Jurnal Agricultural Biosystem Engineering
https://jurnal.fp.unila.ac.id/index.php/ABE/index
ISSN 2830-4403
Received: May 25, 2024
Accepted: June 6, 2024
Vol. 3, No. 2, June 28, 2024: 228-237
DOI: http://dx.doi.org/10.23960/jabe.v3i2.9105

Impact of Deficit Irrigation on Bell Pepper (Capsicum annuum var. Grossum) Cultivation

Ridwan[1], Annas Setia Bekti Nugroho[1], Elhamida Rezkia Amien[1*], Sandi Asmara[1], M. Amin[1]

[1]Jurusan Teknik Pertanian, Fakultas Pertanian, Universitas Lampung

**Corresponding Author:* elhamida.rezkiaamien90@fp.unila.ac.id

Abstract. *The purpose of this study is to determine the effect of deficit irrigation application on the growth of bell pepper plants and to assess the efficiency of irrigation water application for bell pepper plants. The design used in this research is a Completely Randomized Design with 4 levels of deficit irrigation treatments and six replications. The procedures involved in this study include analysis of soil moisture to determine field capacity and permanent wilting point, treatment conditioning, planting, plant maintenance, observations, and finally, harvesting. The data obtained were tested for homogeneity of variances using the F-test, and if there were differences among treatments, further analysis was conducted using the Least Significant Difference test at the 5% level. The results of the data analysis are presented in tables, graphs, and diagrams. Deficit irrigation treatments significantly affected the plant height and leaf number parameters. The plant response to irrigation was limited under deficit irrigation based on total fruit weight, where bell pepper plants produced the best fruit under the 80% deficit irrigation treatment, with an average total fruit weight of 242.17 grams. Meanwhile, in the ID4 treatment, the plant results were less favorable due to stress. The response of the results to water (Ky) indicates that the Ky value (Ky <1) for bell pepper plants in the ID2, ID3, and ID4 treatments shows values less than 1, meaning that these treatments are tolerant to water stress.*

Keywords: *Bell Pepper, Deficit, Irrigation, Yield Response*

1. Introduction

Paprika (*Capsicum Annum* var. Grossum) is a plant native to subtropical regions of Central America and is not indigenous to Indonesia (Štursa et al., 2018). Paprika is a horticultural crop classified as a vegetable that is commonly used for food consumption. Besides being used for daily consumption, paprika also serves various purposes in the food processing industry. Paprika is a highly potential horticultural commodity for development due to its high demand, making it a valuable vegetable and a contributor to foreign exchange through exports. The demand for paprika has been increasing both domestically and internationally (Dasipah et al., 2011). According to the BPS (2017), the productivity of paprika in Indonesia in 2017 was 28.76 tons per hectare, whereas the potential productivity of paprika generally ranges from 54.97 to 56.16 tons per hectare.

Cultivating crops in drylands indeed requires careful planning, especially in water management or irrigation. The fluctuating availability of water each year and high physiological processes like evapotranspiration can lead to significant decreases in groundwater levels (Mahmud et al., 2022), thereby causing stress to plants and affecting their productivity.

One strategy to conserve water in agriculture is by improving water use efficiency (Sumaryanto, 2006). One method used is deficit irrigation, where plants are given less water than their optimal requirements but without reducing productivity (Rosadi, 2012). With this approach, water usage can be minimized without sacrificing yield.

Based on this explanation, research on the impact of deficit irrigation in the early growth stages of two varieties of bell pepper plants (*Capsicum annuum* var. Grossum) is crucial. The main objective of this research is to evaluate how deficit irrigation affects the growth of bell pepper plants and to assess the efficiency of irrigation water application in the context of bell pepper cultivation.

2. Research Metodology

This research was conducted at the Green House Laboratory Integrated Field of the Faculty of Agriculture, University of Lampung, with a duration of approximately 160 days. The tools used in the cultivation process included a bucket (46 cm tall and 32.5 cm in diameter), a digital scale with a capacity of 10 kg, a soil sieve with a size of 0.5 cm, a 1000 ml measuring glass, sacks, and a hoe. Meanwhile, the tools used for analysis were an oven, a digital pH meter, an analytical balance, and cups. The materials used included Red Star F1 bell pepper seeds produced by Known You, soil media, NPK fertilizer, and water.

The design used in this research was a Completely Randomized Design (CRD) with 4 levels of deficit irrigation treatments and six replications. The treatments conducted are shown in Table 1. From these factors, 4 treatment combinations were obtained. Each treatment was replicated 6 times, resulting in 24 experimental units with one plant per unit.

Table 1. Levels of deficit irrigation treatments

Treatments	Explanations
ID1	Soil moisture content was conditioned to (0-20)-100% KAT
ID2	Soil moisture content was conditioned to (0-20)-80% KAT
ID3	Soil moisture content was conditioned to (0-20)-60% KAT
ID4	Soil moisture content was conditioned to (0-20)-40% KAT

Note: KAT is Soil moisture content

2.1. Research Procedure

2.1.1 Soil Moisture Content (KAT) Analysis

Measurement was conducted by determining the soil moisture content (KAT) using the Gravimetric method, which involves weighing. Weighing was performed daily in the morning (06:00-07:30 WIB). The irrigation water application method was carried out using the following equation:

$$JI = W_{fc} - W_i \quad (1)$$

JI is the amount of irrigation water (grams), Wfc is the weight of the plant container at field capacity (grams), and Wi is the weight of the plant container on day i (grams).

The gravimetric method is used for each treatment by returning the water supply to field capacity condition. The irrigation water supply is calculated using the following equation:

$$JI = W_{ba} - W_{bi} \quad (2)$$

Where Wba is the weight of the plant container at the upper treatment limit (grams), and Wbi is the weight of the plant container today (grams).

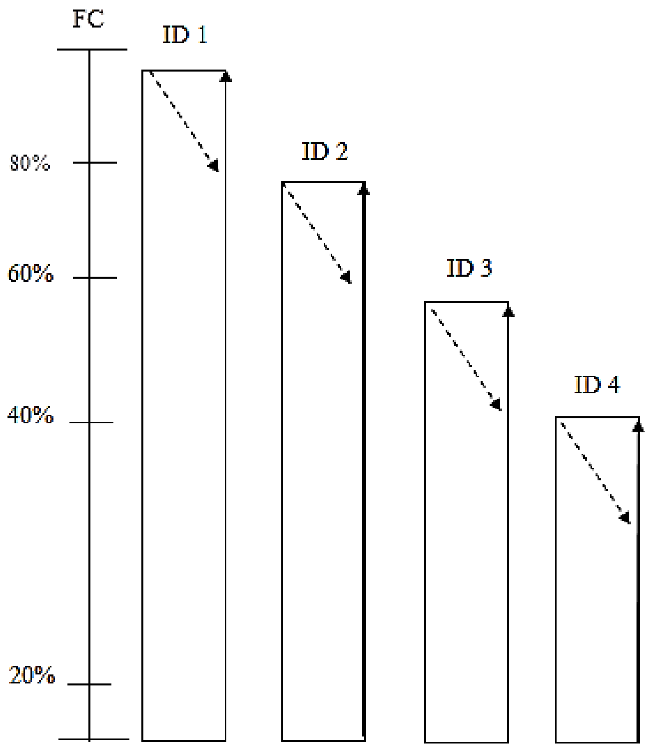

Figure 1. Ilustration of deficit irrigation treatments

2.1.2 Pepper Seed Planting

Pepper planting is carried out after the seedlings are sown and then transferred to the growing medium in buckets after 2 weeks. Planting is done with a single system in each bucket with 1 pepper plant per hole.

2.1.3 Plant Maintenance

Plant maintenance is carried out 7 DAT (days after transplanting). The goal is to meet the soil space and nutrient needs of the plants so that competition is minimized. Plant maintenance includes fertilization, weed control, and irrigation according to each treatment. The fertilizers used are NPK, KNO3, and MKP.

2.1.4 Observation and Measurement

Observations are divided into three parts: daily observations, weekly observations, and final observations. Daily observations involve measuring the water needs of the plants. Water needs are calculated using daily evapotranspiration data, which is determined by weighing each treatment.

Weekly observations include monitoring plant height and leaf count, starting from 1 week after planting until 12 weeks after planting. Final observations are conducted during pepper harvesting, assessing total pepper production and response to yield (Ky).

2.1.5 Harvesting

Harvesting is carried out at the beginning of the 13th week after planting, in the morning. Harvesting is done by picking the pepper fruits and observing the yield.

2.2 Data Analysis

The obtained data is tested for homogeneity of variance using the F-test, and if there are differences in the treatments, it is followed by the Least Significant Difference test at the 5% level. The test results are presented in the form of tables, graphs, and diagrams.

3. Results and Discussion

3.1. Soil Analysis

The soil used in this study is Podsolic soil. This soil is red-yellow in color and has few nutrients. The soil that has been collected is then analyzed for its NPK values, soil pH, and wet basis moisture content. Wet basis moisture content is used to measure field capacity (FC) and permanent wilting point (PWP) using the gravimetric method. The nutrient content of the soil used can be seen in Table 2.

Table 2. Results of soil content analysis

Variable	Value
Total N	0.06 %
Available P	1.97 ppm
Exchangeable K	0.17 me / gram
C-Organic (%)	0,38 %
pH	5.76
Wet basis Moisture content	4.69 %

These elements Nitrogen (N), Phosphorus (P), and Potassium (K) are important elements that influence plant growth, while pH is a determining factor for soil fertility. Additionally, a micronutrient needed by peppers is Sodium (Na), which functions in osmosis (water movement) and ion balance in plants. Field capacity of the soil is measured to determine how much water the soil can hold. The soil used has a field capacity of 41%. Therefore, the deficit irrigation water requirements of 80%, 60%, and 40% of available water are respectively 38%, 35%, and 40% of Field Capacity (41%).

3.2. Water Requirements

The effect of deficit irrigation treatments on the water requirements of pepper plants is presented in Figure 2. Data show that the water requirements of the plants from various treatments were the same during weeks 1-3. However, there was a significant increase during weeks 4-12. The water requirements for each treatment increased with the growth of the plants. The highest water usage was in the ID1 (100%) treatment, while the lowest water requirement was in the ID4 (40%) treatment.

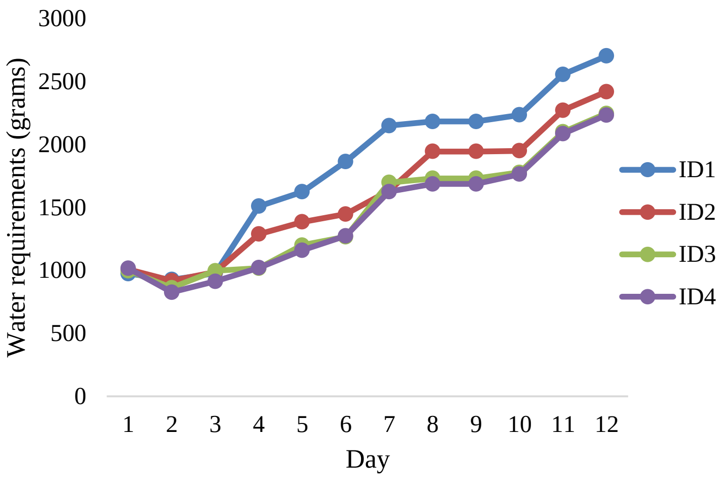

Figure 3. Plant water requirements

The results of the ANOVA test on the effect of deficit irrigation on the water requirements of pepper plants are presented in Table 3. Table 3 shows that the effect of deficit irrigation on the water requirements of pepper plants is significant at the 0.05 level. Furthermore, the effect of deficit irrigation on the water requirements of pepper plants was tested using the Least Significant Difference test at the 0.05 level.

Table 3. ANOVA test on the effect of deficit irrigation on the water requirements of Pepper plants

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	862021.792	287340.597	14.19	<.0001
Error	20	404933.167	20246.658		
Corrected Total	23	1266954.958			

Table 4 presents the data of the Least Significant Difference test on the effect of deficit irrigation factors on the water requirements of pepper plants. The data show that in treatment ID1, it differs from treatments ID2, ID3, and ID4, and is the treatment with the highest water requirements. This indicates that deficit irrigation affects the water requirements of the plants. In treatment ID1, the plants had better growth, thus requiring more water to grow and produce fruit. Plants in treatments ID2, ID3, and ID4 did not require as much water as those in treatment ID1 because the plants in those treatments did not grow as well as those in ID1.

Table 4. Least significant difference test of deficit irrigation factors on plant water requirements

Treatment	Mean value	Notation
ID1	2702.67	a
ID2	2418.50	b
ID3	2246.17	c
ID4	2232.50	c

The factors of the right amount and timing are important in deficit irrigation. Providing the right amount of water to peppers at the right time can maintain plant productivity. From the research conducted, irrigation water was given to peppers weekly with a daily interval of 500 ml per day, applied gradually each day.

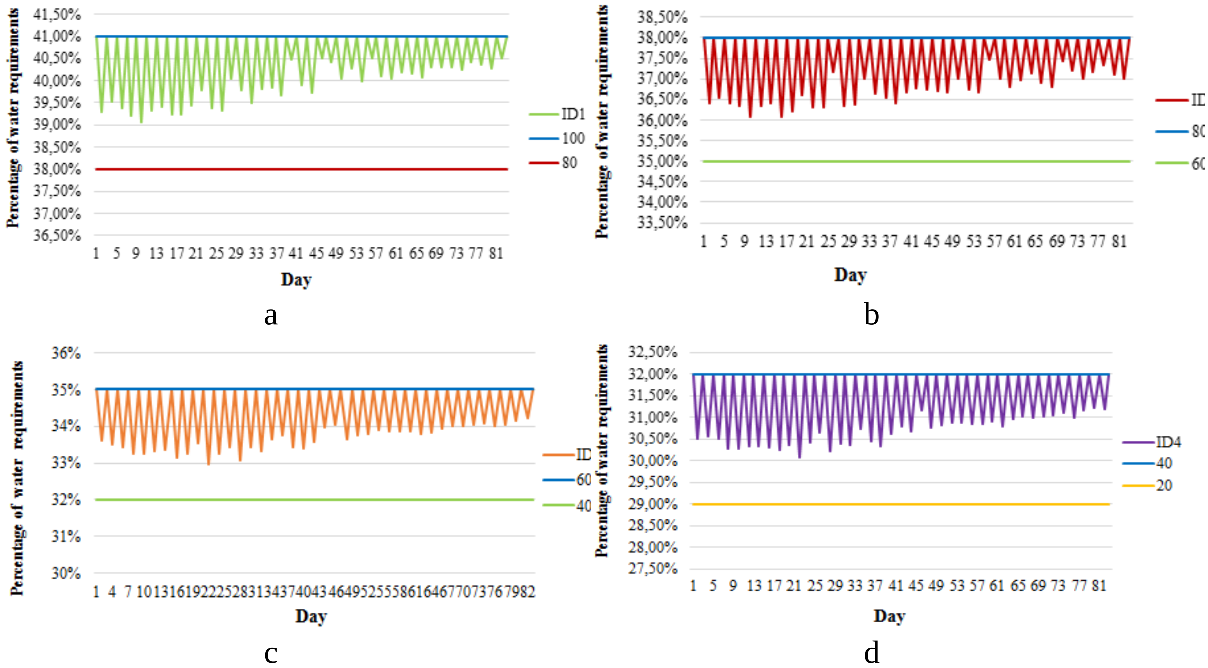

Figure 4. Graph of irrigation water requirement percentage (a) 100%, (b) 80%, (c) 60%, and (d) 40%

Based on Figures 4a and 4b, the percentage of water for the 100%, 80%, and 60% deficit irrigation treatments did not affect plant growth and pepper plant production because the irrigation water was always returned to the field capacity (FC) position, and in these treatments, it was far from the permanent wilting point (PWP). However, plant production was more optimal with 80% irrigation water compared to the 100% deficit irrigation treatment. Plant production with 60% irrigation water was not as optimal as with the 100% and 80% deficit irrigation treatments. In the 40% deficit irrigation treatment, plants experienced stress (Figure 4d). The plant's response to 40% irrigation was wilting and slow growth because this treatment was near the lower limit, resulting in small fruits.

3.3. Plant Height

Plant height growth from various treatments increased significantly from 1 to 6 WAT (weeks after transplanting). Then, from 7 to 12 WAT, there was no significant growth because this phase had entered the generative phase. The best plant height growth was in the ID1 (100%) treatment. The lowest plant height growth was in the ID3 (60%) treatment. Treatment ID1 showed better growth compared to other treatments.

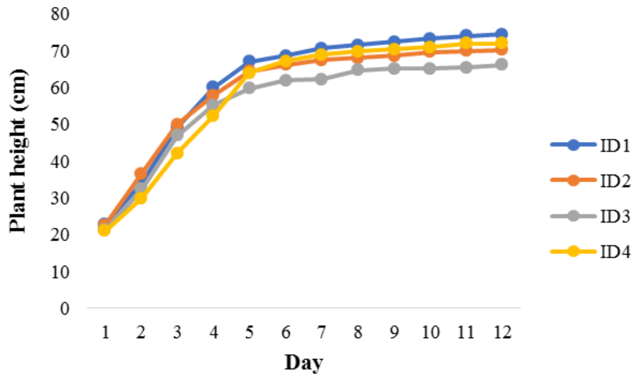

Figure 5. Pepper plant height

The height of pepper plants is 50-100 cm when planted in soil. From the plant height growth data, an ANOVA test was conducted to determine whether there were significant differences in each treatment's effect on deficit irrigation on pepper plants. The results are presented in Table 5. Table 5 shows that the effect of deficit irrigation on the height growth of pepper plants is significant at the 0.05 level. Furthermore, the effect of deficit irrigation on pepper plant height was tested using the Least Significant Difference test at the 0.05 level (Table 6).

Table 5. ANOVA Test on the Effect of Deficit Irrigation on Pepper Plant Height Growth at 12 WAT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	221.441	73.813	3.58	0.032
Error	20	412.348	20.617		
Corrected Total	23	633.789			

Table 6. Least Significant Difference test on the effect of deficit irrigation factors on plant height

Treatment	Mean value	Notation
ID1	74.38	a
ID4	71.83	a
ID2	70.13	ab
ID3	66.03	b

Table 6 presents the data of the Least Significant Difference test on the effect of deficit irrigation factors on the height of pepper plants. The data show that treatments ID1, ID2, and ID4 differ from ID3 and have the best plant height. This indicates that deficit irrigation affects vegetative growth because, in the lowest deficit irrigation treatment (ID3), plants experienced poor height growth.

3.4. Number of Leaves

The effect of deficit irrigation treatments on the number of leaves of pepper plants is presented in Figure 6. The data show that the growth in the number of plants from various treatments was relatively the same from 1 to 2 WAT (weeks after transplanting). However, in the 3rd week, treatments ID1 and ID2 experienced significant increases and performed better compared to treatments ID3 and ID4. The best leaf number growth was in treatments ID1 (100%) and ID2 (80%). The lowest leaf number growth was in treatments ID3 (60%) and ID4 (40%).

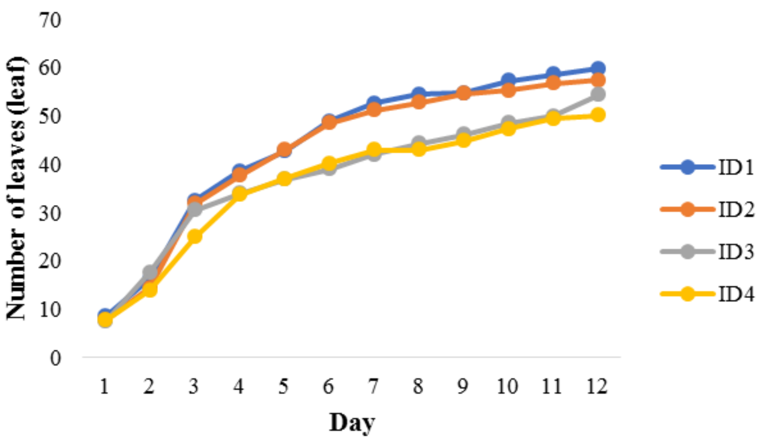

Figure 6. Number of pepper leaves

Based on the data on the effect of deficit irrigation on the number of leaves of pepper plants, an ANOVA test was conducted to determine the significant differences in each deficit irrigation treatment on the number of leaves of pepper plants. The results can be seen in Table 7. Table 7 shows that the effect of deficit irrigation on the number of leaves of pepper plants is significant at the 0.05 level. Furthermore, the effect of deficit irrigation on the number of leaves of pepper plants was tested using the Least Significant Difference (LSD) test at the 0.05 level.

Table 7. ANOVA Test on the effect of deficit irrigation on the number of leaves of pepper plants at 12 WAT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	315.458	105.152	6.40	0.003
Error	20	328.500	16.425		
Corrected Total	23	643.958			

Table 8 presents the data of the Least Significant Difference test on the effect of deficit irrigation factors on the number of leaves of pepper plants. The data show that treatments ID1 and ID2 differ from ID3 and ID4 and have the highest number of leaves. This indicates that deficit irrigation affects the number of leaves because the lowest deficit irrigation treatment, ID4, had fewer leaves compared to the other treatments.

Table 8. Least significant difference test on the effect of deficit irrigation factors on leaf growth

Treatment	Mean value	Notation
ID1	59,83	a
ID2	57,50	ab
ID3	54,33	bc
ID4	50,16	c

3.5. Pepper Production

The effect of deficit irrigation treatments on the height growth of pepper plants is presented in Figure 7. The lowest weight of pepper fruits (Figure 7) was in treatment ID4 (40%), while the highest weight was in treatment ID2 (80%).

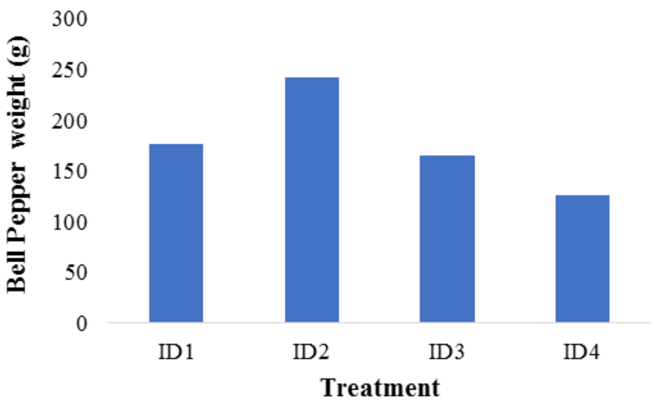

Figure 7. Bell pepper weight

To determine the significant difference in the effect of deficit irrigation on the total weight of pepper fruits, an ANOVA test was conducted, and the results are presented in Table 9. Based on Table 9, the Least Significant Difference test could not be performed. Thus, it can be concluded that deficit irrigation in this treatment does not affect the production of pepper plants.

Table 13. ANOVA Test on the Effect of Deficit Irrigation on Dry Biomass

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	42415.458	14138.486	2.98	0.056
Error	20	94929.500	4746.475		
Corrected Total	23	137344.958			

3.6. Yield Response

Yield response (Ky) is a factor that indicates the plant's response to water stress. Yield response to water is a function of the relationship between crop yield and irrigation water supply (Ditia, 2016). Water stress during flowering is a very sensitive period for seeds (Hariyono, 2009). Yield response (Ky) indicates the plant's response to water stress; if the Ky value is less than 1, it indicates that the plant is not resistant to water stress, whereas a Ky value greater than 1 indicates that the plant is resistant to water stress. The Ky values for treatments ID3 and ID4 indicate values less than 1, meaning that these treatments are not resistant to water stress. The Ky values for each treatment are ID1: 0, ID2: 3.575681, ID3: 0.077458, and ID4: 0.348522. The Ky values can be seen in Table 14.

Table 14. Yield response to water (Ky) values for deficit irrigation treatments of pepper plants

Treatment	**Eta (ml)**	**Etm (ml)**	**Eta/Etm**	**1- Eta/Etm**	**Ya (gram)**	**Ym (gram)**	**Ya/Ym**	**1- Ya/Ym**	**Ky**
ID 1	2702.67	2702.67	1	0	176	176	1	0	0
ID 2	2418.50	2702.67	0,894855	0,105145	242.17	176	1.375965	0.375965	3,575681
ID 3	2246.17	2702.67	0,831092	0,168908	164.67	176	0.935625	0.064375	0,381124
ID 4	2232.50	2702.67	0,826054	0,173946	125.33	176	0.712102	0.287898	0,348522

Note: Eta is the actual evapotranspiration, Etm is the maximum evapotranspiration, Ya is the actual yield, Ym is the maximum yield, and Ky is the yield response value.

4. Conclusion

Deficit irrigation treatments significantly affect plant height and the number of leaves. The plant response to limited irrigation based on the total fruit weight indicates that peppers can produce the best fruit with an 80% deficit irrigation treatment. The average total fruit weight was 242.17 grams. In the ID4 treatment, the plant results were not as good because the plants experienced stress. The yield response to water (Ky) shows that the Ky value (Ky < 1) for pepper plants in treatments ID2, ID3, and ID4 is less than 1, indicating that these treatments are resistant to water stress.

References

DaryonoBudi Setiadi, Sigit Dwi Maryanto. 2018. *Keanekaragaman dan Potensi Sumber Daya Genetik Melon*. Universitas Gadjah Mada Press. Yogyakarta.

Ditia, A. 2016. Pengaruh Fraksi Penipisan Air Tanah Tersedia pada Berbagai Fase Tumbuh terhadap Pertumbuhan, Hasil, dan Efesiensi Penggunaan Air Tanaman Kedelai (Glycine Max [L] Merr.). (*Skripsi*). Fakultas Pertanian Universitas Lampung.

Hariyono. 2009. Keragaan Vegetatif dan Generatif Beberapa Varietas Tanaman Padi (Oryza sativa L.) Terhadap Cekaman Kekeringan Pada Fase Pertumbuhan yang Berbeda. *Jurnal Ilmu-Ilmu Pertanian*. 18: 88 – 98.

Hansen, V.E., O.W. Israelsen., G.E. Stringham., E.P. Techyan. dan Soetdjipto. 1986. *Dasar-Dasar dan Praktek Irigasi Edisi Keempat*. Erlangga, Jakarta.

Mahmud S., Rosadi, R.A.B., Triyono, S. 2022. Pengaruh irigasi defisit pada stadia vegetatif terhadap hasil dan efisiensi penggunaan air tanaman Kedelai (Glycine Max [L]. Merr). *Jurnal Agricultural Biosystem Engineering,* 1(4): 564-573.

Sumaryanto. 2006. Peningkatan efisiensi penggunaan air irigasi melalui penerapan iuran irigasi berbasis nilai ekonomi air irigasi. *Forum Penelitian Agro Ekonomi*, 24(2): 77-91

Rosadi, R.A.B. 2012. *Irigasi Defisit*. Lembaga Penelitian Universitas Lampung, Lampung.

Widaningrum., Miskiyah, dan Christina Winarti. 2016. Aplikasi Bahan Penyalut Berbasis Pati Sagu dan Antimikroba Minyak Sereh Untuk Meningkatkan Umur Simpan Paprika. *Jurnal Penelitian Pascapanen Pertanian.* 13(1): 1-11.