the two structures were obtained so: in the first week temperature of outdoor and protected cultivation seem to have wide variation and the rest of the weeks it varied only reasonably. The maximum temperature measured in protected cultivation was about 29.32ºC and 28.9ºC in outdoor cultivation. Observations of air temperature at 1:30 pm showed that the variation was more during the first week than in the second, third and fourth week. The minimum temperature in protected cultivation structure was found to be 34.59ºC and 33.53ºC in outdoor cultivation. The graph also indicated that maximum temperature in protected cultivation was 36.08ºC and in the case of outdoor cultivation was 35.6ºC. Similarly, the air temperature at 5:00 pm of protected cultivation and outdoor cultivation structure denoted the difference in temperature in week 1 to be more than other weeks. The maximum temperature in protected cultivation structure was found to be 32.3ºC and 30.54ºC in outdoor cultivation. The minimum temperature in outdoor cultivation was 28.83ºC and 29.17ºC in protected cultivation.

Light intensity recorded using lux meter, gave the maximum result in the outdoor cultivation. The maximum light intensity in protected cultivation at 8:00am was found to be 7928.5 lux and 19701 lux in outdoor cultivation. The minimum light intensity was 6912 lux in protected cultivation and 10212.85 lux in outdoor cultivation. The variations of light intensity at 1:30 pm revealed that the maximum light intensity was observed during the third week and it was 58744.28 lux in outdoor cultivation and 20948.57 lux in protected cultivation. The minimum light intensity in the outdoor cultivation was 29685.7 lux and 17444.28 lux in protected cultivation. The maximum light intensity measured at 5:00pm in protected cultivation was about 3688.8 lux and 8710 lux in outdoor cultivation. The minimum light intensity in protected cultivation was found to be about 2267.85 lux and 4924.4lux in the outdoor cultivation.

The maximum RH was obtained in the protected cultivation. The RH in the first week had comparatively less variation than in the other weeks, the maximum RH obtained in the protected cultivation was 85.11% and the minimum RH was 78.98% during 8:00 am. The maximum RH obtained in the outdoor cultivation was 80.06 % and minimum RH was found to be 73.31%. Among the observations taken, the first week indicated only a slight difference in RH as per the figure4.8 shown. The maximum RH in protected cultivation was 81% and minimum RH was 58.05%. The minimum RH observed in the outdoor cultivation was 48.47% and maximum RH was 57.86%. The first week had a small difference in RH at 5:00pm than another week's observation. The maximum RH in protected cultivation was 87.7% and minimum was 66.15%. The maximum RH in outdoor cultivation was 76.8% and minimum was 58.96%.

The biometric observations including height of the plants were taken at the time of harvesting. The height of selected plants from each tier was observed for 15 days and correspondingly plotted in the graph. The growth of wheatgrass in protected cultivation was found to be increased. Among the protected cultivation, the T_3 yielded with maximum height, 24.5cm and T_1 included in the outdoor cultivation seemed to have minimum height of 15.7cm.

After another interval of 15 days, the plant height after regrowth was again measured both in outdoor cultivation and in protected cultivation. The studies revealed that there was a decrement in the overall average heights after the first cutting. At the end of second harvesting, the measurement of wheatgrass was taken again and the values are plotted on the graph. The height of wheat grass was maximum in the T_3 protected cultivation.

The root samples collected from the three different tiers of either structure was measured. The length seemed to be more in the one without protected structure. This may be due to the reason that always-required moisture is remained within the accessible region in the protected structure. Therefore, the roots of the grass need not distribute well in the soil and establish enough.

Using the available data soil moisture for the outdoor and protected cultivation was calculated. Data pretended that the soil moisture content remained high in the protected cultivation.

The observation on yield for wheatgrass was recorded after each days of interval, and thus two harvesting was done on the same crop's vegetative growth. The weight taken after the first trim from 3cm above the soil surface was 95.8g in protected cultivation and 73.7g in outdoor cultivation. Increment of growth in second harvest also revealed that the maximum yield was in protected cultivation, i.e., 52.7g and 42.7 g in the outdoor cultivation. Tray at bottom gave the better yield among the other trays placed middle and top.

The system for cutting the fodder was developed, primarily for the tray cultivation system. The easiness in harvesting and collecting the fodder grass seemed to be more advantageous than the non-uniform trimming which is conventionally practiced. The wheatgrass cutter, which was effectively fabricated for the tray cultivation, had an operational width of 27cm, i.e., the width of the propagation tray. The trimming was done at a height of 3 cm from the rooting media. A uniform cutting was obtained in the cutting process along the lengthwise movement of the mechanism and collecting of the cuttings can be done within the cutter.

Scope of the study

- The study can be extended by fabricating a motorised cutting mechanism above the tray.
- The study can be elaborated by considering the effect of light, different rooting Medias etc.
- The study can be extended by considering different trays made using various materials.

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APPENDICES

APPENDICES

APPENDIX I

Climatological observations in the structures

		PROTECTED CULTIVATION				OUTDOOR CULTIVATION			
		RH (%)	Light intensity (lux)	Temperature(°C)		RH (%)	Light intensity (lux)	Temperature (°C)	
				Max	Min			Max	Min
22/11/17	M	73.09	10300	30.32	30.22	72.81	15000	29.91	29.31
	N	62.57	17800	37.19	37.01	54.05	27600	36.42	36.14
	E	71.05	1590	33.53	33.51	68.28	6890	31.25	31.01
23/11/17	M	82.59	6750	28.82	28.8	74.14	9630	27.32	26.99
	N	54.62	11800	39.43	39.4	50.32	12400	38.31	38.12
	E	87	3600	32.32	31.93	85.3	4930	30.99	30.81
24/11/17	M	83.59	5830	27.90	27.90	82.49	11590	26.8	26.7

	N	62.85	38300	36.10	36.02	59.34	60900	35.04	35.00
	E	86	4350	30.09	30.01	84.3	4930	30.08	30.00
25/11/17	M	82	14720	33.66	33.53	80.1	14900	32.3	32.1
	N	78.11	23900	39.11	39.1	72.01	42100	38.07	38.01
	E	87.15	2830	32.31	32.11	80.99	3290	29.99	29.91
26/11/17	M	82	11500	30.1	30.01	79.5	14300	28.9	28.8
	N	80.1	20900	35.97	35.07	76	31900	28.9	28.9
	E	86	2420	31.97	31.92	84	2490	27.31	27.22
27/11/17	M	83	3100	29.9	29.3	80.9	4930	28.45	28.44
	N	47.91	5500	38.16	38.02	45.06	5900	36.95	36.8
	E	67	2080	32.41	32.27	65.1	11600	30	30
28/11/17	M	80	3300	25.03	25.01	75.7	1140	24.3	24.2
	N	49.3	3910	36.8	36	48.3	27000	36	35.8

	E	86	3440	34.34	34.02	70	1020	32.60	32.4
29/11/17	M	82.59	6750	28.44	28.28	74.43	9630	27.92	27.91
	N	54.62	3280	39.33	39.03	50.31	12400	38.07	38.01
	E	87	2110	32.54	32.43	69.54	5280	31.88	31.86
30/11/17	M	85	5420	29.07	29.01	77.04	16010	28.09	27.91
	N	85.5	8690	31.37	31.38	68.10	26500	31.30	31.26
	E	86.5	1761	28.02	28	69.92	5960	29.06	28.98
1/12/17	M	86.5	2880	27.91	27.88	74.7	11630	27.85	27.8
	N	83	10200	33.29	33.13	63.09	26500	32.14	32.09
	E	92.5	6490	26.39	26.11	84.84	5960	25.55	25.48
2/12/17	M	82	3830	32.47	32.46	66.13	6090	32.19	31.14
	N	62.85	21800	36.1	35.9	59.24	69200	35.8	35.52
	E	86.5	1480	28.93	28.89	74.99	4620	28.29	28.23

3/12/17	M	82	15950	29.18	29.04	68.97	44800	31.46	31.18
	N	77.5	25800	38	37.52	48.58	96900	37.51	36.4
	E	87	1770	30.01	29.9	71.75	5170	29.54	29.52
4/12/17	M	86.2	4260	26.5	26.54	85.02	6800	26.4	26.3
	N	80.5	35400	37.42	37.33	52.82	32500	36.48	34.42
	E	87	2120	29.4	29.4	77.17	16000	29.08	29.02
5/12/17	M	83.5	9630	29.09	29.02	76.2	15550	30.51	29.70
	N	50.1	22000	40.9	39.1	49.34	84000	38.3	38.01
	E	88	1310	29.24	29.2	73.39	3950	28.68	28.55
6/12/17	M	85	10340	27.8	27.74	78.95	12470	28.45	28.42
	N	81	26300	37.23	37.12	54.65	10200	35.70	35.49
	E	88	2190	30.13	30.08	73.97	7500	29.40	29.16
7/12/17	M	82.1	10300	33.12	33.11	80.01	45000	33.36	33.17
	N	81	26500	34.44	34.28	59.60	89600	35.45	35.09
	E	86	3120	30.6	30.57	69.62	18250	30.44	30.36

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8/12/17	M	87	8430	27.64	27.55	83.06	20800	28.68	28.62
	N	82	25700	35.78	35.03	54.25	79300	36.65	35.52
	E	78.7	2200	29.4	29.42	77.17	3200	29.08	29.01
9/12/17	M	86.2	4260	26.4	26.01	85.02	6800	26.33	26.52
	N	78.5	22800	41	40.60	54.68	81100	37.69	36.95
	E	87.5	2230	30.55	30.47	73.41	7870	29.94	29.83
10/12/17	M	85.5	4330	27.03	27.01	82.2	6930	26.5	26.42
	N	77.5	20500	41.13	41.09	43.78	72600	38.69	37.54
	E	87	3090	31.75	31.27	70.61	14560	30.90	30.80
11/12/17	M	87	4130	24.48	24.46	81.18	13310	27.96	27.92
	N	85	4340	30.78	30.76	70.44	13610	29.89	29.78
	E	88	1005	28.78	28.76	77.26	2240	28.44	28.39
12/12/17	M	83	11580	33.46	33.44	70.02	32600	32.54	32.05

	N	82	20500	37.02	36.25	56.72	64800	34.66	34.59
	E	77	2040	30.19	30.13	71.71	7350	29.86	29.54
13/12/17	M	87.5	1230	28.60	28.48	82.12	1320	29.18	28.74
	N	86.5	15700	32.03	31.94	71.4	18400	31.06	30.96
	E	86	3190	31	30.98	73.56	12420	30.11	30.08
14/12/17	M	87.5	7030	30.47	30.42	85.5	38400	29.8	29.01
	N	80	21600	36.65	36.55	52.81	66400	36.82	36.42
	E	87	2190	30.21	30.18	74.71	6570	29.71	29.4
15/12/17	M	83.76	3740	26.22	26.15	79.52	10390	25.98	25.97
	N	52.7	4010	37.28	37.05	44.18	14400	36.37	35.8
	E	74	9070	32.13	31.99	64.84	1860	31.59	31.17
16/12/17	M	82.65	4560	25.74	25.72	81.72	9420	26.25	26.26
	N	45.36	7400	38.71	38.56	44.5	9230	36.67	36.49

	E	63.74	1100	32.02	31.99	53.27	2600	31.86	31.88
17/12/17	M	54.07	8990	34.26	34.25	46.45	65700	34.11	34.1
	N	46.45	3780	35.42	35.44	42.31	7840	35.02	34.92
	E	59.73	1020	31.96	31.95	50.09	2510	31.3	31.13
18/12/17	M	76.52	7400	25.62	25.63	69.36	9420	25.37	25.2
	N	48.2	45300	35.5	35.51	45.08	62200	35.15	34.6
	E	51.66	9070	31.44	31.41	49.93	1860	31.39	31.24
19/12/17	M	82.34	9420	23.68	23.79	72.5	9700	21.58	21.48
	N	48.09	13500	26.89	25.25	36.29	15300	26.35	25.77
	E	51.69	2690	22.52	22.4	48.85	3720	22.46	22.3
20/12/17	M	76.34	3790	28.6	28.52	70.43	4200	27.87	27.51
	N	62.99	7830	33.78	33.78	54.38	23600	29.91	29.08
	E	67.22	1590	32.55	32.54	59.30	6860	32.95	32.7

21/12/17	M	80.8	2230	25.96	25.93	72.25	8980	25.5	25.5
	N	52.19	38700	36.15	36.13	45.35	50600	36.12	36.11
	E	54.37	3280	34.23	34.23	56.1	5920	34.40	34.14

APPENDIX II

Determination of soil M.C in outdoor and protected cultivation system

		Wt. of can W1(g)	Wt. of moist soil+ can (g)	Wt. of dried soil+ can(g)	Moisture content (%)
Outdoor cultivation	T1	33.8	38.8	37.87	22.85
	T2	19.62	24.62	23.52	28.2
	T3	28.62	33.62	32.84	18.48
Protected cultivation	T1	25.72	30.72	30.04	15.74
	T2	17	22	20.66	32.97
	T3	28.81	33.81	32.67	29.53

APPENDIX III

Determination of RLD

Outdoor cultivation		Length of Root(cm)	RLD(cm/cm^3)
T1	Sample 1	9.3	0.048
	Sample 2	9.2	0.047
	Sample 3	9.2	0.047
	Sample 4	9.4	0.0483
	Sample 5	9.3	0.048
T2	Sample 1	9.2	0.047
	Sample 2	9.2	0.047
	Sample 3	9.1	0.046
	Sample 4	8.9	0.0457
	Sample 5	8.7	0.0447
T3	Sample 1	13.5	0.0693
	Sample 2	13	0.067
	Sample 3	13.4	0.0689
	Sample 4	13.5	0.0693
	Sample 5	13.2	0.0678
Protected cultivation			
T1	Sample 1	7.5	0.0385

	Sample 2	7.5	0.0385
	Sample 3	7.5	0.0385
	Sample 4	7.4	0.03803
	Sample 5	7.6	0.03906
T2	Sample1	8.3	0.0426
	Sample 2	8.2	0.042
	Sample 3	8.3	0.0426
	Sample 4	8.1	0.0416
	Sample 5	8.2	0.042
T3	Sample 1	8.5	0.0436
	Sample 2	8.4	0.0432
	Sample 3	8.5	0.0436
	Sample 4	8.5	0.0436
	Sample 5	8.6	0.044

DEVELOPMENT AND EVALUATION OF A TRAY TYPE PROTECTED CULTIVATION SYSTEM FOR FODDER CROPS

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ABSTRACT

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ABSTRACT

A study was conducted to develop a tray type protected cultivation system for fodder crops (wheatgrass) and to compare the fodder growth in the developed protected tray type cultivation system to that from tray type cultivation system without protectivecovering. A cutting mechanism for the tray type protected cultivation system was also fabricated. Two identical sets of tray type cultivation systemstructuresfor fodder crops was fabricated with three trays each and one was clad with a protective covering of UV stabilised plastic sheet. These structures were installed with the lengthy dimension in the east -west direction. Germinated wheat (*triticum aestivum*) seeds were planted in the trays of these two structures and the climatic parameters like relative humidity, temperature, light intensity etc. and the plant biometric parameters like root length ratio, weight of the wheat grass cuttings collected etc. and soil characteristics were determined. The performance of the fodder crop under the protected as well as the control structure was compared with respect to the observed yields of the wheat grass cuttings. The biometric details such as plant height, plant weight, root length density and the yields of the wheat grass cuttingssignificantly varied between the two structures, for the two harvests.The analysis of these data suggested that adoption of developed protected tray type cultivation system is advantageous than tray type cultivation system without protective covering.

The fabrication of the cutting mechanism for the tray type protected cultivation systemwas done using a slider crank mechanism.The performance of fabricated cutting system enhanced the easiness in cutting the fodder uniformly, therefore this system could be widely adopted in the small-scale tray type cultivation systems.