European Journal of Agricultural and Rural Education (EJARE)
Available Online at: https://www.scholarzest.com
Vol. 5 No. 02, February 2024
ISSN: 2660-5643

EFFICIENCY OF DRIP IRRIGATION TECHNOLOGIES IN COTTON GROWING

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Article history:

Received: 14th December 2023
Accepted: 10th January 2024
Published: 20th February 2024

Abstract:

This article presents the results of a scientific study on the effect of irrigation rate, salt content in the soil, and cotton yield on the development of drip irrigation using the Bukhara-8 variety of cotton in conditions of medium-sandy, meadow alluvial soils of the Bukhara region. These soils have moderate salinity and a specific mechanical composition. The cotton was irrigated 16 times according to the 2-13-1 system, with irrigation scheduling of 75-80-65 % field capacity (Fc),. · With a total consumption of 3685 m^3 ha^{-1}, the 5th option consumed 1405 m^3 ha^{-1}, less water than the control option. The best yield was observed in option 5, at 4.69 t ha^{-1}, which was 0.91 t ha^{-1} higher than the control option.

Keywords: Bukhara-8 variety of cotton, drip irrigation, irrigation method, irrigation rate, soil salinity, chlorine ion, dry residue, cotton yield.

Today, scientists worldwide are conducting research in specific priority areas aimed at mitigating the adverse effects of water scarcity. These include the widespread adoption of water-saving technologies, enhancement of saline land reclamation, and ensuring stable and high agricultural crop yields. Increasing the efficiency of water-saving irrigation technologies, particularly in regions facing water scarcity, is crucial for achieving consistent and high crop yields, as well as for improving soil reclamation efforts and enhancing soil water-physical properties and salt regulation. This focus on increasing productivity represents a promising direction for agricultural advancement.

In recent years, with the increasing water scarcity in the Republic of Uzbekistan, there is an urgent need to implement water-saving irrigation technologies to ensure a stable and high yield of agricultural crops, particularly on saline soils. The country has a total of 4.3 million hectares of irrigated areas, with over 40 percent, or 2 million hectares, affected to varying degrees by salinity. In the Bukhara region alone, this figure accounts for 86 percent of its 275.509 thousand hectares of irrigated land. Therefore, research aimed at mitigating the adverse effects of water scarcity in saline areas, as well as the implementation of water-saving irrigation technologies, and the scientific justification of crop irrigation and fertilization methods to ensure high and consistent yields from agricultural crops, are considered crucial.

Several scientists are currently conducting research on the implementation of water-saving technologies in the republic. Specifically, Khamidov M. and Matyakubov B. observed changes in the soil's water-physical properties at the Experimental Fields due to various factors such as field preparation, planting, agronomic practices, irrigation techniques throughout the growing season, and the impact of irrigation standards. The minimum soil compaction recorded was 0.01-0.02 g/cm^3, with irrigation scheduling of 70-80-60 % Fc. The soil's water permeability was also noted to be 70-80-60 % Fc, and by the end of the vegetation period, it had increased by 0.031 mm/min compared to the control option.

In the conditions of the old irrigated meadow sierozem soils of the Syrdarya region, Shamsiev A. discovered that the seasonal irrigation requirement for cotton is slightly reduced when using mulching options with black polyethylene film and straw between the rows, compared to traditional irrigation methods. In typical gray soils, mulching with film and straw between the rows resulted in soil moisture levels ranging from 70-70-60 % of Fc, whereas with seasonal irrigation, these levels were approximately 65-65-60 %. Across different options, there was a reduction in water usage: 184 (4.2%), 160 (3.6%), and 1066 (27.9 %) m^3 ha^{-1} respectively. Additionally, in the options with inter-row mulching, there was a 12,7 % reduction in the seasonal irrigation rate (equivalent to 556 m^3 ha^{-1}) for soil moisture levels of 65-65-60 % Fc. Similarly, for soil moisture levels of 70-70-60 % Fc, there was a 13.2 % reduction (equivalent to 582 m^3 ha^{-1}).

Avliyakulov M. and Durdiev N. conducted an analysis of the agrophysical properties of soil under different irrigation regimes. They found that the field moisture capacity ranged from 21.1 % to 21.6 % in the 0-70 cm layer and from 21.2 % to 21.8 % in the 0-100 cm layer. Under the 70-70-60 % irrigation regime, the bulk density increased by 0.02-0.04 g/cm^3 in the soil layers at depths of 0-30 cm, 30-50 cm, and 50-70 cm. For the 70-75-65% irrigation regime, this increase was 0,03-0,06 g/cm^3. It was observed that water permeability decreased by 49.95 m^3 ha^{-1} in both the 70-70-60 % and 70-75-65 % irrigation regimes by the end of the operational period. The soil is primarily characterized by a false structure, attributed to the dispersion of soil structure resulting from irrigation.

In the meadow-sierozem soils of the Andijan region, Isashov S. conducted an experiment where cotton was irrigated using the 1-2-1 system with the Andijan-35 and Andijan-36 varieties. During the season, water usage ranged from 2304 to 2650 m^3 ha^{-1}. In comparison, another set of cotton crops was irrigated 35 times using the 6-19-10 system, utilizing 2566 to 2692 m^3 ha^{-1} of water, resulting in a water saving of 52.7 % to 54.9 % compared to regular irrigation practices. The yield for the Andijon-35 variety was 1.69 to 1.73 t/ha, whereas for the Andijon-36 variety, an additional yield of 1.42 to 1.44 t/ha was achieved. Furthermore, it was observed that the level of profitability increased by 19.3 % to 20.4 % with the Andijon-36 variety.

Nazaraliev D., Isaev S., and Tadjiev S. have noted that water-saving and soil-protecting zigzag-shaped ridges are employed in the irrigation of agricultural crops, particularly in lands prone to irrigation erosion. These ridges are watered at a rate of 0.15 liters per second, maintaining soil moisture at 70-70-60 % Fc during the vegetation period, with a total water consumption of 886-962 m^3 ha^{-1}. It is recommended to apply a seasonal irrigation rate of 6050-6100 m^3 ha^{-1} for optimal crop growth.

Hakimov Sh., Tursunov I., and Yakubov T. reported that when polymer complexes were used in an experimental field planted with cotton, soil moisture before irrigation was maintained at 70-80-65 % Fc. The cotton crop was irrigated four times according to the 1-2-1 scheme. The first irrigation applied a recommended water volume of 750 m^3 ha^{-1} during the period from germination to flowering, followed by 640-680 m^3 ha^{-1} during the flowering-bud bearing period, and 850 m^3/ha during the ripening period. The total seasonal irrigation rate was 2920 m^3/ha, resulting in a water saving of 860 m^3 ha^{-1} compared to the control option.

Experiments were conducted to develop an irrigation procedure based on drip irrigation technology for the Bukhara-8 variety of cotton in the moderately saline, medium alluvial soils of the Bukhara region. These soils have a water table level of 2.0-2.5 meters and a mineralization of 3 g/l, with sediments collected during 2017-2019 having a concentration of 0-5.0 g/l. The experimental plots for developing the irrigation procedure were arranged in a single layer with three sections, each covering an area of 720 m^2 (100 m in length, 7.2 m in width), resulting in a total experimental field area of 2160 m^2 and a total area of 12960 m^2. All agricultural activities were carried out according to the approved technological guidelines for the Bukhara region and the developed irrigation procedure for cotton using drip irrigation technology.

Table 1

An experimental system to develop irrigation procedures for cotton using drip irrigation technology in the Bukhara region.

(Experiment 1)

Options	Irrigation technology	Irrigation scheduling of Fc, %	Mineral fertilizers, kg/ha	Irrigation rates, m^3/ha
1(control)	irrigation	70-5-65	N-250; P_2O_5 - 180; K_2O-100	actual measurements
2	drip irrigation	70-70-65		0-40 cm of the soil before flowering , according to the moisture deficit in the 0-70 cm layer during the flowering and fruiting phase
3		70-75-65		
4		75-75-65		
5		75-80-65		
6		80-80-65		

In the scientific research aimed at developing irrigation procedures based on cotton drip irrigation technology, irrigation was conducted based on soil moisture levels. Control of cotton irrigation, designated as the 1st option, occurred at 70-75-65 % of the recommended pre-irrigation soil moisture for the VI-hydromodule region of the Bukhara region, corresponding to the marginal field moisture capacity. Cotton was irrigated five times during the season, with each irrigation applying 865-1132 m^3 ha^{-1} of water. The interval between irrigations ranged from 18 to 22 days, resulting in a seasonal irrigation rate of 5090 m^3 ha^{-1}.

In the experiments involving drip irrigation of cotton, irrigation was carried out based on the soil moisture levels. Before flowering, irrigation targeted the insufficient moisture in the 0-40 cm layer of the soil, while during the flowering, fruiting, and ripening phases, irrigation addressed the insufficient moisture in the 0-70 cm layer of the soil. In variants 2-6 of the study, drip irrigation technology was employed for cotton cultivation. In variant 2, where cotton was drip-irrigated, irrigation followed the 2-10-1 system, with 13 irrigations conducted during the season. The water usage rate for each irrigation ranged from 272 to 405 m^3 ha^{-1}, resulting in a seasonal irrigation rate of 3988 m^3 ha^{-1}. The interval between irrigations was 6-13 days, and the duration of each irrigation session ranged from 4^{05} to 6^{05} hours. In this option, a water saving of 1102 m^3 ha^{-1}, equivalent to 22 % of river water usage, was achieved compared to the control option.

Additionally, the soil moisture before irrigation is maintained at 70-75-65 % Fc. In the 3rd option, irrigation is conducted using drip irrigation in the 2-11-1 system, with an irrigation rate of 264-354 m^3 ha^{-1} and a seasonal irrigation rate of 3854 m^3 ha^{-1}. This represents a reduction of 1236 m^3 ha^{-1}, or 24% less than the control option. In this scenario, the interval between irrigations ranged from 6 to 12 days, with irrigation sessions lasting from 4^{00} to 5^{20} hours, occurring between May 29 and September 3.

In the 4th experimental variant, involving drip irrigation of cotton, pre-irrigation soil moisture is maintained at 75-75-65 % Fc. Irrigation is carried out using the 2-12-1 system, with 15 irrigation cycles during the season. Each irrigation applies 235-316 m^3 ha^{-1} of water, resulting in a seasonal irrigation rate of 3761 m^3 ha^{-1}, which is 1329 m^3 ha^{-1}, or 26 % less water used compared to the control option.

In the 5th observation variant, where soil moisture before cotton irrigation is 75-80-65 % Fc, irrigation is conducted using the 2-13-1 system. In this variant, cotton is irrigated 16 times during the season. The irrigation rate ranges from 216 to 304 m^3 ha^{-1}, with a seasonal irrigation rate of 3685 m^3 ha^{-1}. The interval between irrigations ranges from 5 to 14 days, with irrigation sessions lasting from 3^{15} to 4^{35} hours.

In drip irrigation of cotton, pre-irrigation soil moisture is maintained at 80-80-65 % Fc. In the 6 th option, irrigation is conducted 17 times using the 3-13-1 system. The irrigation rate ranges from 201 to 308 m^3 ha^{-1}, with a seasonal irrigation rate of 1486 m^3 ha^{-1}, representing a 29 % reduction, or 3604 m^3 ha^{-1} less water used compared to the control option.

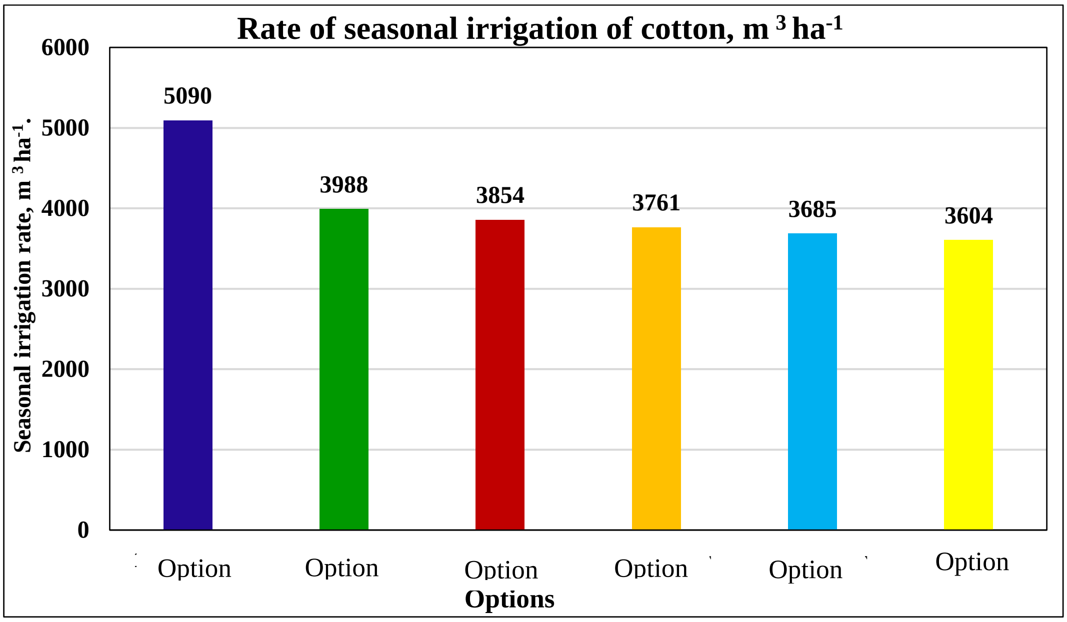

Figure 1. Seasonal irrigation standards in cotton drip irrigation technology.

One of the main reasons for the decrease in productivity is the significant impact of harmful salts on plant growth. During the research, the levels of salts (chlorine ions and dry residue) in the soil were measured at the beginning of the cotton growth period, before and after each irrigation, and at the end of the growth period. In the scientific research, at the beginning of the growing season, the concentration of chlorine ions in the plowed 0-40 cm layer of the soil was 0.010 %, in the 40-70 cm and 0-100 cm layers, it was 0.011 %. Meanwhile, the concentration of dry residue was 0.159% in the plowed layer, 0.144 % in the sub-layer, and 0.154 % in the 1-meter layer.

At the end of the vegetation period, the salt levels in the soil were measured. In the control group, which was irrigated according to version 1, the chlorine content in the soil was 0.031 % in the plowed 0-40 cm layer, 0.026 % in the sub-plowed 40-70 cm layer, and 0.026 % in the 1-meter layer. The dry residue content was 0.459 %, 0.392%, and 0.369 % respectively.

Before cotton irrigation, the soil moisture in the second variant, which utilized drip irrigation, was 70-70-65 % Fc. At the end of the growing season, the chlorine ion content in the plowed 0-40 cm layer was 0.027 %, and in the sub-plowed 40-70 cm layer, it was 0.026%. In the 1-meter layer, it was 0.029 %. The dry residue content was 0.352 % in the plowed 0-40 cm layer, 0.368 % in the sub-plowed 40-70 cm layer, and 0.382 % in the 1-meter layer.

Compared to the control variant, there was a decrease of 0.004 % in chlorine ion content in the plowed layer, while in the 1-meter layer, this indicator increased by 0.003%. The dry residue content in the plowed layer was 0.107% less, while in the 1-meter layer, it increased by 0.013 %.

During drip irrigation of cotton, the soil moisture before irrigation is maintained at 70-75-65 % Fc. In the 3rd option, the concentration of chlorine ions in the soil is 0.025 % in the plowed 0-40 cm layer, 0.027 % in the sub-plowed layer, and 0.028 % in the 1-meter layer. The corresponding levels of dry residue are 0.348 %, 0.366 %, and 0.378 % respectively.

During drip irrigation of cotton, the soil moisture before irrigation is maintained at 75-80-65% Fc. In the 5th option, the concentration of chlorine ions in the soil at the end of the growing season is 0.023% in the 0-40 cm layer of tillage, 0.023 % in the 40-70 cm layer below tillage, and 0.028 % in the 1-meter layer. The corresponding levels of dry residue are 0.340 %, 0.361 %, and 0.374 % respectively.

It is observed that the accumulation of salts in the soil was 0.008 % less in the plowed layer in terms of chlorine ion compared to the control option irrigated conventionally, while it was observed to be 0.01-0.02 % higher in the sub-plowed and 1-meter layers. Additionally, it was observed that the levels of dry residue increased in the sub-plowed and 1-meter layers.

In the 6th variant of the experiment, where the pre-irrigation soil moisture was 80-80-65 % compared to the marginal field moisture capacity, the concentration of chlorine ions in the soil at the end of the growing season ranged from 0.023 % to 0.027 % in the plowed, sub-plowed, and 1-meter layers. The levels of dry residue were 0.339 % in the plowed 0-40 cm layer, 0.358 % in the sub-plowed 40-70 cm layer, and 0.373 % in the 1-meter layer. In this variant, the accumulation of salts in the soil decreased in the plowed layers in the drip-irrigated variants, while it increased in the sub-plowed and 1-meter layers.

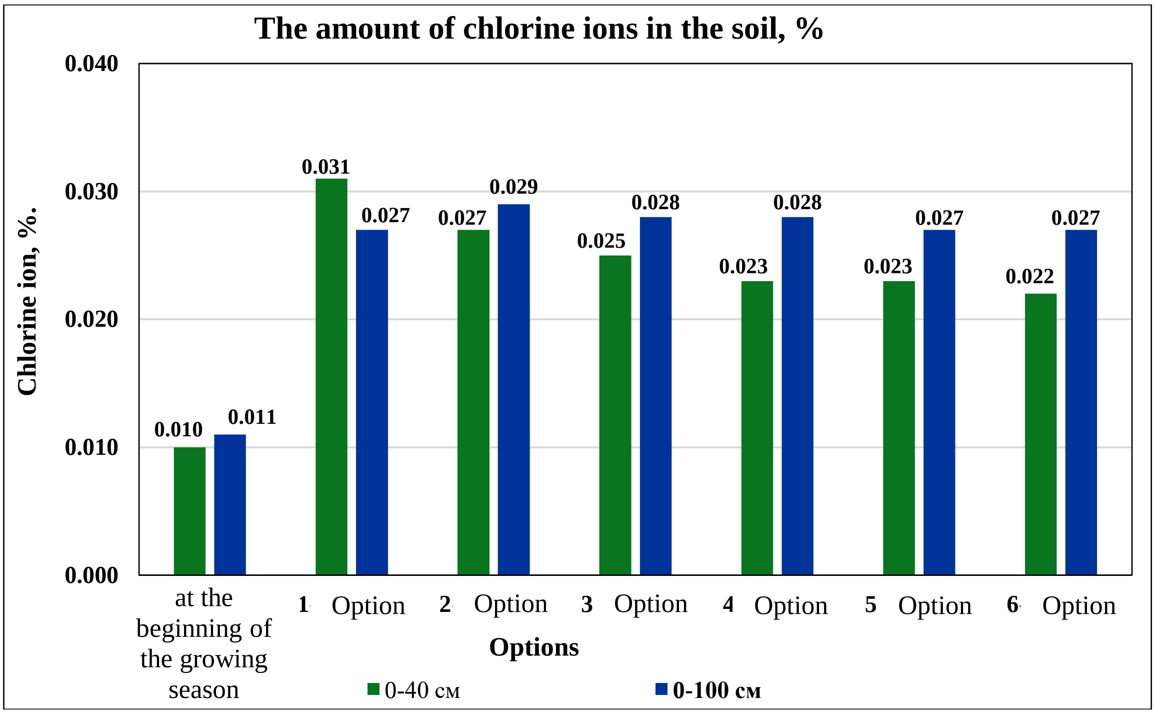

Figure 2. Effect of drip irrigation technology on soil chlorine ion content in cotton cultivation.

In experiments conducted to develop drip irrigation methods for cultivating the Bukhara-8 cotton variety in the Bukhara region, the average cotton yield in the control group over three years was 3.78 t ha^{-1}. In the experimental group, the soil moisture before irrigation was maintained at 70-70-65 % Fc. The cotton yield in the field irrigated with drip irrigation at this moisture level was 4.47 t ha^{-1}.

The soil moisture before irrigation was 75-75-65 % compared to the marginal field moisture capacity. In the 4 th variant, the cotton yield was 4.58 t ha^{-1}. Conversely, when the soil moisture before irrigation was 75-80-65 % Fc, the yield was found to be 4.69 t ha^{-1} in the drip-irrigated option 5, which was 0.91 t ha^{-1} higher than the control option. Throughout the research, the same rates of mineral fertilizers, or if not, N-250; P-180; K-100 kg/ha, were applied across all options, and cotton care was consistently carried out.

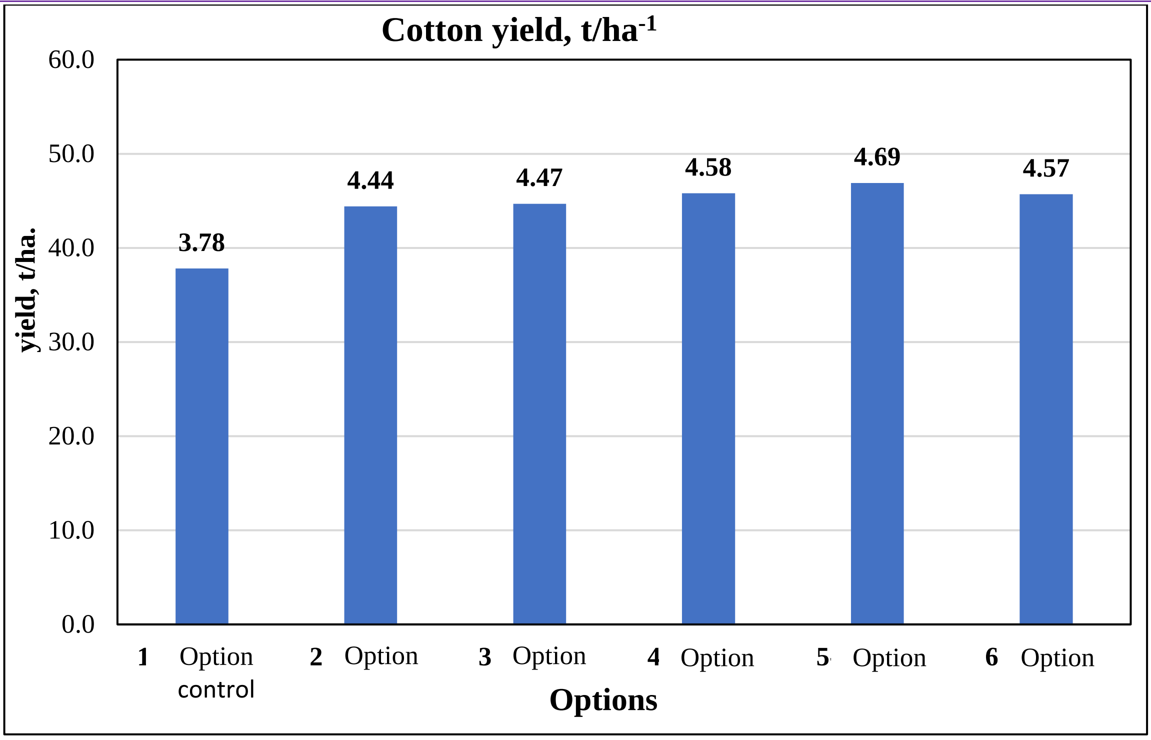

Figure 3. Effect of drip irrigation on cotton yield.

CONCLUSIONS

1. In Bukhara region, a total of 4.1-4.3 billion m^3 of water resources are used for agriculture in one year, and 1.9-2.1 billion m^3 of water is released from irrigated areas through collector-ditch systems. In order to adapt to global climate change and mitigate the negative consequences of increasing water scarcity, it is urgent to introduce water-saving technologies and their science-based irrigation and feeding procedures in the irrigation of agricultural crops.

2. In the moderately saline, meadow alluvial, and medium sand soils of the Bukhara region, the Bukhara-8 variety of cotton was cultivated. The fertilization consisted of N-250, P-180, and K-100 kg/ha. The irrigation was carried out with rates ranging from 216 to 304 m^3 ha^{-1}, and the seasonal irrigation rate was 3685 m^3/ha in the 2-13-1 system. The soil moisture content was maintained at 75-80-65 % Fc. Under these conditions, the yield of cotton was determined to be 4.69 t ha^{-1}.

3. When grown using drip irrigation technology, cotton was fertilized with N-250, P-180, and K-100 kg/ha. The soil moisture content was maintained at 75-80-65 % Fc. At the beginning of the season, the chloride ion content in the soil in the plowed layer increased by 0.010 %, and in the 0-100 cm layer, it reached 0.011%. By the end of the growing period, these levels rose to 0.023 % and 0.027 % respectively. This indicates that the accumulation of chloride ions in the plowed layer was 0.008 % less than in the control option.

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