INSIDE GREENHOUSES FOR CULTIVATION OF TULIP FLOWERS

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Abstract: Tulip is one of the nature's beautiful creation and represents the largest ornamental crop worldwide. It ranks first among ornamental crop for its brilliant colour and exquisite flowers. Tulips are excellent for cut flowers,beds, pots and are grown in open as well under protected conditions(greenhouse).Holland is the largest producer of tulip flowers and bulbs and has become the back bone of flower industry in Netherlands.Recently it is gaining popularity among the flower growers in Kashmir valley because of increasing demand of its cut flowers and bulbs. Its cultivation is a lucrative business and flowers are sold at 50 to 75 INR per flower both in national and international market.

Keeping demand in view there is a need to produce tulips round the year. In Kashmir valley tulips are grown only in limited period i.e, from February to May, as the environmental conditions are best suited for tulips growth during these months. Presently there is no such controlled condition system for tulips in India except countries like Holland, China, New Zealand. In green house not only the temperature but also velocity, humidity and mass flow as well can be controlled. This system can be utilized in such a way that the tulip flowers can be produced throughout the year. The demand for tulip flowers varies throughout the year and the flowers can be supplied to the market throughout the year with the help of this system. This paper presents the design of micro climatic environmental conditions inside greenhouses for cultivation of tulip flowers.

Keywords: Tulip, ornamental crop, exquisite, protected, popularity, humidity.

1.0 Introduction

Tulip is one of the nature's beautiful creation and represents the largest ornamental geophyte crop worldwide. Belonging to family LILIACEAE, genus Tulip consists of 100-150 species, it ranks first among bulbous ornamental for its brilliant colour and exquisite flowers .Tulips are excellent for cut flowers, beds, pots and are grown in open as well as under protected conditions. There are various classes of tulips that differ in their flowering time, flower shape, size and colour.

The largest area under a true bulb crop in the world is that of tulip followed by Narcissus, Iris, Hyacinth and Lily. Holland is the largest producer of tulip flowers and bulbs and it has become the back boon of flowering industry in the Netherland .In India, tulips thrive well in temperate regions of Jammu and Kashmir, Himachal Pradesh, Uttrakhand and similar hilly regions. They do not thrive in the open in tropical climates as they require a cold winter season to grow successfully .However precooled bulbs are being made to flower during winter in plains. The tulip is the major flowering bulb with over 7000 hectares in production there are hundreds of cultivators. Tulips are forced for use as cut flowers, potted plants and growing plants Because of large no of cultivators available, there are tulips for all uses and for almost all climatic zones.

2.0 Botanical Classification

Tulip is a Monocotyledon and is placed in the Lilliaceae family .The major center of origin is situated in central Asia .Diversification took place from the region of Tien-Shan and Pamir-Alai to the north and northeast (Siberia ,Mongolia, and China),south to Kashmir in India ,and west to Afghanistan ,Iran and Turkey. Tulipa includes about 125 species, but few species are grown on a commercial scale

A tulip is a bulbous plant in the genus Tulipa, comprising 109 species with showy flowers in the family Lilliaceae. The species native range includes southern Europe, North Africa, and Asia from Anatolia and Iran in the west to northeast of China. A number of species and many hybrid cultivars are grown in gardens, used as pot plants or as fresh cut flowers. They grow in the cold and snowy winter. Plants typically have 2 to 6 leaves, with some species having up to 12 leaves.Figure 1. Shows section of a Tulip Bulb.

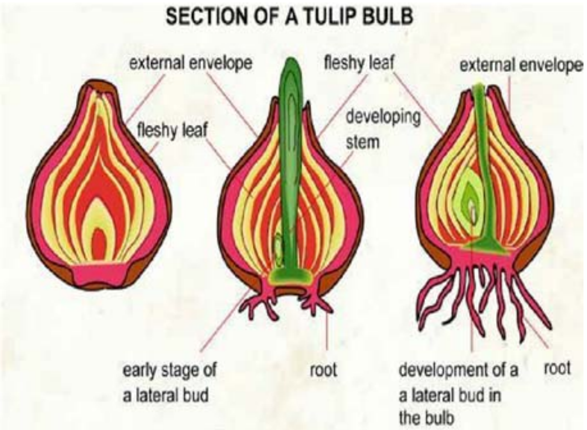

Figure 1. Section of a Tulip Bulb [1]

Tulips are associated with the Dutch because a famous Dutch gardener named CarolusClusius, who was head gardener at the University of Leiden in Holland in 16th century, was the first to plant tulips in what has today become a land renowned for its fields of tulips and daffodils. Holland is the largest producer of tulip bulbs and flowers. Tulips are excellent for cut flowers, beds , borders, pots and are grown in open and as well as under protected conditions. There are various classes of tulip that differ in their flowering time, flower shape, size and colour.

The species are perennials from bulbs, the tunicate bulbs often produced on the ends of stolons and covered with hairless to variously hairy papery coverings. The species include short low-growing plants to tall upright plants, growing from 10 to 70 centimeters (4–27 inch) tall. They can even grow in the cold and snowy winter. Plants typically have 2 to 6 leaves, with some species having up to 12 leaves. The cauline foliage is strap-shaped, waxy-coated, and usually light to medium green and alternately arranged. The blades are somewhat fleshy and linear to oblong in shape. The large flowers are produced on scapes or subscapose stems normally lacking bracts. The stems have no leaves to a few leaves, with large species having some leaves and smaller species have none. Typically species have one flower per stem but a few species have up to four flowers. The colorful and attractive cup shaped flowers typically have three petals and three sepals, which are most often, termed tepals because they are nearly identical. The six petaloidtepals are often marked near the bases with darker markings. The flowers have six basifixed, distinct stamens with filaments shorter than the tepals and the stigmas are distinctly 3-lobed. The ovaries are superior with three chambers. The 3 angled fruits are leathery textured capsules, ellipsoid to subglobose in shape, containing numerous flat disc-shaped seeds in two rows per locule. The flat, light to dark brown seeds are arranged in two rows per chamber and have very thin seed coats and endosperm that does not normally fill the entire seed coat. The species are distributed in two sub-genes, Eriostemones and

Leiostemones, which up to recently could not be intercrossed .The genus probably separated at an early stage of the evolution .The Eriostemones, which includes about 30 species, generally are low growing, having narrow leaves and possess hairs at the inner base of the perianth parts

The present day garden tulips, which belong to the Leiostemones, originated from types introduced into Europe from Turkey after the middle of the 16th century. These tulips had been grown and bred for a long time and shows diversity in flowering, growth, and vigor and flower shape. This is not surprising, since multicolored tulips were grown in Persian gardens as early as the 12th and 13th centuries .These tulips, whose original species have been not been determined have been placed in Tulipa Gaserianana.

3.0 Growth, Development and Flowering

Under natural conditions, tulip seeds are harvested from June to august and sown in august Germination starts during winter and active growth of the leaf occurs in spring .The bulb formed in the extremity of a dropper enlarges quickly in spring and growth ends in May or June.

The tulip bulb has an annual replacement cycle. The annual cycle can be divided into the main phases:

- Root growth occurs rapidly after planting in autumn ,when the soil temperature decreases ,the apical bud ,which has already differentiated the aerial organs also starts to elongate ,but this growth is very slow during winter
- During early spring ,when the temperature rise ,plant growth become active rapid scape and flora bud elongation leads to flowering .In the case of small non-flowering bulbs ,the apical bud only produces one leaf .Flowering tulips form two or more leaves .The transformation of the vegetative buds has been initiated and is epically rapid after flowering .Simultaneously ,the mother-bulb scales shrivel and progressively disappears
- At the end of spring ,the aerial organs senesce and daughter bulb is in an apparent state of dormancy However ,periodical dissection of bulbs shows that an active bud differentiation takes place during this period .also the root in the basal plate becomes very prominent

This demonstrates that continuous changes are taking place nearly all year round and that there are always organs being initiated, growing, senescing, or developing

4.0 Breeding Goal

All tulip cultivation must have acceptable ornamental uses, and breeders must take this aspect into account .Efforts have been made to improve the colour ,shape, and size of the flower as well as the general aspect of the plant,e.g leaves, height, type of growth etc. With the development of new techniques for cut flowers and pot plants forcing the physiological characteristics of the cultivar have become very important .Thus breeding for forcing ability and desirable post greenhouse characteristics is one of the major goal for tulips. A cultivar possessing a good forcing ability makes it possible to produce, usually under greenhouse conditions, a maximum number of high quality flowers square unit and in the shortest period of time Thus forcing ability has at least three major components

- The ability of the cultivar to be forced either very early or very late in the market season
- The quality of the flower, which must have ornamental value and meet commercial requirements that vary with the country and /or the market. For example in Europe generally requires very long stemmed tulips in contrast to the Northern European countries
- The number of tulips flowers per square unit. This depends on the planting density used and the flowering percentage, which must be as close as possible to 100.The planting density is partly determined by the leaf habit .Thus with erect leaves the planting density can be higher

After flowers has been produced ,it must demonstrate a good vase-life (>5 days) after having been subjected to cold storage ,transport ,and delivering conditions .Potted tulips must also have a long life.

5.0 Environmental Conditions

For the production of tulips four factors plays a vital role in the development of tulips they are listed below

- Temperature
- Light
- Humidity and
- Air composition

Tulips require hot dry summers followed by cold and wet winters for their optimum growth and development. Tulip bulb has a cold requirement of many weeks which must be satisfied before it can grow above ground. This cold requirement prevents the emergence of tulip in autumn although temperature and soil moisture conditions are favorable for its growth. After the cold period of winter, plant grows with the rise in temperature and flowers in warm conditions of spring. During hot periods of summer it survives as an underground organ in soil or is lifted for storage.

Among the various environmental factors, temperature is the most important factor affecting growth physiology of tulip. There is an obligatory temperature requirement for tulip growth. It requires warm (17-20°C), cold (2-9°C) and warm (17-20°C) temperature in sequence.

Tulips are indigenous to mountainous areas with temperate climates and need a period of cool dormancy. They do best in climates with long cool springs and early summers, but are often grown as spring blooming annual plantings in warmer areas of the world. The bulbs are typically planted in late summer and fall, normally from 10 to 20 cm (4 to 8 inch.) deep, depending on the type planted, in welldrained soils. In parts of the world that do not have long cool springs and early summers, the bulbs are often planted up to 12 inches deep; this provides some protection from the heat of summer and tends to force the plants to regenerate one large bulb each year instead of many smaller non-blooming ones. This can extend the usefulness of the plants in warmer areas a few years but not stave off the degradation in bulb size and eventual death of the plants.

6.0 Pre-Requisites for the cultivation of Tulip flowers inside the greenhouse

□ **STEP 1**

Give the tulip bulbs the correct amount of chilling by either allowing them to sit in an unheated greenhouse, or by placing them in a cooler. They must not be exposed to light during the chilling time, or they may sprout. The length of chilling required for most tulip varieties is 14 to 16 weeks, depending on the variety. The temperature must stay between 35 and 45 degrees F during this time. Occasionally, you can purchase tulip bulbs that are pre-chilled by the grower. Do not allow tulip bulbs to freeze during the chilling period. If chilling in a cooler, check the tulip bulbs every few days and move them around. This prevents mold and mildew from becoming established between the bulbs. Ensure there are no fruits and vegetables in the cooler with the tulip bulbs. Fruits and vegetables give off ethylene gas as they ripen that kills tulip bulbs. The amount of time from chilling to bloom time will take about 21 weeks, depending on the tulip variety.

□ **STEP 2**

Plant the bulbs in the ground inside the greenhouse, or planting trays filled with potting soil inside the greenhouse, after the chilling period is finished. It takes four to six weeks for the tulips to bloom after planting in the ground or trays inside the greenhouse once they are exposed to the correct temperatures and light levels. When planting the bulbs directly in the ground or in planting trays, plant as close as 2 inches apart and 1 inch below the surface of the soil. This will give you longer and cleaner stems than if you are planting in the field where the bulbs are planted deeper for stability.

- **STEP 3**

Expose the planting area you have chosen for growing your tulips to a steady temperature of 65 to 70 degrees F. You may need to use a greenhouse heater to accomplish this if you're growing in the early spring when outdoor temperatures are still cool. If the temperatures are too warm, provide ventilation. If you're attempting to grow tulips in the heat of the summer, you will need to provide air conditioning, exhaust fans or other cooling device to keep the temperatures down to the desired level. Temperatures that are below the required level will slow down tulip growth and cause the stems to be short. Temperatures that are too warm will cause the bulbs to bloom quickly on long, rangy stems, so keep the temperature at the required level of 65 to 70 degrees F for optimal flower production.

- **STEP 4**

Allow unobstructed sunlight levels through the top and sides of the greenhouse to reach the area the tulip bulbs are planted. No artificial light is necessary once the chilled bulbs are planted and exposed to the right temperatures and normal greenhouse light levels.

7.0 Problem Statement

Tulips are a refreshing reminder to customers that winter is almost over. Customer's desire for color at the end of winter creates a profitable crop for cut flower growers using minimally heated greenhouses and high tunnels. Tulip bulbs can be forced to bloom out at any season (from December through July) for early spring sales at Valentine's Day, Easter, Eid and Mother's Day. Tulip bulbs can also be grown outdoors in raised beds, allowing them to flower naturally for spring sales.

Tulips are gaining popularity among flower growers in Kashmir valley because of increasing demand of its cut flowers and bulbs. The Kashmir valley presents the most congenial climatic conditions for the exploration of this important bulb crop. Its cultivation is lucrative business, and flowers are sold @Rs 50-75 per flower on the various festival occasions. Keeping in view the government of Jammu and Kashmir established a unique garden to boost the morale of flower growers of the valley .Established in 2008, the tulip garden is known as Indira Gandhi Memorial Tulip Garden. Efforts are being made to improve the color shape size of the flower as well as the general aspects of plant e.g. leave height type of growth etc. With the development of new techniques for cut flowers and pot plant forcing, the physiological characteristics of the cultivars have become very important .Thus breeding for forcing ability and desirable post greenhouse characteristics is one of the major goal of tulips. Bulb forcing is divided into three phases .The first is the production phase, the second is the programming phase, which includes the control of floral and root organogenesis and floral maturation, the third phase during which very active plant growth takes place is usually called the greenhouse phase. Very early forcing where the goal is to produce the flower before any occasion like Christmas,Eid etc. requires adaptive cultivation this can only be obtained when the bulb have been produced under conditions leading to early maturity after harvest are subjected to a high temperature.In practice the bulbs are given one week at 34°C before transfer at 17 to 20°C. It is obvious that because of year to year variability such treatment does not yield the same results. The date bulbs are transferred to low temperature several parameters are taken into consideration among which is will the bulb be special precooled or standard precooled .In this project, standard cooling will be taken, in case of standard cooling only a part of cold treatment is applied to dry stored bulbs generally six weeks at 7 to 9°C . Thus it is possible to cultivate the tulips at any time of the year.

8.0 Details of Environmental conditions

The main aim of this project is to cultivate the tulip cut flowers in the month of June. The ambient conditions in the June month is quite harsh.Temperature, humidity &heat flux are quite high which are totally unsuitable for the tulip flowers .Table 1 shows the month wise details of temperature and relative humidity.

Month	Temperature (Degree Celsius)		RH%
	Min	Max	
January	-7	8	80
February	-2	15	85
March	5	20	90
April	10	25	70
May	20	30	60
June	25	33	60
July	25	35	60
August	26	35	60
September	20	30	60
October	5-8	20	60
November	3	10	70
December	-5	5	85

Table 1 Shows month wise temperature (Metrology deptt J&K)

9.0 Experimental greenhouse

The measurements were carried out in an experimental N–S oriented tunnel greenhouse located at the University of Thessaly near Volos, (Latitude 39°44′, and Longitude 22°79′) on the coastal area of Eastern Greece. The geometrical characteristics of the greenhouse were as follows: □ eaves height of 2.4m

- ridge height of 4.1m
- total width of 8 m; and

□ Total length of 20m.

The greenhouse was covered with a polyethylene sheet and was equipped with two continuous openings (roll-up type) located 0.6m from the ground with a maximum opening of 0.9m. The greenhouse was cultivated with a tomato crop, which reached a height 1.5m during the experiments.Figure 2 shows the experimental model

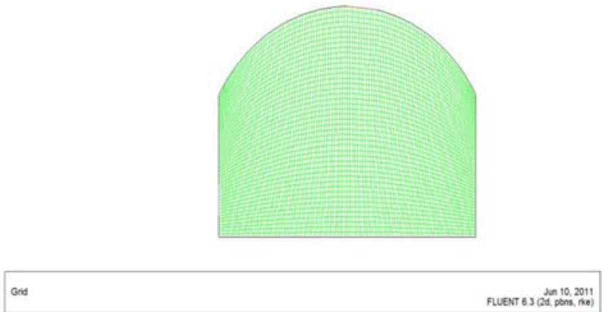

Figure 2 The Experimental Model

9.1. Measurements

Two different types of measurements were conducted in order to validate the simulations:

- Measurements of the three components of air velocity; and
- Measurements of the ventilation rate of the greenhouse.

A weather station tower was installed outside the greenhouse to measure the local climate such as dry and wet bulb air temperatures, wind speed, wind direction and solar radiation. Outside dry and wet air temperatures were measured at1.1m above ground, air speed and direction as well as solar radiation at 1m above the top of the greenhouse

Table 2 presents the mean value (in a time interval of 5 min) of climate conditions during the measurements with the sonic anemometer.

Measurement Positions	Temperature °C	Solar radiation w/m^2	Wind Speed m/s	Wind Direction Deg.
1	29	789	3.70	30
2	30.20	843	2.06	40
3	30.90	867	3.30	45
4	31.20	874	3.30	50
5	31.30	843	2.60	35

Table2 Measured values

9.2 Validation

The effect of ventilation configuration of a tunnel greenhouse with crop on airflow and temperature, velocity, humidity patterns were numerically investigated using a commercial computational fluid dynamics (CFD) code. The numerical model is firstly validated against experimental data collected in a tunnel greenhouse identical with the one used in simulations. A good qualitative and quantitative agreement is found between the numerical results and the experimental measurements. The validation results are shown in Figure 3.

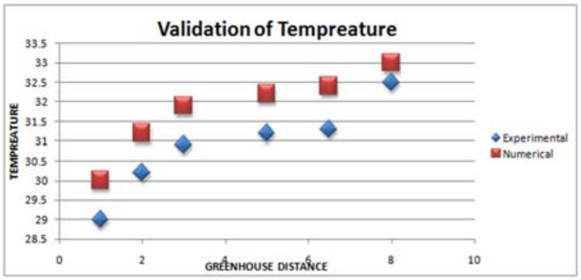

Figure 3 Validation of Experimental and Numerical values

9.3 Mesh & Boundary Condition

After its validation, this shows the scheme used in numeric model is correct, as almost the same results were achieved when validated with the experimental model. CFD model is now used to study the consequences of modified numerical model. Only one change is made, the exit is shifted towards the right of the greenhouse.

For the geometry, a control volume is selected representing a large domain including the greenhouse. The grid structure is structured, quadrilateral mesh with a higher density in critical portions of the flow subject to strong gradients. Body-fitted coordinates were also applied to exactly conform the grid to the contours of the boundary conditions. After several tries with different densities, the calculations were based on a 48 by 20 by 80 grid. This results from an empirical compromise between a dense grid, associated with along computational time, and a less dense one, associated with a marked deterioration of the simulated results.

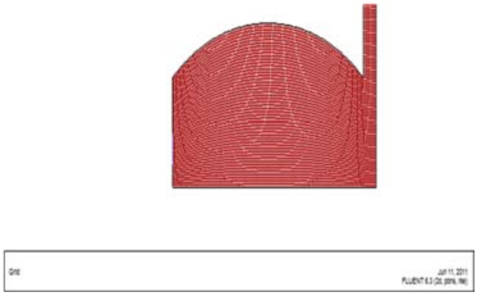

Figure 4Mesh and Boundary conditions of Modified Model

The boundary conditions prescribed a null pressure gradient in the air, at the limits of the computational domain, and wall-type boundary conditions along the floor and the roof whereas the side walls were treated as adiabatic. The boundary values at various regions used in the simulation are listed in table below:

Boundary values used in the simulations

Parameters	**Numerical value**
Wind direction	Perpendicular to the ridge
Temperature Of the cover °C Of outside air °C	 32 30
Inlet air	
Velocity, m/s	0.5
Relative humidity, %	70
Density, kg/m³	1.22
Gravitational acceleration, m/s²	9.81
Specific heat, J /kg°C	1004.00
Thermal conductivity, W/m²°C-¹	0.0263

10.0 Convergence history

The development of the micro climate environment inside the greenhouse system, in hot days, is shown in Figures (5.1) to (5.5)

Figure (5.1) illustrates the convergence properties development. This includes the values of the continuity, momentum, temperatures and turbulent quantities inside the greenhouse. This actually represents how strong the code used is. The code is able to handle free convection inside the greenhouse cavity and air flow channel (chimney) without any problem. Due to the large number of cells used (60000) the convergence required about 290 iterations to be reached. The jump in the convergence values at iteration 223 is due to the activation of the porous medium representing the crop. This technique is found to accelerate the overall convergence of the problem. About 45 min of computation time is required to achieve a converged solution on personal computer.

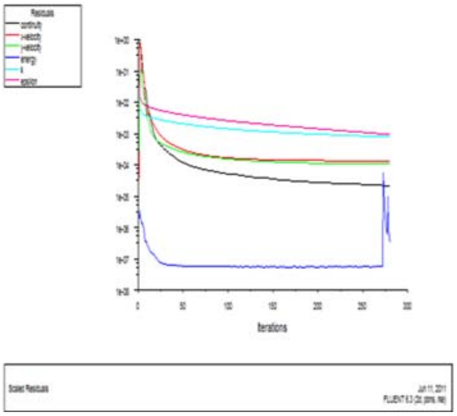

Figure: 5 Convergence history of the greenhouse

10.1Temperature Distribution

Figure 6 shows the temperatures contours within the greenhouse system. Due to the small walls temperature differences, the gravity appears to be not effective within the greenhouse plant cavity. This is mainly because the hottest wall is the top wall (due to solar energy absorption). The temperature distribution within greenhouse is between 285K to 293K which lies within the acceptable growth comfort values

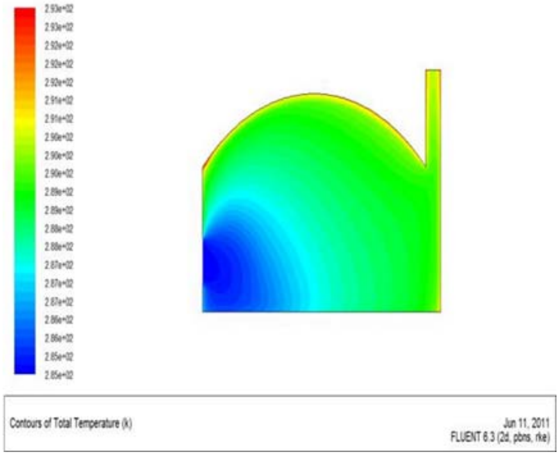

Figure 6 Temperature Distribution

Figure 7 show the free convection as the only driving force for natural flow circulation within the still. Higher air temperature rises upward from plant cavity (heat & mass source) and cold air flow down-ward along the green house (heat & mass sink). Two main large vortices, representing the natural air circulation inside the still, are developed as shown

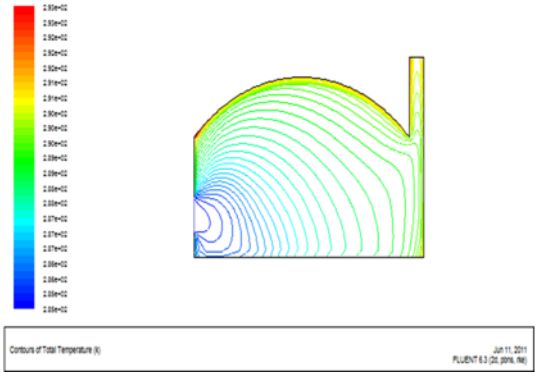

Figure 7 Temperature Distribution without filled

10.2 Velocity Distribution Figures 8 and 9show the flow pattern within the greenhouse in a form of velocity distribution and velocity vector (colored by velocity magnitude). As expected, and due to the symmetric boundary conditions for the greenhouse, a symmetric flow pattern is obtained around the greenhouse. For the greenhouse, two vortices are developed, one near the entrance of the plant cavity and other vortices at entrance of flow channel. Due to the higher resistance of plant to flow, the recirculation vortex developed at the entrance bottom corner has lower velocity than that developed within the top corner vortex. The vortices are more apparent in the velocity vector contours shown in Figure 9

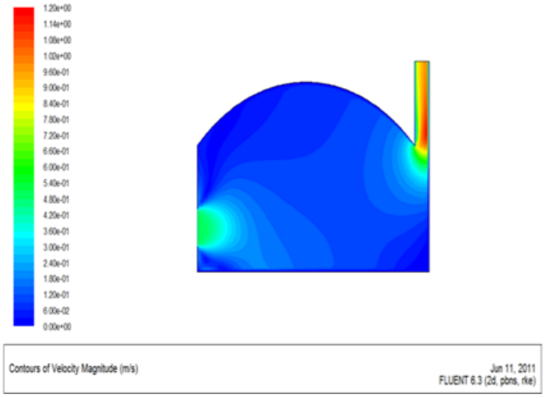

Figure 8 velocity distributions across the greenhouse

Figure 8 shows that within the plants zone, the air velocity varies between 0.1 - 0.2 m/ s which perfectly suits the plants growth as indicated in the comfort values for the plant growth.

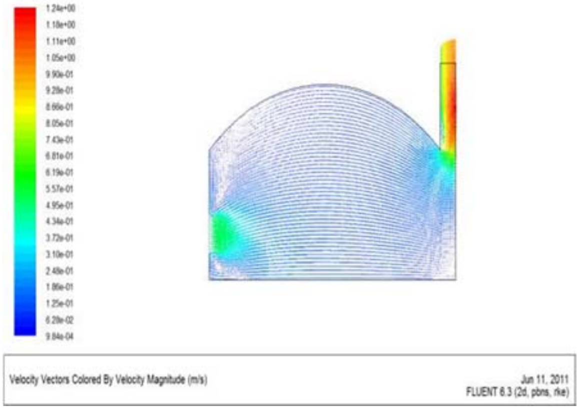

Figure 9 The vortices developed in the greenhouse

Conclusions

Following are the conclusions

- This system presents the best controlled conditions for Tulip growth inside the green house, which make it possible to grow the Tulip flowers round the year
- This system can be utilized in such a way that the tulip flowers can be produced throughout the year .The demand for tulip flowers varies throughout the year and the flowers can be supplied to the market throughout the year with the help of this system
- A numerical simulation of the steady state turbulent flow, temperature and velocity distribution inside an agriculture greenhouse is presented. The micro climatic environmental conditions results have been presented for the preconstruction of a greenhouse system. The results are presented for hot days where cold and humid air (from evaporative cooler) enters the greenhouse and leaves, through a thermal chimney.

- Turbulent flow, energy and humidity concentration equations have been solved using the numerical code FLUENT 6.1. The results have been presented in the form of velocity vectors, stream function, temperature distribution contours. The developed computer package proved to be an effective tool for the study and analysis of the micro climatic conditions of a pre-constructed greenhouse system for optimum plants growth.

- With the selected inlet flow conditions, the flow velocity, temperature, and relative humidity were found to be within the comfort values for plants growth.

- 4. The effect of some important environmental, design, and operational parameters on greenhouse microclimatic conditions and economics have been analyzed. The greenhouse can accept harsher environmental conditions that make its wall temperatures and inlet air temperatures 10 °C. The inlet velocity should not decrease below 0.5 m/s to avoid re circulating vortices that increases the relative humidity within the plants growth zone to un - acceptable values.

- The effect of some important environmental, design, and operational parameters on greenhouse microclimatic conditions has been analyzed. The greenhouse can accept harsher environmental conditions that make its wall temperatures and inlet air temperatures 10 °C. The inlet velocity should not decrease below 0.5 m/s, and the plants transpiration rate should not be higher than 0.2 g/m^3 in order to avoid re-circulating vortices that increase the relative humidity in the plants growth zone to un-acceptable values.

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