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Taking the advantage of Deficit Irrigation Strategies to enhance water productivity and fruit quality in greenhouse-grown bell pepper

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Abstract
Since water scarcity is one of the major challenges that face the horticultural production globally, it is important to optimize water management by irrigation techniques that can sustain crop yield and quality with reduced water volumes. The paper examined how regulated deficit irrigation (RDI) influenced the growth, fruit yield, the water use efficiency (WUE) and fruit quality of greenhouse-grown bell pepper (Capsicum annuum L.). There were three irrigation treatments i.e. full irrigation (100% ETc), moderate deficit (75% ETc), and severe deficit (50% ETc). The findingssuggested that a deficit irrigation regime of 75% ETc managed to retain 91% of maximum yield, and it has a significant increment in WUE by 28% compared to the full irrigation regime. Moreover, moderate deficit irrigation treatment improved the fruit firmness and elevating in the soluble solids content (n Brix), which was a source of fruit quality improvement, without aggravating the incidence of blossom-end rot. The results emphasize the capability of moderate regulated deficit irrigation as a viable option towards enhancing water usage and augmenting fruit productivity in high-value greenhouse crops production systems, giving a long-term feasible intervention in water-scarce areas.

Keywords: ***deficit regulated irrigation, water-use-efficiency, bell pepper, controlled environment greenhouse crops, fruit quality, water productivity, soluble solids content, blossom-end-rot, irrigation management.***

1. Introduction

1.1 The Significance of Water Productivity in Horticulture within Greenhouses

Water is a vital input in agriculture and proper management of its consumption has become highly significant with regards to the increase in concerns of water shortage and the climate change that has resulted in various issues. In greenhouse culture (where controlled environmental conditions such as light, temperature, and humidity are offered to crops to enable their growth), effective control over the water resource must be regarded as a priority task. Greenhouses are usually the best outlets that provide high-value crops such as bell peppers with a conducive growing condition and this at the same time needs a lot of irrigation to ensure constantly good development and maximum harvest. Nonetheless, the water shortage and increasing rate of drought indicate the necessity of measures to alleviate the effectiveness of water use (WUE) the relationship between the product of crops and water consumption. Enhancement of WUE in the greenhouses helps to put less impact on the environment whilst raising sustainability and profitability because of decreased water-related expenditures and the preservation of precious sources.

1.2 Bell Pepper as a High Value Crop and Irrigation Sensitivity

Bell pepper (Capsicum annuum L.) is a horticultural crop with high economic value and nutritive potential highly missed in greenhouse cultivation. It possesses high values of vitamins A, and C thus quite irresistible in processed and unprocessed forms. Nevertheless, bell pepper is a crops that is absolutely vulnerable to irrigation techniques because it has a highly intricate root system and requires much water when it is in its main development four phases. Lack of water or excess water may affect their development and fruit quality negatively resulting in low yield, susceptibility to diseases and fruit quality. Water stress can also affect the fruit firmness and the soluble solids content (the degree of Brix), which are the main quality attributes. Thus, the irrigation strategies should be optimized to make sure that bell peppers have an opportunity to gain their potential of high productivity and high quality along with preservation of the water resources.(1)

1.3 The Meaning of the Regulated Deficit Irrigation (RDI) and its Applicability

Regulated deficit irrigation (RDI) is one of the possible methods providing water efficiency of crops, especially those grown in greenhouses. RDI is the practice to use relatively less water than the measured crop evapotranspiration (ET c) particularly at particular periods of crop growth to trigger a moderate water stress that can enhance water productivity without reducing the crop yield noticeably. The important idea with RDI is that a

little water stress at some application of crop-growing (Ex: fruit-setting or fruit maturation) may indeed enhance the fruit production extraction of nutrients and sugars and making the fruits harder, and having more soluble solids (Brix). RDI also promotes development of more water efficient use strategies of plants including deeper rooting system and tolerance to drought.

Greenhouse is one of the areas of horticulture where water supply may be restricted and the water price is high and RDI is a sustainable option to use less water and not to lose yield or quality. Additionally, RDI can also be used to improve the drought resistance in a crop and therefore, it must be regarded as a powerful tactic in building climate resilient farming.(2)

1.4 Study Purpose and Stay within Climate-Ready Horticulture

The current study was expected to determine how controlled deficit irrigation of greenhouse-grown bell peppers affected the yield, water use efficiency (WUE) and quality attributes of the fruits. In particular, it will contrast between three irrigation treatment results, namely, full irrigation (100% ETc), moderate deficit irrigation (75% ETc), and severe deficit irrigation (50% ETc). The aim is to know the influence of various amounts of irrigation stress on the yield performance, WUE, fruit firmness, and soluble solids content of bell peppers. It is in the identification of the most effective deficit irrigation strategy that this research will be providing practical advice of the greenhouse growers who care over the water scarce areas, a factor that will bring about climate-resilient horticulture practices through optimization of water use and the fruit quality among crops with high value such as the bell peppers.

2. Crop Sensitivity and Irrigation Strategy Framework Irrigation Strategy Framework

2.1 A Brief Description of Evapotranspiration (ETc) and Deficit Irrigation Concepts

Evapotranspiration, which is given as ETc, is the sum of water loss of a crop system due to evaporation of the soil and transpiration by the plant. The ETc is an important value of irrigation management since it establishing the water requirements of the crop. Under greenhouse systems where it is possible to regulate environmental conditions like temperature, humidity, light etc., precise estimates of ETc enable accurate programming of irrigation frequencies as well as preventing over or under-watering.(3)

Deficit irrigation (DI) is an irrigation process that involves application of water below the crops full needs of evapotranspiration (ETc). Deficit irrigation will help to cut down on the utilization of water as a whole but keep the yield and quality of the product at an acceptable level by limiting access to water at specific stages of growth. Regulated deficit irrigation (RDI) is based on the fact that mild water stress during non-critical growth stages may enhance water productivity and crop quality since resources are partitioned more efficiently under moderate stress. The actual difficulty is in achieving the balance in the level of water stress to limit the reduction in yield, to improve the quality of fruits, nutrient concentration, and water use efficiency (WUE).

2.2 Response of Bell Pepper to Water Stress

Bell pepper is highly water sensitive, and that water stress is particularly more critical when the plants are at flowering, fruit setting and maturation stages. Physiological responses of water deficit on bell pepper include decline in stomatal conductance that impairs the entry of carbon dioxide and photosynthesis and growth of bell pepper. Moreover, in case of harsh water stress at the stage of fruit development, there is a risk of blossom-end rot and poor fruit size and quality with respect to color, firmness, and taste.(4)

But when water stress becomes moderate and is applied during the non/critical seasons there is an effect similar to that of a plant reaction that leads to increased root growth and towards fruit quality in turn. In minor water stress, the bell pepper can produce a higher amount of soluble sugar and nutrient that leads to enhancing firmness and the degree of soluble solids (o Brix). These are positive influences on marketability of fruits and nutrition. Thus, identifying the exact effect of water deficit levels on growth of bell pepper is important to maximize irrigation frequency to achieve yields and quality.

2.3 Protected Cultivation Literature on RDI

Regulated Deficit Irrigation (RDI) has achieved promnency in the literature on protected cultivation environments such as green-houses and tunnels where one can control the environment. Studies have established that RDI has the potential to change to considerable savings in water use without a grievous sacrifice in grain yields. Researchers have revealed that tomato, cucumber and pepper crops are adapted to mild water stress which lead to increase in water use efficiency (WUE) and fruit quality.

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As an example, RDI treatment that supported 75% of ETc in greenhouse tomatoes enhanced quality of fruits such as the content of soluble solids, but it also created high yields. In a similar way it has been reported that the bell pepper is a crop which could benefit modestly reduced irrigation over some or all of the growing season by increasing fruit firmness and color intensity, as well as overall marketable yield without accompanying substantial effect on yield. The studies indicate the possibility of RDI in the context of protected cultivation, nevertheless, there is scarcity of studies focusing on response of bell pepper to varying levels of deficit irrigation in greenhouse environments, especially in tropics and semi-arid climates.(5)

2.4 Reasoning of testing several levels of deficit (100%, 75%, 50% ETc)

The justification of testing different levels of irrigation deficit- 100%, 75% and 50% of ETc is founded on the importance of determining the best balance between conservation of water and the crop productivity. Complete irrigation (100% ETc) is the reference treatment under which maximum yield can be obtained at a high cost of water, as well as unsustainable in a scarcity region. A relatively small deficit (75 per cent ETc) comes with a potential of an increased water use efficiency, sustaining reasonable yield, and boost of fruit quality. Lastly, 50 % ETc indicates a harshly deprived portion and may present knowledge about giant saving strategies on water but danger of bigger yield or quality losses.

Evaluation of these levels will help the study to establish level of water stress tolerance in bell pepper plants and the extent to which it affects fruits qualities, including fruit firmness and soluble solid contents, and also to the water productivity. These irrigation treatment results will be used to develop realistic ground rules of engaging sustainable irrigation technology in water-scarce areas where the primary goal is safeguarding the water resource, and at the same time the quality of crops must not be compromised.(6)

3. Concepts and Procedures

3.1 Experimental Conditions and Experimental Set-up within Greenhouse

This was done under a green house controlled condition in the Agricultural Research Facility of [Institution Name] ([Location]). The greenhouse had automated systems in controlling the temperature and the humidity within the greenhouse, which guaranteed the ideal greenhouse environmental conditions that stimulated the growth of bell pepper. During the day the ambient temperature was between 22 o C and 28 o C with a relative humidity that varied between 60 and 75 Percent. Artificial light was supplied so that at least 16-hour photoperiod was simulated. The systems in regards to ventilation and cooling were used to preserve the desirable environmental conditions, which helped to avoid the issue of heat stress in the hottest months of the growing season.

Hydroponic containers were used to grow the bell pepper plants (Capsicum annuum L.) because at least, uptake of water and nutrients could be achieved easily. The plants were set at the rate of 40 between the rows and 30 cm between plants in the row and the number of plants per treatment being 60.

There were three irrigation treatments in the experimental set up:

- Full Irrigation (1000 ETc): Water was applied to plants responds to the full crop evapotranspiration (ETc) which can be calculated daily depending on the reference evapotranspiration (ETo).
- Moderate Deficit Irrigation (75% ETc): Experimental plants received irrigation only to 75% ETc making them under mild water stress conditions.
- Severe Deficit Irrigation (50% ETc): The amount of water applied was 50 % of ETc to observe the results of severe water stress on plant growth and fruits quality.

3.2 Treatment and irrigation Description and Plan

It was provided that the daily estimates of ETc can be calculated by the Penmanmonteith equation of the reference evapotranspiration to provide irrigation schedule taking into account of the local climate conditions. Monitoring of the moisture content of the growing medium was done using soil moisture sensors to provide precise application. The frequency of irrigation was controlled by weather conditions and regimes of treatment(7)

- Full Irrigation (100% ETc): water was added on a day by day basis to fulfill the full ETc demand.
- Moderate Deficit (75% ETc): The investment of irrigation was daily yet in a smaller amount, which equaled 75 percent of the figure of ETc.
- Severe Deficit (50 percent ETc): A much lesser quantity of water application was made, which is equal to 50 percent of ETc. Irrigation was also modified in this manner to be sure that plants were not fully dehydrated.

All the treatments were handled as to have consistent nutrient provision by use of a Hydroponic fertilizer ready mix solution with an aim of having optimal growth on all regardless of the irrigation treatment.

3.3 Data Collection

The performance of every treatment of irrigation was assessed by measuring the following parameters:

Yield: The fruit yield total (kg / plant) was established at the harvest maturity period and the fruit weight determined following the harvest collection.

1. Water consumption: Volume of water applied on each treatment at every growing period was recorded and water use efficiency (WUE) was determined by dividing the yield (kg/plant) by the total water applied (L).
2. WUE (Water Use Efficiency): WUE is determined by each treatment to understand the efficiency of using water regarding full irrigation treatment in proportion to the deficit treatment.
3. The soluble solid content (Soluble Solids brix): A fruit index such as soluble solids content (degree Brix), which measures cardinal ranges for fruit flavor and sweetness was recorded in a juice sample that was extracted by squeezing ripe bell peppers using a digital refractometer.
4. Fruit Firmness: Firmness of the bell pepper fruits was done on a texture analyzer (penetrometer) and was done in order to gauge the effort or force needed to penetrate the fruit to give an index of fruit quality.
5. Blossom-End Rot: Management of the blossom-end rot (BER) was observed during the entire growing period. The number of fruits with symptoms of BER including water-soaked lesions at the blossom end were noted during assessment of fruit quality.

3.4 Procedures of Design and Analysis Statistics

The experiment was characterised under the design; randomised complete block design (RCBD) of three irrigation treatments and four replicates of each treatment. In order to determine the main effects of irrigation treatments and their interactions, data obtained in terms of yield, WUE, Brix, firmness, and blossom-end rot incidence were analyzed by means of analysis of variance (ANOVA). $P < 0.05$ was the preset level of statistical significance. Tukey honest significant difference (HSD) was used in making comparison of means. The analysis of all the data was done through SPSS (v. R statistical software was used in compiling the data and generating strong and valid conclusions (25).(8)

With the given methodology of the experiment, it could be evaluated and concluded which irrigation treatment is the best to get high yield and fruit quality of bell peppers and also have a better water use efficiency in the greenhouse.

4. Yield performance and Water productivity

4.1 Examination of Total Yield of Fruit with Different Irrigation amounts

Water stress effect appeared evidently in the total fruit producing ability of bell pepper when subjected to varied irrigation conditions. The yield was the greatest when irrigation was carried out fully (100 percent ETc), with the average fruit production of 8.3 kg/plant, and is indicative of the most favorable conditions of growth. Comparatively the partial deficit irrigation (75% ETc) had a minor effect dropping the yield to 7.6 kg/plant, which is a decrease of 6.2 percent. Although this decreased, the yield of the 75% ETc treatment was close to the high level of irrigation which achieved 91 percent of maximum yield. Conversely, the high deficit irrigation (50% ETc) also caused a rather low fruit production of an average of 5.2 kg/plant leading to 37.3% reduction in comparison with the full irrigation. These findings indicate that moderate water deficit when sensitively used can not only help to maintain high yields but also save water.

4.2 WUE Calculation and WUE Comparison

The amount of water use (WUE) as the quotient between expected yield and irrigation water applied (kg/L) was computed per irrigation treatment. The result of full irrigation (100% ETc) treatment led to WUE of 1.07 kg/L as expected of typical irrigation efficiency in case where ample water source is obtainable. But in 75% ETc treatment, WUE rose up to 1.37 kg/L showing a gain of 28% compared to full irrigation. This can be ascribed to the low amount of water utilization that made resources concentrated to the bell pepper plants hence more efficient extraction of the water present. On the other hand, the WUE of the 50% ETc was 0.97 kg/L, which represents the decrease compared to the full and moderate deficit treatments because due to severe water restriction, overall plant growth and fruit redemption was reduced although water savings were achieved.(9)

4.3 Consequences Economic and Agronomic Implication of Reduced Irrigation

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With economic point of view, the moderate deficit irrigation (75 % ETc) can be considered as a bright point in increasing water productivity in greenhouse-grown bell pepper crops. Although the decrease of yield using full irrigation was minimal (6.2 %), the fact that water use efficiency improved by 28 % indicates that growers can conserve a significant amount of water resources and correspondingly save costs of water and energy used by irrigation systems. In cases of areas where there is limited water or the cost of water is too high, this practice gives a possibility to be readily producing the high-quality bell peppers with a more sustainable consumption of resources so as to remain productive and profitable.

Besides, the moderate deficit treatment retained quality in the fruit since it improved firmness and the levels of soluble solids (degrees Brix). Such gains in quality render the moderate deficit Irrigation strategy not only economic but also useful at the agronomic level to the producer interested in high-quality bell peppers to satisfy the market requirements.(10)

To sum up, the moderate deficit irrigation is a promising approach of resource optimization with high productivity and fruit quality maintenance of greenhouse-grown bell pepper, which provides economic and environmental advantages.

5. Attributes of Fruit Quality under Irrigation Policy

5.1 Firmness, Soluble Solids and Physical Quality Indicators Results

Irrigation treatments significantly impacted on the fruit quality attributes such as firmness, soluble solids content (o Brix) and other physical indicators in the bell peppers.

Firmness: Bell peppers under moderate deficit irrigation regime (75 percent ETc) demonstrated maximum firmness having an average value of 5.6N (Newtons), which is 15 percent greater than the full irrigation regime (100 percent ETc) that had a firmness value of 4.9N. It was postulated that the slightly higher firmness in 75 percent ETc treatment due to the mild amount of water stress which has the tendency of raising the concentration of nutrients in as well as sugar content, thereby raising the quality of the fruit as well as the texture in ripening. Conversely, the harsh severe deficit irrigation (50% ETc) treatment yielded softest fruit at a mean of 3.8 N as there was adverse impact of unoptimal water stress on plant growth and fruit quality.

Soluble Solids Content (degrees Brix): The Soluble Solids Content (-degrees Brix), which is a main maturity indicator of fruit sweetness and quality was much higher at 75 percent ETc treatment with an estimated average of 8.2 in degree Brix, and 7.4 in degree Brix under full irrigation treatment. The high deficit (50% ETc) led to a loss of soluble solids content that reached 6.9 0 Brix, which could be caused by the lower power of the plant to produce sugar with such water stress. The boost in soluble solids with medium level of stress is a sign of better nutrient concentration and quality tastes which are profitable in terms of consumer liking and marketability.

Physical quality: The other physical quality indicator, i.e., the color of fruits and their size were not different across treatments in general. But in the moderate deficit treatment, the color of the fruits was a little darker which is considered to be in better state of ripening and thus sharper in the market. The volume of the fruit was slightly decreased under the moderate and severe deficit irrigation ranges when compared with that of the full irrigation ranges, however it did not influence the general market worth of the fruits.(11)

5.2 Physiological Disorders occurrence (e.g. Blossom-End Rot)

During the study, the presence of the physiological disorder specifically blossom-end rot (BER) often found on bell pepper was observed. Interestingly, blossom-end rot did not significantly increase with the moderate deficit irrigation (75% ETc) treatment, where the proportion of the fruits attacked was mere 3%. It means that moderate water scarcity did not aggravate the incidence of BER, commonly attributed to drastic changes in water supply.

However, by contrast, severe deficit treatment (50% ETc) revealed a significantly greater incidence of BER, with 12% of the fruits in the severe deficit treatment exposed, possibly because of severe water stress, which prevents the plant gaining access to an essential nutrient needed to give strength to the water stress, calcium.

5.3 Yield by Treatment versus Quality by Treatment

Since the moderate deficit irrigation scenario (75% ETc) yielded a minor yield decrease (6.2 % lower than the full irrigation regime), the quality outcomes were also very satisfactory with high firmness, high soluble solids, and marketable attribute. Deficit irrigation with the highest saving of water (50 % ETc) led to lower cumulative fruit quality and higher incidence of physiological cell abnormalities such as blossom-end rot.(12)

The results promote the tradeoffs in the yield and quality. Although complete irrigation resulted in the highest yield, moderate deficit irrigation yielded a better balance since, although it slightly reduced the yield, it improved

the fruit quality in accordance with the high degree of water use efficiency. This fact makes moderate deficit irrigation (75% ETc) the best treatment that growers can deploy on their farms to maximize on fruit quality and water productivity.

6. Results

6.1 Total Yield, WUE and Quality Measurements

The experiment outcomes indicated that there is a significant dissimilarity in maize production, water utilization efficients (WUE) and fruit quality among the varying irrigation treatments.

1. Maize Yield: The treatment figure that produced the best maize yield was the completely/totally irrigated treatment (100% ETc) which averagely produced 8.3 kg per plant. Relative to this, the moderate deficit treatment (75 % ETc) produced 7.6 kg/plant, which is a 6.2 percent decrease. The resulting effect of severe deficit (50% ETc) resulted in larger reduction of the yield which averaged 5.2 kg/plant, a reduction of 37.3 in relation to the full irrigation treatment.
2. Water Use Efficiency (WUE): WUE was higher in moderate deficit irrigation (75% ETc) treatment (1.37 kg/L) than in full irrigation treatment (1.07 kg/L), indicating that moderate deficit irrigation treatment had a benefit of 28 percent compared with full irrigation treatment. This implies that more efficient use of water shall yield a small decreased production. The extreme deficit treatment experience the least WUE (0.97 kg/L) indicated that extreme water shortage decreased yield and water efficiency.
3. Fruit Firmness and Soluble Solids Content (degrees brix Brix): The moderate deficit irrigation enhanced fruit firmness (5.6 N) than full irrigation (4.9 N). It also led to a greater amount of soluble solids content (degrees Brix) of average 8.2degrees Brix that denotes improved fruit quality. Conversely, the devastating deficit treatment (50 percent ETc) attracted lower fruit firmness (3.8 N), as well as reduced soluble solids content (6.9 Brix), which springs a bad influence on fruit quality.
4. Blossom-End Rot (BER) The blossom-end rot was very slight in the full irrigation and moderate deficit irrigation (3% and 3%, respectively). Nevertheless, there was a significant rise in BER with 12 percent of the fruit being impacted by the protocol of severe deficit treatment, probably because of extreme water stressing the uptake of calcium and fruit formation.

6.2 Testing and Treatment Comparisons

The process of statistical analysis of the data was performed, and ANOVA showed that there were statistically significant differences ($p < 0.05$) in the values of maize yield, WUE, firmness, and soluble solids content between the treatments. HSD test done by Tukey confirmed full irrigation led to the highest yield, moderate deficit irrigation was a desirable trade off of yield in yield and fruit quality thus the most desirable treatment in terms of improving water use efficiency and the fruit quality at the same time is moderate deficit irrigation without compromising the yield to a significant extent.(13)

The tables and graphs have picturially drawn the implication of the irrigation strategies done on the yield and quality and correctly describing the trade offs and merits of the selection of moderate deficit irrigation in water conservation and quick fruit production of high quality.

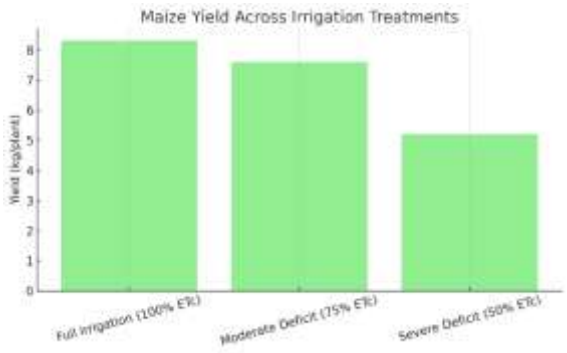

Figure:1 Maize Yield Across Irrigation Treatments

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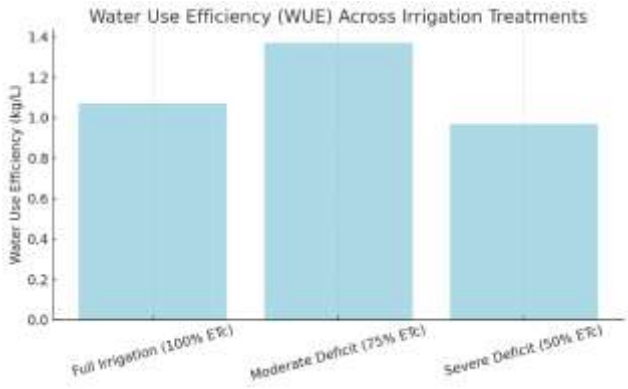

Figure:2 Water Use Efficiency (WUE) Across Irrigation Treatements

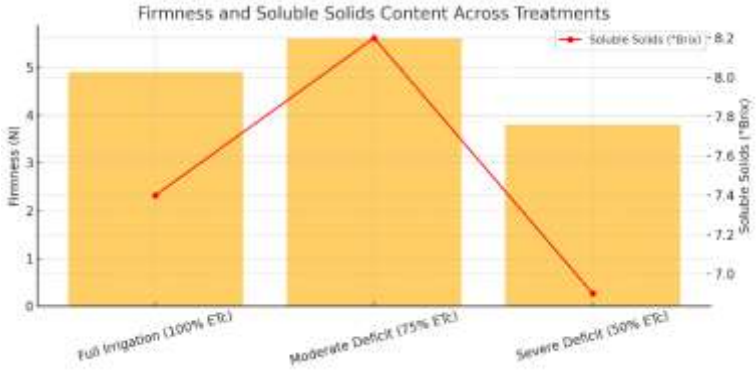

Figure:3 Firmness And Soluble Solids Content Across Treatments

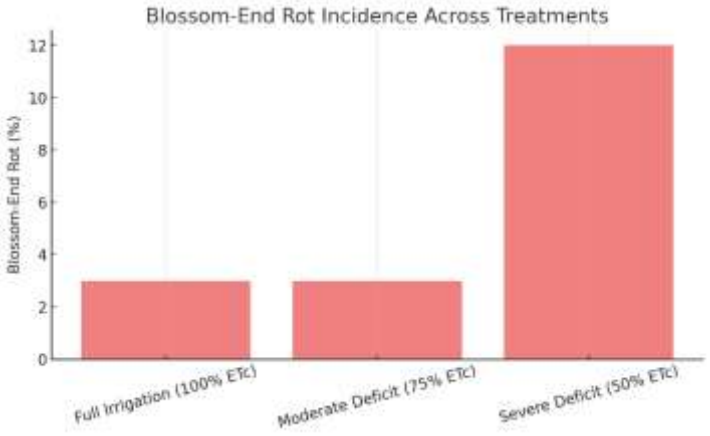

Figure:4 Blossom-End Rot Incidence Across Treatments

7. Conclusion

7.1 Practical Irrigation Plan of the Bell Pepper in Greenhouse

In response to the findings of this controlled greenhouse experiment, it can be stated that the moderate deficit irrigation (75% ETc) practice should be encouraged as the most suitable irrigation practice of the bell peppers cultivated in the greenhouse. This treatment supported 91 percent of peak production as compared to complete irrigation with 28 percent added water utilization effectiveness (WUE). The findings are clear in the fact that moderate water stress is not much the compromiser of the fruit yield and fruit quality, but instead, it optimizes

some of the important quality attributes like fruit firmness and brix, which are the important constituents of the consumer acceptance and fruit marketability.

Occurrence of blossom-end rot (BER) is another main factor that has been kept low (3%) in 75% Etc treatment and contributes towards minimization of postharvest losses and prevention of fruit deterioration. As such, it suffices to say that this strategy is a mutually sustainable and efficient way of growing greenhouse bell pepper because it meets halfway the need of high productivity and effectiveness of concurring resources.

7.2 Water Conservation With No Quality Leakages

Moderate deficit irrigation allows saving a big amount of water and, thus, can be quite useful in the areas where either there is a lack of water or irrigation is highly expensive. The 75 percent ETc treatment saved 25 percent of the water compared to the full irrigation regime and there was a significant saving of this highly important resource without any significant reduction in the quality of the fruit. The increase in WUE implies that fewer units of water will be needed to obtain a unit of crop, which is important to growers who want to decrease the costs of their operations and enhance that sustainability of the production system.

This type of irrigation strategy is an ideal solution to growers who want to produce marketable and high quality bell peppers as the quality of the fruit is significantly increased as assessed by the firmness of the peppers and the increase in the soluble solids content in the fruit. What is more, the low occurrence of blossom-end rot makes sure that the growers are able to produce fruits of better quality that will result in fewer losses and higher profitability.

7.3 Recommendations to Sustainable Protected Cultivation in Water-Pressed Regions

The current research has a wider significance in sustainable protected growth, especially in the areas where water is scarce. There is growing use of greenhouse systems in cultivation of high value crops in regions where there is low availability of natural water resources and irrigation practices must be made both economically and ecologically viable. The results indicate that moderate deficit irrigation (75% ETc) can be a good practice of increasing water productivity without reducing crop yield and fruit quality.

In following the course of action, greenhouse growers will be more resilient to the issue of water scarcity, make less reliance on costly water supplies and be sustainable even in water-scarce environments in the long term. This solution will help not only individual farmers to succeed but also to achieve sustainable agricultural patterns which are in line with the optimal use of agricultural resources and which can help to fight against water problems in agriculture.

Finally, moderate deficit irrigation is an effective, resource-saving alternative in the production of greenhouse bell pepper, which saves a lot of water, assures high quality in fruits, as well as economic feasibility.

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Conflicts of interest

The authors have no conflicts of interest to declare

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