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Some Constructional, Environmental Control and Plant Growth Aspects of Green House at Indian Antarctic Station "Maitri"

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Abstract

The salient features of constructional parameters, the environmental control system and plant growth statistics in the Green House in Maitri Station, Antarctica are described.

Introduction

During the IX Expedition a Green House (GH) was added to the main building of Maitri on the north-eastern side, for the purpose ot growing ornamental plants and some green vegetables on experimental basis. The size of the Green House is 10.6 m x 2.66 m and siting has been done in such a way so as to get maximum sunlight through glass house effect. Principle of modular construction has been adopted for selection ot the size and structural components, keeping in mind the futuristic scope ot expansion ot the station. The super structure consists of prefabricated components/panels supported upon telescopic columns and grillage beams of steel and timber. Frontal views of Maitri Station with Green House during summer and polar nights are depicted in Fig. 1 and Fig. 2.

An environmental control system, to simulate conditions suitable tor plant growth in the severe climatic conditions of Antarctica, has been incorporated in the Green House Term-perature, humidity, oxidation, carbon dioxide, illumination, air change and *pH* value have been kept in mind while designing the systems.

Construction Details

A. Siting

Siting ot GH posed initial problems because the building was to be connected to the main structure for ease of functional aspects. As on the western side of the main building, the Klargester and disposal system already existed, the GH could be suitably sited towards A' block, in the eastern side of the main station. The orientation and siting was done in such a way, so as to get more solar insolation and also to keep the shelter integrated with the main building keeping its maintenance in mind. The preliminary marking done alter preparing the site for the foundation work has been shown in Fig. 3.

The geometry and the shape of the GH has been designed in such a way so that it would receive maximum sunlight during summer months. The corners are chamfered and roof is slopy to cater for high winds and the least snow accumulation on the roof (Fig. 2).

Fig. I. Frontal view of Maitri station with Green House (GH) during summer. The four newly erected summer huts and a bath module are seen in the foreground.

Fig. 2. Green House and Maitri station during polar nights.

B. Foundation

The terrain of the area around Maitri Station consists of hard metamorphic rocks with boulder strewn all over. The pits for foundation had, therefore, to be dug manually. No blasting could be undertaken in the proximity of existing building for reasons of the safety of the Station.

The foundation system consisted of telescopic columns and grillage beams fitted with timber planks on it. After digging the ground, 14 numbers of telescopic columns were erected and top surface was maintained at same level, as that of the existing main block, by levelling. The levelling was manually checked by water level technique. The general layout of the columns for the GH is shown in Fig. 4. Centre line of the columns and its inter distances were checked horizontally and diagonally. The telescopic columns can negotiate, a relief difference upto the undulation of one metre to give a level top surface to support grillage beam structure. Herein, columns were especially grouted in the pits with the help of bolts and special cement concrete, taking into account the cold region engineering aspects (Eranti *et al.,* 1986, Pathak, (1990) Manual R & DE Engrs, 1989). The cement concrete was mixed with appropriate quantity of calcium chloride to provide adequate compressive strength to the foundation.

The strength of the foundation was further improved upon by the controlled curing. Beams were placed on the columns and after ascertaining levelling and their desired accuracy, these were suitably welded. Sole plates were placed on the beams and fixed after checking. Level of the floor panel of the GH was brought to the same level as that of the floor level of the main block. The beams and composite timber floor panels serve the purpose of stopping heat transfer from ground and structural component to the GH and help fixing the superstructure on to the foundation system.

C. Superstructure

The superstructure of GH has dimensions of 10.6 m x 2.66 m while the height is inclined from 3.9 m to 2.9 m. The superstructure consists of prefabricated panels. The panels are made up of timber framework and 12 mm thick marine plywood cladding with PU foam as insulating core. Maximum surface area has been provided with windows for fitting special type of sandwiched toughened glass. Air gap sandwiched method has been adopted for selecting the glazed portion. The Teflon glass is expected to provide insulation and prevent heat loss during winter. The wall panels were erected with the help of wall connectors after checking its verticalness and alignments with the sole plates. Typical profile cut connectors for various joints such as middle, end connectors etc. have been inserted in the panel joints and junctions to facilitate easy construction. Nails and screws have been used as fixtures and fastners. Matching the grooves of the roof connectors and projections on the wall connector, the roof panels were fixed in a given sequence. A slope of about 1 m is attained in 2.7 m width of the roof to cater for snow load, high wind velocity etc. The completed roofing was further strengthened by PGI strapping sheets at all the edges to fasten connectors and roof panels more strongly.

The back wall of the GH along with main block is having only one door and three glass windows. The glazing is expected to provide insulation and prevent heat loss during winter. The GH under construction has been shown at Fig. 5.

Fig. 3. Marking of site for foundation work ofGH.

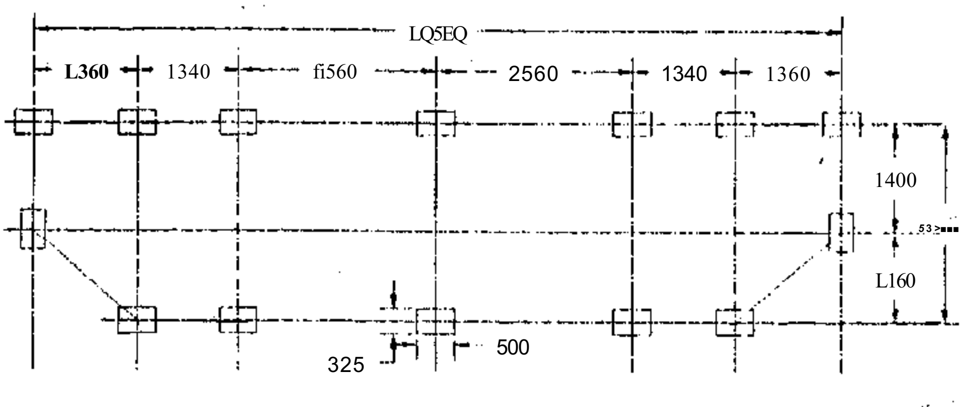


Fig. 4. ***Column layout for superstructure.***

D. Interfacing with Main Block

The GH was interfaced with main block after positioning the environmental control equipment by opening a door through the existing corridor passage. The entire gap of 2 ft width between GH and main block was covered by wooden panels and utilised later for keeping stores connected to GH Project.

E. Sealing

The final gaps between the joints of the doors, windows and walls of the GH were suitably filled with gypsum paste and gypsum board. The floor of the-GH was made water proof by fixing rubber tiles all around. The wooden shelves were constructed to accommodate the water trays to be kept for the plant growth. The readymade shelves were also used for this purpose. A wash basin was fixed on the northern wall of GH. Only one door has been provided as entry point for better control of environmental effects.

Environmental Control System

The control of the environment inside the Green House is most important factor of its overall design. This is more so, as the normal climatic condition in the region are quite adverse. Some of the important control parameters and systems (Fig. 6) are described below:

A. Plantcare Control System (PCS)

Plantcare control system designed and installed, consists of a control console, an air handling unit, a nutrient management unit and an air compressor.

B. Temperature

The dry temperature inside the GH is sensed at four locations, averaged and displayed. Depending on the temperature set, the flow of hot water in the air handling unit (AHU) radiators is turned ON/OFF. The heated air is being circulated in GH. In case the temperature cannot be maintained by the radiators, air heaters provided in the AHU are switched ON/OFF automatically by the low set point relay of the temperature controller.

C. Humidity

The humidity in GH (wet temperature) is sensed at four locations, averaged, automatic look up of the phychometric tables is done and direct % RH is displayed on the control console. Depending on the % RH set, humidification will be effected by fagging and dehumidification by air exhaust.

D. pH Monitoring

The *pH* value of the nutrient solution is continuously monitored and displayed on the control console. On line monitoring may be either at the suction or discharge of the nutrient pump. The settings on the controller would automatically actuate the *p*H (LO) and *p*H (HI) solenoid, to allow for suitable dozing (alkaline or acidic) or the nutrient in the tank.

E. Electrical Conductivity

Electrical conductivity of the nutrient solution is continuously monitored and displayed on the control panel. Here too, on line monitoring is done in series, with the *p*H monitoring.

Two alarm set points are provided to signal low or high conductivity of the solution.

Fig. 5. GH under construction.

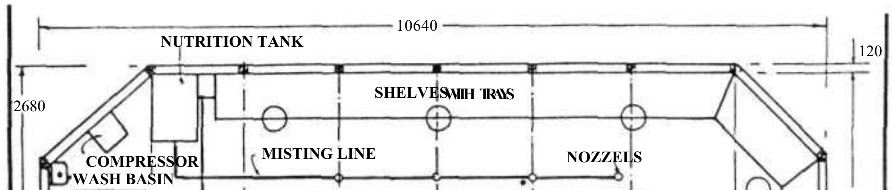


Fig. 6. Environmental Control System for GH.

F. Nutrient Heating

A temperature indicator/controller with sensor is provided to monitor the nutrient temperature which is also displayed on the control console. The temperature of the nutrient is maintained at set value by ON/OFF action of the nutrient heaters in the nutrient tank.

G. Aeration

The nutrient solution is aerated by clean compressed air which is bubbled through the solution in.the tank in a settable ON/OFF cyclic mode. The ON/OFF timing may be set as also the air flow.

H. Lighting for Photo-Synthesis

In the Antarctic region average natural daylight level is low and the days are short or there are no days during an appreciable part of the year. This restricts plant growth. The CONLEX PCS has made provision for a controlled DAY/NIGHT cycle through a 24 hour cyclic settable timer and sodium vapour lamps.

Experimental Growth of Plants

The severe Antarctic climate limits the number of land plants that can be grown here. Only lichens, mosses and other lower forms are found during a short duration of austral summer. Normal climatic conditions in the Maitri region such as low ambient temperatures between 9°C to -35°C, very long polar days nights, low humidity and wind speed upto 90 knots are quite adverse to plant growth. Optimum conditions for plant growth were, therefore, maintained inside the green house (temperature maintained between 18^{C}C to 25°C, humidity between 40 to 70 percent, average carbon dioxide level of 400 ppm). The light requirement for photosynthesis was provided through high pressure sodium vapour lamps. Translucent curtains were used for preventing prolonged sunlight during polar days.

Green house with all the above mentioned controls started functioning with effect from 23rd July 1990. The following seeds were sown.

1. *Coriandrum sativum* (Corriander)
2. *Spinacia oleracea* (Spinach)
3. *Rhaphanus sativum* (Radish)
4. *Dolichos lablab* (Beans)
5. *Capsicum annum* (Chilli)
6. *Solanum melangena* (Brinjal)
7. *Lycopersicum esculentum* (Tomato)
8. *Zea mays* (Maize)
9. *Solanum tubrosum* (Potato)
10. *Allium sativum* (Onion)
11. *Cucumis sativa*
12. Gudesia flower
13. Squash

14. Fodder grass

Apart from these, sprouted cuttings of potato and onions were also sown.

Materials and Methods

All the seeds used were supplied by DARL, Almora, except sprouted potato buds which were obtained from the Russian station. Plants were grown in pots inside the Green House. The temperature inside the Green House was maintained between 18°C to 25°C by using hot water radiators and hot air blowers. Humidity varied from 40% to 70% using electrically operated humidifiers.

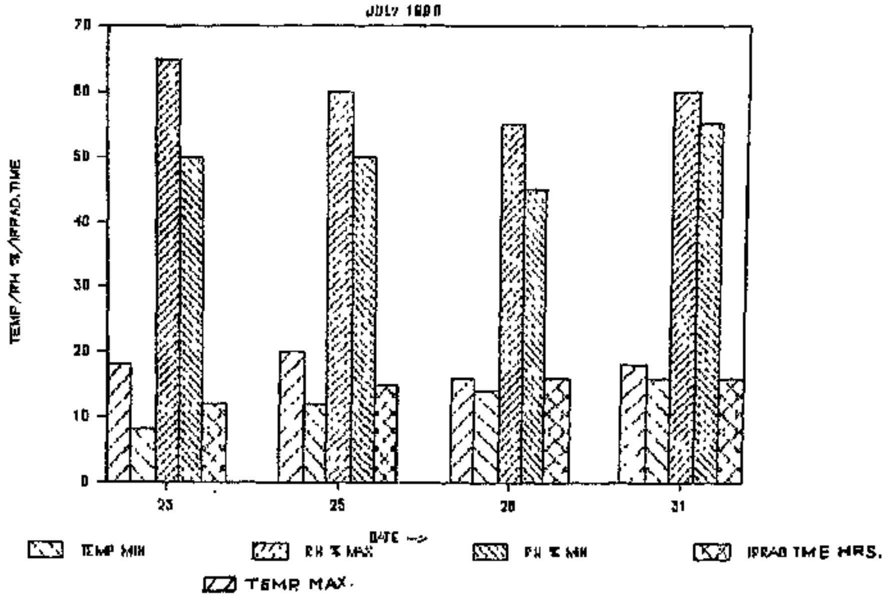
Artificial light of 7000 lux per square metre at the height of 1.5 metre was obtained by using high pressure sodium lamps during polar nights for a period ranging from 6 to 18 hrs. Translucent curtains were used for creating day/night cycle, during polar days. Watering of the plants was done twice daily, in the morning and evening. The temperature and humidity were continuously monitored by using wet/dry thermometer. Actual maximum/minimum temperature, humidity and duration of irradiation lights are given in Figs 8A to 8F.

Progress/Results

All seeds sprouted within seven to ten days and rate of growth was satisfactory. Corriander and spinach plant heights were less because of high density of plants. In order to meet the corriander requirment of the kitchen, its cultivation was considerably increased. FRP tray of 45 x 35 x 10 cm size were used for cultivation. Radish plants also gave good

Fig, 7. Cultivation of plants in FRP pots in GH.

CONTROLLED PARAMETER IN GREEN HOUSE



CONTROLLED PARAMETER IN GREEN HOUSE

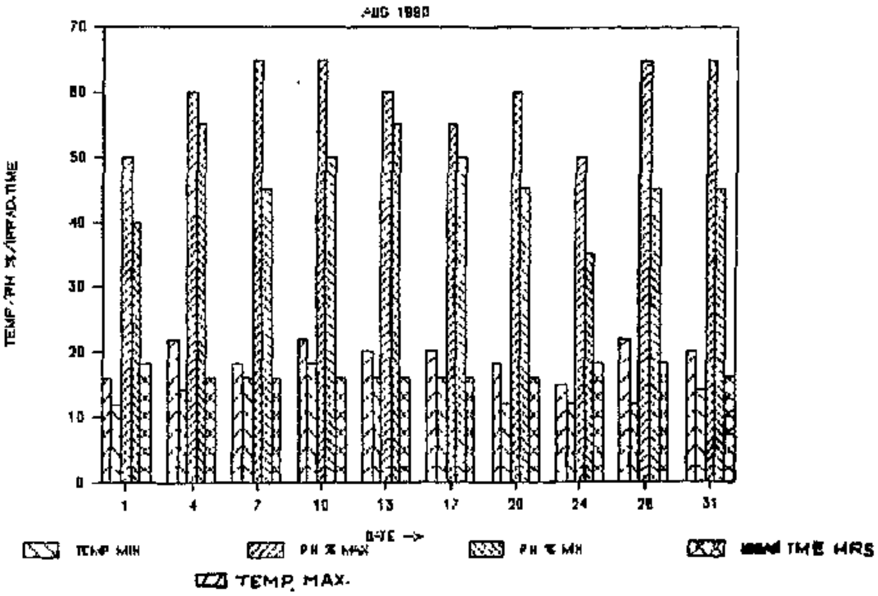
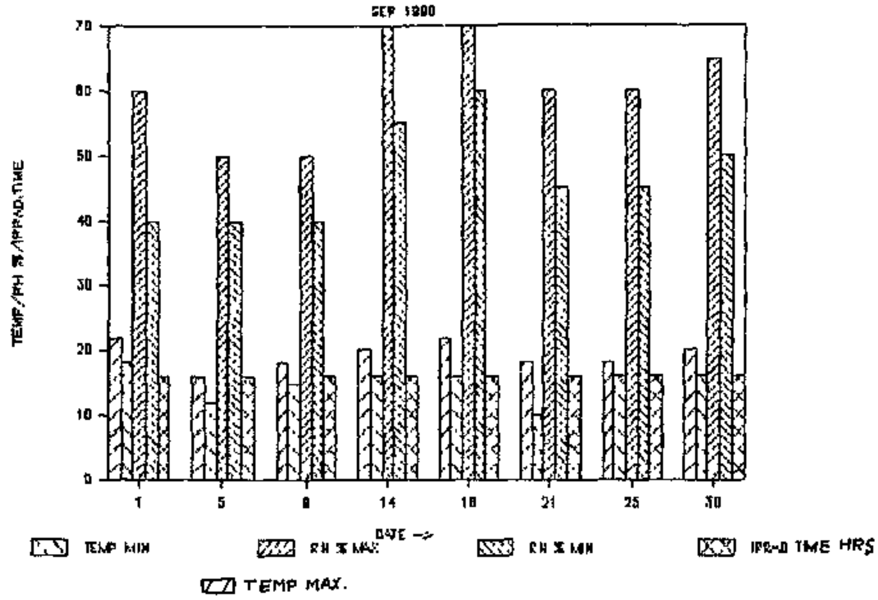


Fig. 8A-B. Controlled parameters in GH for July 1990 to Dec. 1990

CONTROLLED PARAMETER IN GREEN HOUSE



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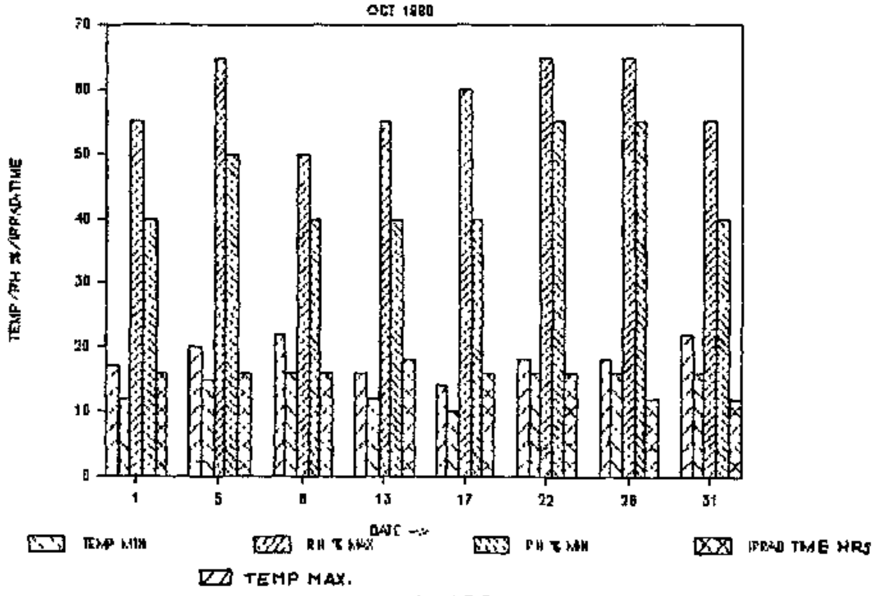
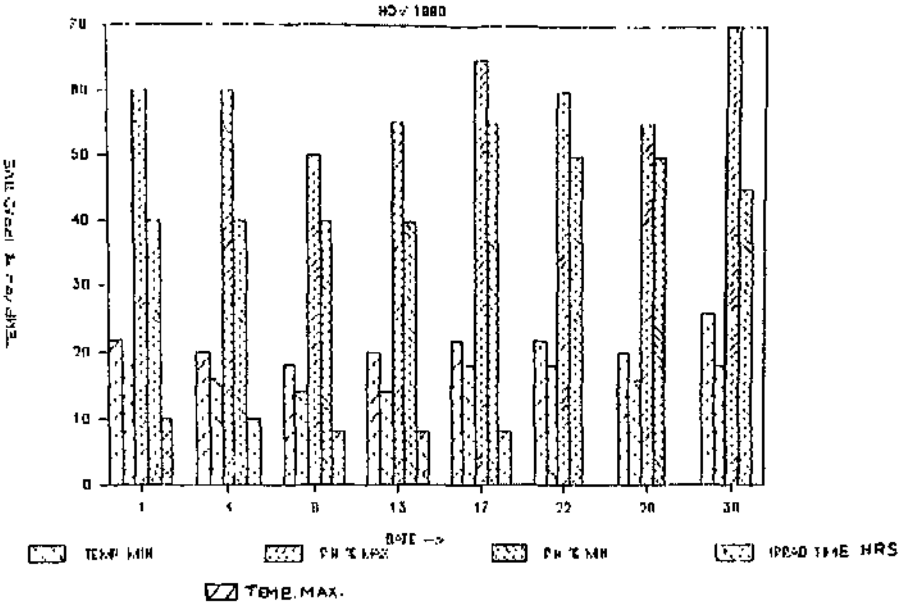


Fig. 8C-D.

CONTROLLED PARAMETER IN GREEN HOUSE



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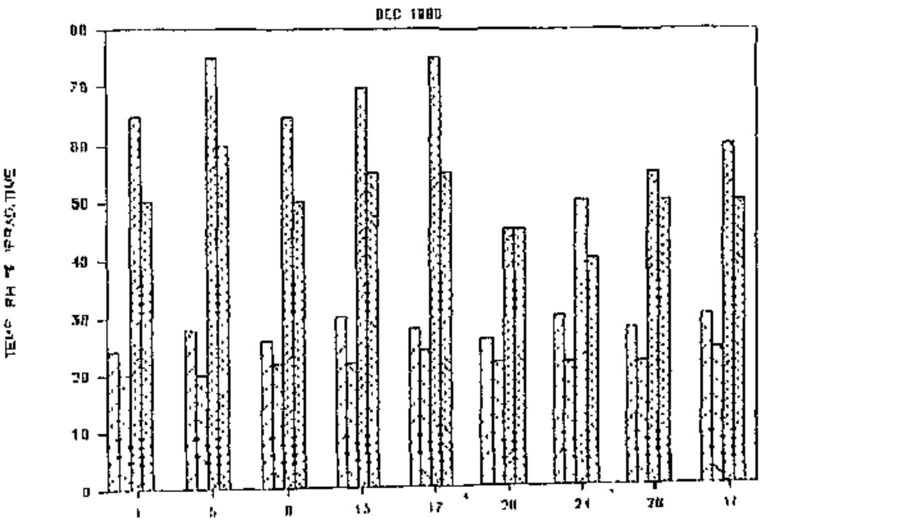

Fig. SE-F.

size of radish root. One radish plant was allowed to grow till it yielded fruits. It grew like a bush with clusters attaining an height of about 70 cms and covered an area of 60 sq cm. The plant gave 100 to 150 radish fruits. The potato plants yielded six to eight potatoes varying between 3 cm and 4 cm in dia. Tomato plants grew to a height of 70 cm to 100 cm. Supports were given to hold them vertical. Each plant yielded six to ten tomatoes of 4 to 6 cm in dia. Gudesia and corn flower plants blossomed lavishly, which enhanced and beautified the

Table 1: Plant Growth Data Inside Green House, Maitri

Sl. No.	Vegetables/ Flower/ Crop	No. of seeds	Date sown	Date sprouted	No. of seeds sprouted pot/tray	Plant height cms	Yield/% of seed sown	Seeds treatment	Rema-rks
1.	*Coriandrum sativum*	300	23-7	30-7	285 (95% of seed sown)	10-15	270 (90% of seed sown)		
2.	*Spinacia oleracea*	300	23-7	29-7	250(83%)	10-15	225(75%)		
3.	*Rhaphanus sativum*	6	23-7	28-7	2(33%)	25-40	2 (33%)		
4.	*Solatium tubrosum*	4 (cut pcs)	23-7	27-7	7(100%)	20-30	7 (100%)		
5.	Mustard seed	12	23-7	31-7	6 (50%)	30-40	6 (50%)		
6.	*Lycopersicum esculentum*	9	25-8	31-8	8 (92%)	60-90	8 (92%)		
7	*Allium sativum*	24	18-8	26-8	12 (50%)	25-30	12 (50%)		
8.	*Dolichos lablab*	15	20-10	24-10	12 (80%)	15-20	12 (80%)		
9.	*Cucumis sativa*	8	20-10	30-10	5 (62%)	100-200	5Nos (50 gms per plant)		
10.	*Capsicum annum*	6	23-7	30-8	3 (50%)	40-42	Nil		
11.	*Solanum melangena*	10	23-7	30-8	4 (40%)	20-30	Nil		
12.	*Zea mays* (Maize)	5	20-10	26-10	2 (40%)	100	Nil		
13.	Gudesia flower	75	20-8	23-8	50(66%)	30	3 to 4 flowers per plant		
14.	Corn flower	30	20-8	24-8	15 (50%)	30	3 to 4 flowers per plant		
15.	Fodder	30	20-10	25-10	15 (50%)	40	Nil		

green house. FRP pots of size 30 cm dia/square height of 30 cm were used for cultivation of these plants (Fig. 7).

Growth Statistics

Progress of horticulture of various plants is given in Table 1.

Horticulture can be taken up on a big scale at Maitri station, Antarctica. Congenial conditions and enough window space for growing plants are available in the generator room, boiler room and workshop area where temperature is maintained between 20 and 25^{C}C and adequate carbon dioxide is also available. For lighting, high pressure sodium lights may be used during polar nights. The local soil may be good for cultivation if silt from the Klargester is used as manure, as it is produced by bio-degradation of kitchen waste without using any chemicals.

Conclusion

The Green House constructed at Maitri during IX Antarctic Expedition has yielded good experimental growth of plants. The fresh green plants and colourful fruits in other wise a white desert gave a morale boosting to the wintering personnel. The Green House structure also has withstood the test of the time.

Acknowledgement

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