Testing of the Fertigation Equipment in Operation Conditions

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Abstract: *The fertigation equipment developed within the FERTIRIG project, PN-II-PT-PCCA-2013-4-0114, financial agreement no. 158/2014, has been tested under real operation conditions at ICDP Pitesti Maracineni, on local irrigation facilities existing in the experimental - demonstrative plots, in fruit trees such as plum, pear and apple, which are fruit species of greatest importance for the Romanian fruit growing.*
It has been designed and developed in accordance with the fertilization / fertigation technologies developed in the previous stages by the specialists in the field of horticulture from the project partners.

Keywords: *Fertigation, injection device, fruit plantations*

1. Introduction

The irrigation system is installed in plantations usually prior to tree planting or immediately after planting, in order to ensure soil watering especially in the rooting area.
Drip irrigation hoses or micro-sprinklers are placed on the soil or near the soil under the rows of trees, and watering is applied more often and with lower watering norms, especially during the first half of the growing season, until rooting is ensured, then irrigation is monitored according to the soil water voltage values given by moisture sensors installed in the parcels since the year of planting the trees.
The plantations fertilizing is based on soil fertility status, established by soil analysis or foliar diagnosis. When applying fertilizer dosages, it should be taken into account that the trees capitalize about 30-40% of the amount administered, and from this a part is blocked in the permanent organs of the tree, and the other part is exported through the harvest, the leaves and the wood that falls to the cutting.
The right moment for fertilizers application is still discussed by the researchers. Phosphorus potassium, organic fertilizers and one third of nitrogen must be applied in the autumn before ploughing, and the rest of the nitrogen, split in two doses, must be applied in spring during blooming and during the intense growth of the sprouts.
The process of nutrients absorption is not an uniform process during the active vegetation period, but it shows certain intensification or slowing-down, depending on several factors, such as: the physiological specificity of the species, the vegetation phenological phases, the light regime, heat and water, the presence of various substances in the soil, soil reaction (the pH) [1].

2. Material and method

The recommended recipes with dosages of the most commonly used soluble fertilizers used worldwide for plum and pear species are presented for plantations equipped with local irrigation installations and soluble fertilizer dispensers [1]. Monthly dosages, or dosages per certain phenological phases of the vegetation season, shall be divided into weekly or, at the most, two-weekly applications. Soluble fertilizers will be applied simultaneously with local irrigation in stages of at least 3 hours each. Of course, the recommendations in Tables 1 and 2 will be adjusted according to the foliar diagnosis. This will be done annually on samples of leaves harvested between July 15 and August 15, within the laboratories of Pedology and Agrochemistry County Offices.

Table 1: Fertilization recipe in plum plantations on fruit

Month	Requirements as to the mineral elements (kg/ha)				Recommended fertilizing (kg/ha)			
	N	P_2O_5	K_2O	MgO	Potassium nitrate	Mono-ammonium phosphate	Ammonium nitrate	Magnesium nitrate
March	5	5	5	0	10	10	5	0
April	10	15	25	5	60	20	0	30
May	25	15	40	5	85	25	10	30
June	30	15	50	15	120	25	5	100
July	30	5	50	15	130	10	5	100
August	25	5	45	10	100	5	25	60
September	5	5	10	5	10	5	0	25
Annual total	130	65	225	55	515	100	50	345

Table 2: Fertilization recipe in pear plantations on fruit

Month	Requirements as to the mineral elements (kg/ha)				Recommended fertilizing (kg/ha)			
	N	P_2O_5	K_2O	MgO	Potassium nitrate	Mono-ammonium phosphate	Ammonium nitrate	Magnesium nitrate
March	12	10	15	0	40	15	20	0
April	20	15	25	5	60	25	15	25
May	35	20	35	10	85	30	0	32
June	40	15	35	15	88	20	40	60
July	25	10	30	10	70	8	8	55
August	6	5	5	8	10	0	0	45
September	8	5	10	5	10	8	0	30
October	10	5	5	0	25	5	15	0
Annual total	156	85	160	53	388	111	98	247

Note: The amount of administered fertilizer is divided into weekly dosages and it is applied for at least 3 hours of irrigation; the recommendations will be adjusted according to the foliar diagnosis.

The ICDP Pitesti Maracineni experimental - demonstrative fields of intensive fruit growing are equipped with irrigation – fertilizing equipment, which administer the water and the fertilizer elements specific of each crop.
The application of water and soluble minerals is done in phases, dosages, moments and phenological phases, specific to the physiological and technological requirements of each fruit crop.

The fertilization is carried out with equipment for injection of the various primary solutions in the irrigation system arranged for a particular crop.
In principle, the technology for irrigation with dripping tube or micro-sprinkler irrigation is limited to local watering, with controlled amounts of water, correlated with the soil absorption capacity and evapotranspiration of the crop in question, distributed around plants, mainly in the root development area. The use of such equipment, facilities and drip irrigation systems or micro-sprinkler systems is particularly suitable for horticultural crops (fruit trees, vineyards, vegetables, flowers), in the field or in protected areas, with availability for a high degree of mechanization.

3. Results

The fertigation facility in ICDP Pitesti-Maracineni, which the tests on the fertigation equipment have been conducted upon, fig. 1, is made up of the supply pipe, connected by a branch pipe (figure 2) to the underground pressure network, the vent valve with tap (fig.3), that is the closing / opening tap for inlet of the irrigation water in the installation, the sand filter (fig.4), mounted on a circuit parallel to the main circuit of the irrigation system (bypass), tap separating the main circuit from the circuit crossing through the sand filter, water meter (figure 5), screen filter (figure 6), the network of pipes distributing the irrigation water to the serviced plots (2 by dropping and 2 by micro-sprinkling) solenoid valves (figure 7) mounted on each distribution network, with control from a supervisor point.

Fig.1 Fertigation system for intensive fruit plantations

Fig. 2. Branch pipe of fertigation system

Fig. 3. Vent valve with tap

Fig. 4. Sand filter

Fig. 5. Water meter

Fig. 6. Screen filter

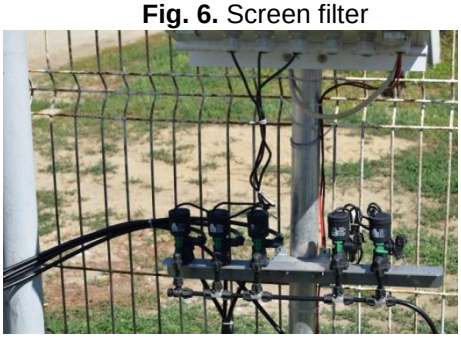

Fig. 7. Solenoid valves for irrigation plot selection

For commissioning of the installation one shall proceed as follows:
- Shut off the tap valve of the main pipeline and open the tap on the vent valve to remove the air from the installation;
- Depending on the turbidity of the irrigation water, a choice is made to introduce it into the distribution network either through the main circuit or through the sand filter circuit, by properly handling the inlet / circuit separation valves;
- The water passes through the meter, which records the volumes of transiting water, the screen filter with 120 μm fineness, which holds the particles in suspension and prevents the clogging of the distribution elements of the installation (dripping devices / micro-sprinklers) and reaches the solenoid valves; the plot to be irrigated is selected by closing / opening these valves.

On the main pipeline, upstream of the water meter there are mounted pressure couplings with ¾ 'tap valves, for branching the injection device, fig. 8, which absorbs the primary solution from the mixing tank, fig. 1.

Fig. 8. Branching of the injection device to the local watering system

The main features of the local irrigation system (including 2/4 distribution networks) are:
- The underground pipeline for water supply to installation = Ø 100 mm
- The pipeline connecting the primary solution injection device = Ø 50 mm
- Distribution hoses on rows of trees = Ø 16 mm
- Distance between dripping devices along the watering hoses = 1 m
- Flow rate of dripping devices = 2 (4) l / h
- The length of the trees rows (of the watering hoses) = 160 m

- Number of hoses (rows) = 35 (45)
- The primary solution dosage will be 80-100 (100-150) l
- The administration time will be within 3 hours, as is the minimum administration duration of a watering standard.

The injection device [2] was tested with a primary solution of 0.2% concentration prepared from the Magnisal* chemical product [3].
*Magnisal is a totally water soluble fertilizer that contains 11% nitrogen as NO_3 and 16% magnesium as MgO; the product solubility is 173 g/100 g water at a temperature of 0°C, 200 g/100 g water at 10°C, 225 g/100 g water at 20°C, 256 g/100 g water at 30°C, 289 g/100 g water at 40°C; concentration (%), pH and electrical conductivity (mS / cm) vary as follows: 0.1/5.56/0.88; 0.2/5.51/1.69; 0.3/5.37/2.52; 1.0/4.85/7.58; 5.0/4.06/29.9.
The main advantages of the product are: Magnisal is a totally water-soluble fertilizer; all nitrogen is in the form most accessible for the plant (NO_3); it is the most effective fertilizer for preventing and treating magnesium deficiency; it is the most recommended magnesium source for foliar spraying.

Table 3: The technical and functional characteristics achieved with the injection device [4]

Pres. in the watering pipe, bar	Working pressure of injection device, bar	Injection pressure, bar	Supply flow of injection device l/min	Discharge flows from drive chambers 1 and 2, l/min	Volume of drive chambers 1 and 2, ml	Control chambers volume of directional valves 1 and 2, ml	Injected flow rate of primary solution, l/min
3.7	3.5	3.6	3.79	1.596/1.444	42/38	11.1/11.6	1.4
Frequency of mobile assembly, double strokes/min	Control chambers flow of directional valves 1 and 2, l/min	Efficiency of injection device $\eta = Q_{inj}/Q_{supply\ of\ inj.\ device}$ %					
38	0.418/0.432	36					

4. Conclusions

On the main pipeline of the irrigation facility, between the points of the connecting pipe of injection device, a tap valve as a diaphragm will be fitted, by means of which pressure drop will be achieved; Δp = pressure drop of the injection device - injection pressure, which will facilitate the injection process of the primary solution, in a continuous operation of the device.
For the control and monitoring of the working parameters, it is necessary to make a hydraulic circuit parallel to the main pipeline of the installation (which is the power supply circuit of the injection device), equipped with specific parts (taps, Y route filters, directional valve, pressure reducer with gauge, flow meter), similar to those in the test stand structure, fig. 9.

Fig. 9. Elements of control and monitoring of the working parameters

The advantages of fertigation

- It makes water, energy and labour force savings;
- As a result of the watering lack for leaves and fruits, the appearance of specific diseases is reduced;
-The low atmospheric humidity reduces the appearance of cryptogamic diseases;
- Applied pesticides are not washed off the leaves with irrigation, thus prolonging their action period;
- There is reduced the density of weeds and their excessive growth as a result of watering / fertilizing lack for the strips between the rows;
- It ensures an increased efficiency of use by the crop plants of the mineral fertilizers, applied simultaneously with irrigation water;
- It does not pollute soil and surface or deep water, due to local administration done in small and frequent dosages of fertilization recipes;
- It ensures an uniform watering and without water and fertilizer losses on slope or uneven ground;
- During the fertilization, other technological works can be applied in orchards;
- Upgrading of the old sprinkler irrigation systems only requires connecting the new equipment of local irrigation to the former.

Economic efficiency

This method of fertilization is the most efficient, both in terms of the yield of the fertilizer mixture use by the crop plants and in terms of energy and water consumption and labour force consumed for the administration of a chemical fertilizer dosage.

Local water distribution, only near the root system of plants, results, for the same balances of water used by plants, in low consumption, namely lower by about 50-60% of water consumption specific to sprinkler irrigation, which implicitly results in reduced costs of water supply.

The application of fertilizer irrigation reduces the labour force involved by more than 50%, and the yield of fertilizer usage by crops is higher than 80%.

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