Почвознание агрохимия и екология, 59, 2/2025
Bulgarian Journal of Soil Science Agrochemisty and Ecology, 59, 2/2025

DOI: https://doi.org/10.61308/IOCR9197

Precision agriculture in growing three apple varieties in the Republic of Bulgaria

Antoaneta Gigova*, Vesela Petrova-Branicheva

Institute of Soil Science, Agrotechnology and Plant Protection "Nikola Pushkarov" - Sofia, Agricultural Academy
Corresponding author*: antoaneta.gigova@abv.bg

Citation: Gigova, A., & Petrova-Branicheva, V. (2025). Precision agriculture in growing three apple varieties in the Republic of Bulgaria. *Bulgarian Journal of Soil Science Agrochemisty and Ecology, 59*(2), 32-38.

Abstract

In the conditions of the changing climate, with tendencies towards warming and drying, it is necessary to make new innovative solutions for the cultivation of fruit trees.

In 2020 - 2021, on the territory of the experimental field "Chelopechene" of ISSAPP "N. Poushkarov" an experimental trial was conducted with three varieties of apple, Florina, Golden Delicious and Granny Smith, created in 2017. The soil in the research area is leached Cinnamon forest. Three different varieties of apples were studied - T1 - Florina, T2 - Golden Delicious and - T3 - Granny Smith under irrigation conditions with maintenance of pre-irrigation soil moisture 70% of the FC. In terms of precipitation, both years are very dry with a probability of exceedance of 95.67% (2020) and 94.07% (2021). For 2020 on average, during the vegetation period of the apple orchard , to maintain the soil moisture in the range of 70% of FC to 100% of FC, it was necessary to apply 10 irrigations with an irrigation norm of 380 mm, and for 2021, 12 irrigations with an irrigation norm of 510 mm. During the years under review, different yields from the apple plantations were established. The highest yield was found in Florina variety, which was 431% higher compared to Granny Smith variety in third variant T3.

Key words: precision agriculture, orchards, drip irrigation, mulch

Introduction

Apple orchards are one of the most widespread in our country, with the greatest economic effect. On average for 2022, the total areas with apple plantations are 4 433 ha, with an average yield of 1 250 kg.da^{-1}. The territory of our country refers to the areas with unstable humidification. Droughts are particularly frequent, severe and prolonged during the July-September period, when the apple fruits grow intensively. One of the most important measures that ensures normal growth of trees, regular and high-quality yields is irrigation.

Research in our country showed that the optimal pre-irrigation soil moisture for the apple is 70-80% of the FC in the layer up to 0.60 m, where the main part of the root system is located, and the soil moisture must be maintained above this level (Petrova and Kireva, 2016; Gaidarova and Daskalova, 2012).

Institute of Soil Science, Agrotechnologies and Plant Protection "Nikola Poushkarov", Sofia, has been dealing with the problems that arise on the way to sustainable agriculture for decades. Green technologies in the cultivation of fruit trees are the subject of scientific experiments conducted at the Chelopechene experimental field, at the Agricultural Academy with three varieties of apples. The first time, scientific and laboratory research is being carried out on the application of water-saving technology - plastic mulch for three different varieties of apples. They are innovative methods that help improve production efficiency while reducing environmental impact.

Main objective: Establishing the most favorable variety of apples (from three different varieties) grown on leached Cinnamon forest soil for the Kremikovtsi area under water saving technologies (drip irrigation and plastic mulch).

Materials and methods

Field experiments were conducted on the territory of ISSAPP "N. Poushkarov" experimental field in Chelopechene near town of Sofia, Bulgaria during 2020 and 2021. The experimental field, with geographical coordinates: 42°44′22.8″N, 23 ° 28′3.7″E is part of the South-West Sofia field, located at 550 m above sea level. This area has continental climate characterized by cold winter and hot summer.

The object of the research is an intensive apple orchard, planted in the autumn of 2017. The soil in the study area is Leached Cinnamon forest soil formed on diluvial deposits. According to the FAO international classification, they are defined as Chromic Cambisol. In terms of mechanical composition, the soil is heavy sandy - clayey in the arable layer and slightly clayey in the subsoil layer. Water-physical properties change layer by layer through 0.10 m to 1.00 m depth. The soil of the experimental field is defined as medium to highly permeable with medium filtration capacity. Infiltration into the arable horizon, due to its less structure, is small and increases with depth. The experimental section is flat with a slightly pronounced micro relief with a total slope of 1.5%. The water-physical properties of this soil subtype on average for the layer 0-0.60 m deep are as follows: bulk density - 1.47g.cm^{-3}, field capacity (FC) - 22% and wilting point 10% for 0-0.60 m layer.

From the chemical analysis of an average sample at a depth of 0-0.60 m at the beginning of the experiment we found that the soil was well stocked with nitrogen, very low stocked with phosphorus and medium stocked with potassium (according to the AL method), (table 1). We did autumn soil feeding with 5 kg.da^{-1} P_2O_5 active substance, 6 kg.da^{-1} K_2O active substance in the inter-row treatment. Nitrogen fertilizers in the form of ammonium nitrate during vegetation in two applications of 6 kg.da^{-1} N active substance with the irrigation system. In order to maintain the optimal content of nitrogen in the leaves - from 2.2 to 2.8%, phosphorus 0.18-0.30% and 1.1-1.6% potassium (Apostolova et al., 2014). The annual amount of precipitation in the area is 196 mm (2020) and 203 mm (2021), with an average of 355 mm over a series of 60 annual observations. Precipitation is too unevenly distributed, both seasonally and monthly. Summer is very dry and hot. High mid-day temperatures further exacerbate

Table 1. Agrochemical analyzes of Leached Cinnamon forest soil in the Experience Field of ISSAPP "N. Poushkarov"

pH		Σ N-NH_4 + NO_3	P_2O_5	K_2O	Humus
H_2O	KCl	$mg.kg^{-1}$		$mg.100g^{-1}$	%
6.8	6.1	96.2	2.7	25.0	3.35

the effect of drought at this time of the year.

Method of plotting the experiment: The experiment was plotted by the method of long plots with four replicates of each tracked variant, with three trees each.

Experience options:

1) Drip irrigation with 100% irrig. norm on apple trees of the Florina variety

2) Drip irrigation with 100% irrig. norm on apple trees of the Golden Delicious variety

3) Drip irrigation with 100% irrig. norm on apple trees of the Granny Smith variety

The pre-irrigation soil moisture is 70% of the FC in all variants and the soil moisture is maintained from 70% to 100% of the FC during the entire vegetation period.

The inter-row distances of 2 m are consistent with the type of substrate and the possible dimensions of the crowns after their final formation. The row spacing is 3 m. The size of the experimental plot is 18 m², for one decre - 166 trees.

Apple variety "Florina" (fig. 1) ***is a new variety selected in France***, where it is also known as Kerina. The tree is strong growing, with a dense cone-shaped crown. It ripens around October 10-20. The fruits have a yellow-green main color, and the cover color is fuzzy and striped, red to dark red, covering almost the entire fruit.

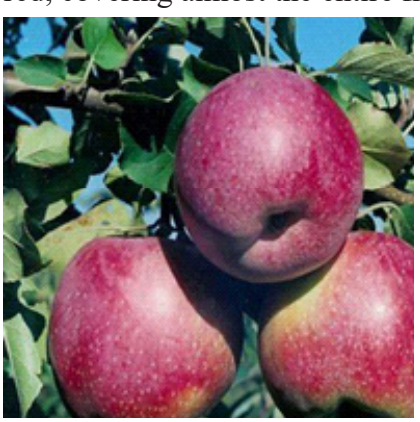

Fig. 1. Apples variety Florina

Golden Delicious (fig. 2) – this is our well-known fruit with a yellow color and a large size. It ripens between September 15 and 20. The taste is sweet, slightly acidic and aromatic with excellent quality. This tree is extremely vigorous and very prolific.

Fig. 2. Apples Golden Delicious

Granny Smith (fig. 3) is a popular apple variety created in 1868 in Australia. The name of the variety translates as "grandmother Smith", and is named in honor of Maria Anna Smith.

It ripens in the period from September 20 to 30. The flesh is whitish, dense, juicy, sweet, slightly acidic, with a slight aroma, pleasantly refreshing, of good to very good quality.

Fig. 3. Apples Granny Smith

Size of the irrigation and irrigation norms

Irrigation rates are calculated according to

the formula:
$m = [10H.\alpha.(\delta t \text{ from FC} – \delta t \text{ pre-irrig.SM})]K_1$)
where:
m - size of the irrigation rate in mm
α - bulk density of the soil in g/cm^3
H - depth of the active soil layer in m
δt from FC - marginal field moisture content in % relative to the absolute dry weight of the soil
δt - pre-irrigation soil moisture in % relative to the absolute dry weight of the soil

To monitor the dynamics of soil moisture, soil samples were taken every 10 days at a depth of 0.60 m, every 0.10 m in 3 repetitions and processed according to the classical weight thermostat method by drying at 105^o C. The obtained data for soil moisture were analyzed using Microsoft Excel.

The obtained data for yield were statistically analyzed using ANOVA software.

Irrigation technology and technology

Soil humidity in the plantation is maintained by means of a drip irrigation system. The water source is a borehole with a depth of 42 m, located right next to the apple orchard. This will provide a good technical solution to the irrigation field and system as a whole. In intensive orchards, usually 2 to 4 drippers are placed per tree, spaced at a distance of 0.90-1.00 m between them. The drip line is located at a distance of 0.50 m from the tree trunks (Kireva et al., 2017).

The distances between the drippers along the length of the irrigation pipeline are chosen in view of the contours of soil moistening in order to ensure uniform moistening of the entire row strip (Petrova et al., 2010). For drip application, clean irrigation water is required to prevent clogging of the drippers, and the water is supplied to the distribution network under a pressure of 1 atm. For more efficient use of water, reduction of evaporation and conservation of soil moisture and temperature in the present study we apply plastic mulch.

Results and discussion

Meteorological characteristics of the experimental years 2020/21 in the area of the Chelopechene district – Sofia

The statistical assessment of the experimental year in terms of the temperature sum and the rainfall was made for the period April - September. A 60-year series of data on outdoor air temperature and precipitation for the period 1958 - 2021 was examined and the probabilities of exceedance is determined. In terms of air temperature, both years 2020 and 2021 are characterized as very warm with 7.78% and 9.13% probabilities of exceedance. In terms of rainfall, both years are very dry with a probability of exceedance of 95.67% (2020) and 94.07% (2021), represented graphically in figures 4 and 5.

The distribution of monthly average day-night temperatures and precipitation for the growing season are presented in tables 2 and 3.

As can be seen from table 2, the highest average day and night temperatures are observed in the months of July and August, which coincides with the phase of formation of the knots and the ripening of the fruits. In the case of apples, this period is critical for yield formation, since with insufficient irrigation, the fruits fall and cannot ripen. The average temperatures measured at 2 p.m. reach 30-35^o C, which adversely affects the development of the crop and irrigation is required.

The rainfall during the growing season of the crop is unevenly distributed, which necessitates the implementation of irrigation to supplement the soil stock in the range from 70% of the FC to 100% of the FC (table 3).

The analysis of meteorological conditions shows that the studied years are almost the same - warm and dry, which necessitates the implementation of irrigation.

Irrigation regime

The apple orchard during the period of March and until the middle of April had sufficient water supply of the soil profile 0.60 m from the fallen snow and rains during the winter-spring period. The number of irrigations and the duration of the inter-irrigation periods are determined by the age of the trees, the soil and the weather conditions. In the dry years of 2020 and 2021, the need of

Table 2. Monthly sums of daily mean air temperature (in 0 C) in experimental field Chelopechene for the period April – September 2020-2021

Month/year	IV	V	VI	VII	VIII	IX	Sum
2020	322.75	500.0	581.00	670.25	652.50	592.25	3319.00
2021	282.00	495.00	594.00	754.00	711.00	489.00	3327.00
1960-2021	-	-	-	-	-	-	3219.45

Table 3. Monthly precipitation sums (mm) in experimental field Chelopechene for the period April – September 2020-2021

Month/year	IV	V	VI	VII	VIII	IX	Sum
2020	11.9	20.0	19.3	55.0	56.8	34.0	196.9
2021	17.6	31.3	51.4	29.0	57.8	16.4	203.2
1960-2021	-	-	-	-	-	-	354.68

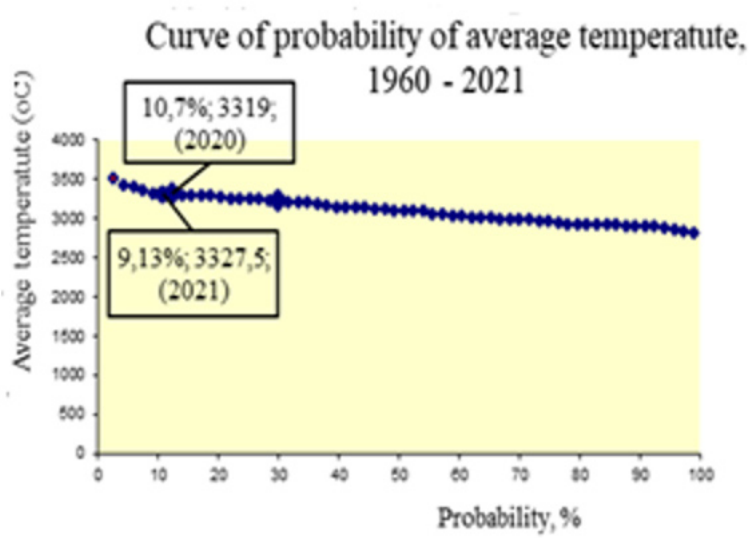

Fig. 4. Probability curve of mean daily temperature for the period 1960 - 2021

Table 4. Yields of an apple orchard in 2020-2021 in different variants

Variant	Yield kgda^{-1}	Difference	% relative yield	Evidence	GD
			2020 year		
Apples of the Florina variety	520	St	100	St	P5% =130
Apples variety Golden Delicious	480	-40	108	+++.	P1% =235
Apple variety Granny Smith	260	-260	200	+++.	P 0.1% =285
			2021 year		
Apples of the Florina variety	1380	St	100	St	P5% =212
Apples variety Golden Delicious	1200	-180	115	+++.	P1% =330
Apple variety Granny Smith	320	-1060	431	+++	P 0.1% =562

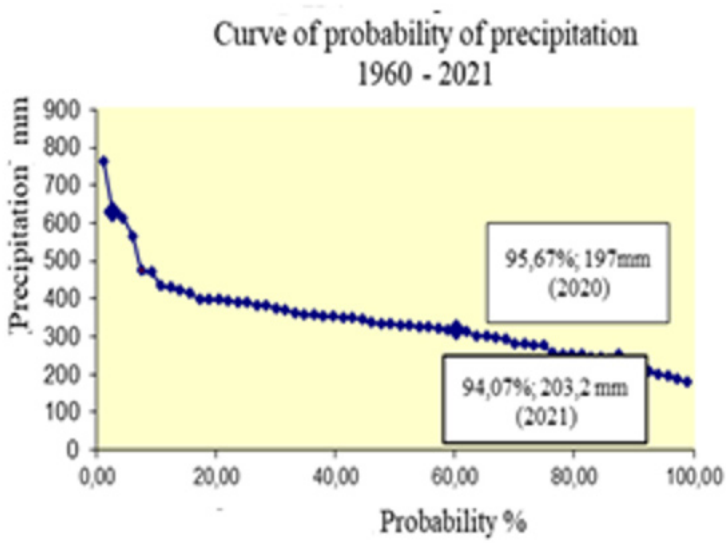

Fig. 5. Probability curve of mean precipitation for the period 1960 - 2021

10-12 irrigations at a net irrigation rate of about 60 mm per apple orchard was established. A moisture-retaining late autumn watering was done to protect the wood from winter frost and prevent it from drying out. With the use of mulch, there was no evaporation from the surface and evapotranspiration was reduced to the absorption of water by the trees, an economy of water up to 30 - 35% soil moisture conservation. For 2020, on average, during the apple vegetation period, to maintain the soil moisture in the range of 70% of FC to 100% of FC, it was necessary to supply 10 irrigation rates with an irrigation norm of 380 mm, and for 2021 10 irrigations with an irrigation norm of 510 mm.

Yield in the intensive apple orchard in the juvenile period.

During the two experimental years of the intensive apple orchard, different yields were established in the variety plots. In 2020, the highest yield was found in the variant irrigated with pre-irrigation soil moisture 70% of FC and application of mulch in Florina variety - 520 kg.da^{-1} and the lowest in Granny Smith variety 260 kg.da^{-1}.

In 2021, the apple orchard had increased yields, due to its biological age, the highest yield in the variant 70% of FC using mulch 1 380 kg.da^{-1} was found again in Florina variety and with 8% lower yield in Golden Delicious (table 4). In the variety Granny Smith, smaller fruits were observed, not meeting the potential of the variety and a low yield of about 320 kg.da^{-1}. The data on the yields of the apple plantation obtained in the tested variants are summarized in table 4. In both years of the test there were statistically proven differences between the variants.

Conclusions

Main green technologies used in growing apples are: drip irrigation and intelligent water management and fertilization systems.

1. Regarding the air temperature, both years 2020 and 2021 are characterized as very warm with 7.78% and 9.13% probabilities of exceedance. In terms of the rainfall, both years are very dry with a probability of exceedance of 95.67% (2020) and 94.07% (2021).

2. For the year 2020, on average, during the vegetation period of the apple orchard, to maintain the soil moisture in the range of 70% of FC to 100% of FC, it was necessary to supply 10 irrigations with an irrigation norm of 380 mm, and for 2021, 10 irrigations with an irrigation norm of 510 mm.

3. For the year 2021 (second year) in the variant with mulch, the yield in the different varieties differed significantly. The highest yield is in the Florina variety for 2020 - 520 kg.da^{-1}, and the lowest is in the Granny Smith variety 260 kg.da^{-1}. In 2021 (third year) the apple orchard had similar yields.

4. For the area of Kremikovtsi, from the studies carried out, we recommend the cultivation of the Florina and Golden Delicious varieties. They are the most favorable of the three varieties with almost equal yields of 1 380 kg.da^{-1} and 1 200 kg.da^{-1} respectively.

Conflict of interest: The authors declared that they have no known competing financial interests

References

Apostolova, M., Nikolova, M., Bistrichanon, S., Valeva, N., Jordanov, A., Kostadinova, S., Manolov, I., Mitova, I., Popov, K., & Shaban, N. (2014). *Good practices for sustainable crop nutrition management*, pp.60 (Bg).

Gaidarova, S., & Daskalova, A. (2012). *Agro-meliorations*, pp. 252-256 (Bg).

Kireva, R., Petrova, V., & Markov, Ev. (2017). Drip Irrigation of Apples at Moderate Continental Climate. *International Research Journal of Engineering and Technology, 4*(9), 642-645.

Petrova, V., Vilcek, J., & Dimitrov, P. (2010). Model and preparation of a program product for efficient use of irrigation water according to its quality. *Agricultural technology, 3*, 96-101 (Bg).

Petrova, V., & Kireva, R. (2016). Optimizing the depth of irrigation wings in water-saving technologies of intensive crops and vegetables. *Journal of mountain agriculture on the Balkans, 19*(5), 170-184 (Bg).

Received: 26th November 2024, ***Approved:*** 11th May 2025, ***Published:*** June 2025