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CONSIDERATIONS ON IRRIGATION AND FERTILIZATION OF AGRICULTURAL CROPS ON SANDY SOILS IN ARID, SEMIARID AND DRY SUB-HUMID CLIMATE

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Abstract: *Project PN-III-P1-1.2-PCCDI-2017-0254, Contract no. 27PCCDI / 2018, within PNCDI III proposes the development of innovative technologies for irrigation of agricultural crops on sandy soils, in arid, semiarid and dry sub-humid climate, applicable to project partners SCDCPN Dabuleni and SCDP Constanta. Expansion and intensity of extreme weather phenomena reduce agricultural output by at least 30-50% per year. In Romania, about 14.7 million hectares of agricultural land, of which 9.4 million hectares of arable land (64% of the arable land), the soils are affected, to a greater or lesser extent, by frequent droughts, over periods long and consecutive years.*
Sandy soils fall into the soil group with a more pronounced manifestation of extreme phenomena (atmospheric, pedological and agricultural drought, strong burning and a major shortage of rainfall, unevenly distributed throughout the vegetation period).
All this leads in the great majority of the growing years to the drastic diminution of the production of large crops, of orchards and vineyards, often going to the compromise of the respective crops. [1]

Keywords: *Sandy soils, arid climate, fertigation equipment*

1. Introduction

The sandy soils in Romania occupy 460 thousand hectares, most of them 208 thousand hectares, in a true "Bermuda Triangle", with the tip at the southern border of Craiova and based on the Danube, in the counties of Dolj, Olt and Mehedinti [2]. In the area of sandy soils in southern Oltenia, the multiannual average of precipitation P is 540 mm, the temperature is 11,2 ºC and the potential evapotranspiration ETP of 700-755 mm. These values lead to a De Martonne moisture index of I = 25-26, to a P-ETP aridity index of -160 ... -210 mm and 100P / ETP of 72-75%. The value of the indices encompasses the sandy area of the Sadova - Corabia settlement in the semiarid and excessively dry type of climate (Donciu C., 1986). Existing hydric resources are insufficient for the optimal growth and development of plants, predominantly drought during the vegetation period. The analysis of thermal and hydric resources has highlighted a tendency to increase the drought over the past two decades, with unfavorable effects on agriculture in southern Oltenia.
On sandy soils, periods of drought can occur at shorter intervals than other soil types. The range of relatively limited humidity on these lands determines the essential feature of watering - small watering standards applied at short intervals.
Low values of water capacity in the field are compensated by the property of sandy soils to provide much of the retained water to plants. Soil retention capacity for water assimilable by plants is low compared to soils with loamy or clayey texture. This is due to the high content of these lands in coarse sand and the low percentage of humus and clay.
Dobrogea is the driest region in Romania, with the lowest amount of atmospheric precipitation. Dobrogea is generally characterized by the existence of two distinct climatic units [3]:

- the eastern part, in the form of a narrow strip (12-15 km) along the Black Sea, where its influence is felt, but where the least rainfall is;
- the central and western parts, where continentalism increases.

The aridity of Dobrogea was previously highlighted by a series of researchers [4] not only due to the lack of atmospheric precipitation but also by the strong winds and the high wind velocity, which are caused in most cases by the existence of continental anticyclones.

The climate is semiarid, continental with hot and dry summers, with frequent dry winds throughout the year, with temperate winters, generally without snow. The average annual temperature is 11.0 ºC and the total active temperature is 3988 ºC, of which 3170 ºC in the growing season, the absolute minimum temperature of -21,4 ºC (1987) and the absolute maximum of 38,4 ºC (1988); annual precipitation 400 mm, out of which 240.7 mm during the vegetation period. The average water deficit (about 400 mm) is covered by irrigation. Once at 10-15 years, temperatures below -20 ° C are recorded, but what causes damage to plantations is spring return frosts (especially April).

The predominant type of soil is limestone chernozem, loosely formed, with loamy texture and good storage and circulation of water. The humus content is between 2.5 and 4%; The pH of the soil is neutral slightly alkaline (7.0-8.1) across the profile.

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Thermal resources, strong sunstroke and irrigation during periods of drought can favorably affect agricultural crops on sandy soils. The possibility of capitalizing on these poorly fertile soils and the early production (7-10 days in advance of other areas) are some arguments for the development of horticulture in these areas. The soils of Dobrogea are mostly favorable to the cultivation of fruit trees, especially peach (including nectarine), apricot and almond. Generally, the fertility and production potential of these soils decreases from south to north, to the mountainous area and the delta area [5].

2. Considerations on irrigation and fertilization of agricultural crops on sandy soils in arid, semiarid and dry sub-humid climate

The need for water is different during the vegetation period, because the passage of plants through different stages of development requires different living conditions, so the need for water cannot be the same throughout the vegetation period. In plant life, depending on the vegetation phases and stages of development, periods (relatively short) occur during which the water deficit is reflected in production. These periods are known as "critical phases for humidity".

The critical phase for humidity coincides with the most intense growth period, overlapping in general with the breeding phase. Reproduction organs are formed in several stages, namely: differentiation, formation of reproductive organs, fertilization and formation of the fruit. Meteorological factors (air humidity, heat, light, precipitation) also have a direct influence on the need for irrigation. Precipitation is the most important source of soil moisture and an important indicator for appreciating the need for irrigation; they are characterized by multi-annual average, with high variability for different climatic zones.

In the correct management of the supplementation of irrigation plants' irrigation water, an essential role is the knowledge of the water consumption of plants under the given soil and climate conditions, tab. 1

Table 1: Climatic characterization of the area of sandy soils in southern Oltenia during the period of vegetation (1985-2002) (Ploae P., 2002)

Month	Climatic indexes					
	12 p / (t+10) (De Martonne)		100 p / ETP % (Donciu)		(Δ p/ Δ t)10 (Seleaninov)	
	Value	Qualifying	Value	Qualifying	Value	Qualifying
IV	24.8	moderately dry	79.5	dry	1.5	suficiently
V	26.1	moderately dry	55.8	very dry	1.1	suficiently
VI	22.0	semiarid	42.6	excesively dry	0.9	insuficiently
VII	20.2	semiarid	31.4	excesively dry	0.8	insuficiently
VIII	11.1	arid	23.2	excesively dry	0.5	insecure agriculture
IX	13.1	arid	50.6	very dry	0.7	insecure agriculture

Research by Marinica Gh. et al. at CCDCPN Dabuleni points out that for the water consumption of different species of agricultural plants, sandy soils provide between 4 and 9% of their own reserve. The rest of the consumption needs are provided by irrigation of 29 - 60% and of precipitation 34 - 62%.
Among the studied species, bean, rye, wheat, sorghum, early potatoes are highlighted with low water consumption (2850 - 4900 m3 / ha). Maize and soybean recorded the highest water consumption (7340 - 7760 m3 water / ha).
Behavior of sandy soils in water and plant interrelations, tab. 2, has led to some peculiarities in the design of irrigation on these lands. Hydrotechnical schemes of facilities should ensure that small watering standards (300-400 m3 / ha) and frequent (5-7 days) are built on decentralized organizational structures (small plots) that are permanently operational in time and space.

Table 2: Water consumption and sources of coverage for some plant species grown on sandy soils

Crop	Medium production (q/ha)	Water consumtion (m^3/ha)	Sources of coverage					
			Soil store		Rainfall		Irrigations	
			%	m^3/ha	%	m^3/ha	%	m^3/ha
Rye	34.2	4165	9	385	62	2580	29	1200
Wheat	40.7	4680	8	400	55	2580	37	1700
Sorgh grains	85.4	4900	9	440	60	2960	31	1500
Maize	70.8	7760	8	624	38	2960	54	4176
Bean	25.7	4160	4	160	60	2500	36	1500
Soybean	30.2	7340	6	450	34	2500	60	4480

The contribution of irrigation water to the production of sandy soils is greatest in the dry years, when the production increases in irrigated crops increase up to 10 times the non-irrigated crops. Administration of these quantities of water by irrigation, tab. 3, involves fairly high costs with the application of watering, requiring between 8-12 watering at soybeans and 2-3 watering at bean.

Table 3: Elements of the irrigation regime for some cultivated plant species on sandy soils

Crop	Elementes of irrigation regime			
	P min. recommandate	Watering standard (m^3/ha)	Number of watering	Irrigation standard (m^3/ha)
Rye	1/2 i.u.a/ 50 cm	300-450	2-4	750-1650
Sorgh grains	1/2 i.u.a/ 50 cm	300-450	3-4	1200-1650
Bean	1/3 i.u.a/ 50 cm	500-550	2-3	1050-1600
Wheat	1/2 i.u.a/ 50 cm	350-450	3-5	1250-2150
Maize	1/2 i.u.a/ 70 cm	350-450	7-11	3150-4800
Soybean	2/3 i.u.a/ 50 cm	300-400	8-12	3200-4700
Tomatoes	2/3 i.u.a/ 50 cm	300-400	5-7	2100-2850
Peach	1/2 i.u.a/ 100 cm	450-550	4-5	2000-2500
Grapevine	1/2 i.u.a/ 100 cm	450-550	4-5	2000-2500

The direct effect of the addition of water in the soil through irrigation is reflected in crop yields obtained from irrigated crops compared to non-irrigated crops. Irrigated harvest yields are higher on sandy soils compared to zonal soils, ranging from 4630 kg / ha to sorghum, 39.0 t / ha in tomatoes and 8.0-10.1 t / ha in vines and fruit trees.
In the climatic conditions specific to Dobrogea, the difference between the ETc values and the mean average rainfall values calculated with probabilities of 50 and 80% [6] resulted in the optimum irrigation water requirements NAI), for thermophilic tree species with the largest share, peach and apricot. Methods of irrigation arrangements for fruit crops and technical elements of watering (watering standard, minimum ceiling, application rate and water spray) depend fundamentally on the type and properties of soils.
The useful water capacity (CU) is different for the main soils in Dobrogea. On the 100 cm depth, chernozems and chernozems (gray soils) show CU values of approximately 150-210 mm. The recommended watering regime, depending on the useful water capacity, has relatively high and medium values in Dobrogea's agricultural soils, about 600-900 m3 / ha for chernozems and 400-600 m3 / ha for Greek chernozems [7].
The average water application rate should not exceed 5-7 mm / h in the soils with moderately permeable soils, respectively 7-9 mm / h in the soils with chernozem type.
Recommended watering methods are primarily methods characterized as localized watering (dripping, micro-sprinkling).
The fertilization of agricultural crops aims at maintaining the high fertility status of the soil, human intervention by the administration of organic and chemical fertilizers in order to restore the nutritional balance of the soil, being an indispensable practice.
The research carried out for 6 years on sandy soils from Dabuleni, which aimed to increase the soil's trophic potential through the annual administration of organic fertilizers in large quantities of 20-80 t of manure / ha, 30-120 t of compost / ha and 1-4 t of vegetal debris / ha, have highlighted the improvement in the supply of organic matter and easily accessible mineral elements in the surface layer of the soil). The bioaccumulation process is more intense in variants with added organic matter than the control, which is evidenced by higher values of organic carbon. Organic fertilization also had a beneficial effect on the state of assurance of the soil with total nitrogen, mobile phosphorus and accessible potassium, with higher values especially in the case of manure and composted marc.

Table 4: The influence of ameliorative fertilization on the soil chemical properties is presented (Ion P. et al.,1996)

Source of organic matter	C. org (%)	N_t (%)	P-AL (ppm)	K-AL (ppm)	T (me/100 g sol)	PH (H_2O)
N200 P80 K80 (Mt)	0.240	0.037	46	83	4,8	6.2
Manure	0.282	0.041	60	111	7.1	6.6*
Composted marc	0.323*	0.050	56	127	7.0	6.7*
Vegetable debris	0.265	0.042	48	103	5.6	6.5
DL5%=	0.079	0.018	25	55	3.4	0.4

Improving the state of soil supply with organic matter has led to the improvement of the adsorbent soil complex, reflected in the total cation exchange capacity. With the increase of the cationic exchange capacity, there is also an improvement in soil buffering capacity, with pH values being higher for all organic fertilized variants.
The large and annual administration of organic fertilizers (manure, compost seed) has boosted the biological activity of the soil expressed by the global index - dehydrogenase activity, also increasing the number of bacteria, tab. 5.

Table 5: The Influence of Ameliorative Fertilization on Soil Biological Activity, 0-20cm (Ion P. et al., 1996)

Source of organic matter	Dehydrogenase activity (mg formazan/100g sol)	Number of bacteria (mil./1 g sol)	Number of microscopic mushrooms (mii/1 g sol)
Mineral fertilizers	5.19	25.12	15.25
Manure	6.86	67.37	16.16
Composted marc	8.52	62.62	18.62
Vegetable debris	5.68	26.00	245.75

Nitrogen fertilizer administration must be correlated with the maximum plant absorption period, which coincides with the intense increase of the vegetative part and the achievement of the production. Most of the unused plant nitrogen is lost by leaching, contributing to the pollution of soil and groundwater with nitrates (Table 6) (Mihaela Croitoru, 1996, 2001).

Table 6: Nitric nitrogen distribution on the soil profile in plum plantations (Mihaela Croitoru, 1996)

Version	Depth(cm)	N - NO_3 (ppm)
N200P80K100	0 - 20	28.0
	20 - 40	30.8
	40 - 60	24.0
	60 - 80	28.4
	80 - 100	75.2

For the climatic conditions in Dobrogea, a normally supplied soil should contain over 0.5% of total nitrogen, 150-200 kg / ha of phosphorus, 500-800 kg / ha of potassium [8]. Peaches, the main fruit growing in Dobrogea, require more nitrogen fertilization than other tree species.
For normal growth and optimal production, peach requires 13 essential nutrients, which must be found in the plant in different amounts, tab. 7. Phosphorus, potassium, a portion of nitrogen and

organic fertilizers are incorporated in the autumn at the time of planting, and the rest of the nitrogen is applied fractionally in bloom and in the intensive growth phase of the sprouts.

Table 7: Necessary for nutrients on peach and nectarine [9]

Macroelementes	Level of nutrients in leaves			Level in mature fruits (%)	Motility in plant *
	Deficiency (%)	Optim level (%)	Excess (%)		
Nitrogen	2.3	2.6-3.0	-	1.0-1.5	medium
Phosphorus	-	0.1-0.3	-	0.1-0.3	high
Potassium	1.0	over 1.2	-	1.5-2.5	high
Calcium	-	over1.0	-	0.05-0.15	lower
Magnesium	0.25	over 0.25	-	0.05-0.15	high
Chlorine	-	-	0.3	-	high
Sulfur	-	-	-	-	lower
Microelementes	**Deficiency (mg/kg)**	**Optim level (mg/kg)**	**Excess (mg/kg)**	**Level in mature fruits (mg/kg)**	**Motility in plant ***
Iron	60++	over 60++	-	20-80	lower
Manganese	20	over 20	-	5-10	medium
Zinc	15	over 20	-	10-20	lower
Boron	18	20-80	100	20-50	lower
Copper	-	over 4	-	5-10	lower
molybdenum	-	-	-	-	medium

* Indicates the ability to pass from old leaves to young leaves and fruit
++ Leaves samples will be harvested in April and May

In an irrigated orchard by the localized method, fractional doses of soluble minerals - fertilizers - can be applied depending on the specific phenological phases of peaches and the expected level of fruit production. Doses and fertilization recipes should be correlated with soil agrochemical analysis and foliar diagnosis.
Fruit plants with falling leaves, such as peaches, which are not nutritionally well-fed, especially with respect to nitrogen, are more exposed to frost damage. Flowering buds of poorly or poorly fertilized orchard species are less healthy and more easily damaged by frost. Using nitrogen application in the middle of summer or after harvesting, a stronger growth and development of tree buds may be induced and some flowering delays, especially in stone fruit species such as peach and apricot. Trees that are not properly fertilized tend to lose leaves earlier in the autumn and flowers earlier in the spring, which increases sensibility to frost damage [5].
Phosphorus is also important for cell division and is therefore important for tissue recovery after frost.
Potassium has a favorable effect on water balance and plant photosynthesis.

3. Considerations on fertigation equipment of agricultural crops

Fertilization is the process by which water and fertilizers are administered simultaneously, via an assembly of irrigation equipment and fertigation equipment.

As a rule, the fertigation equipment includes the injection device of the primary solution in the irrigation water, the primary solution preparation vessel, the measuring equipment and the adjustment of the working parameters, the hydraulic connection elements between the components of the equipment, respectively the equipment and the irrigation installation. Choosing the right fertilization equipment is just as important as choosing the correct nutrients. Incorrect selection may damage parts of the irrigation system, affect the efficient operation of the irrigation system or reduce the effectiveness of nutrients.

Injection of fertilizers in water is made by: differential pressure; vacuum; the absorption of fertilizer; pumping.

Of the equipment that performs the differential pressure injection, the diluent may be mentioned, fig. 1, which is a sealed container in which water-soluble solid fertilizer is introduced. The container is mounted in parallel with the main pipeline of the irrigation installation and the injection is made after the screen filter. In order to work in optimal conditions, a device (valve, diaphragm, diameter reduction) is installed on the supply pipe of the irrigation system, which creates a hydraulic load drop; the water dilution point of the diluent will be in front of the device that creates the hydraulic load drop and the fertilizer injection after the device.

The diluent consists of a recipient 1, a tap 2 located on the water inlet in the tank, a tap 3 on the discharge of the fertilizer solution in the tank, two hoses 4 and 5, a connection to the watering system circuit 7 and a 6 trunk with sieve, into which solid fertilizer soluble in water is added.

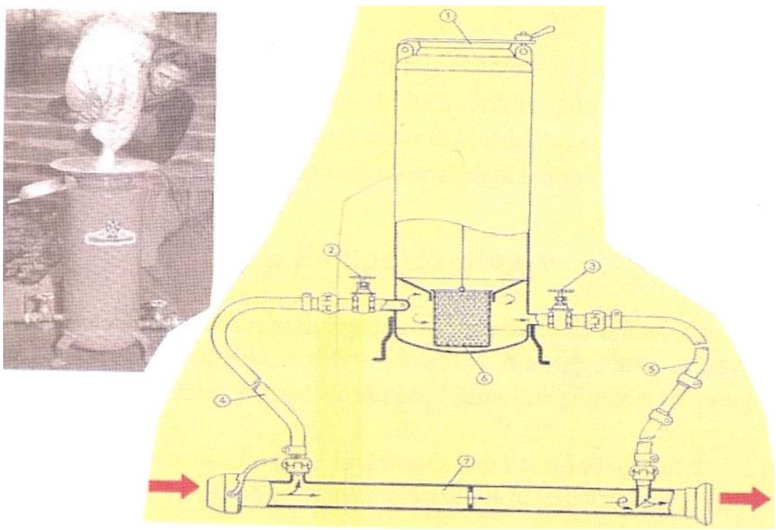

Fig. 1. Component of fertilizer equipment with diluent

Advantages of the diluent. The technical solution is simply constructive, it works hydraulically, the dilution is very convenient to achieve because it allows the direct use of soluble solid fertilizers. The investment is reduced and can be used with watering installations with a fixed watering position.

Disadvantages and precautions for use. The process of dissolving the fertilizer evolves differently during a load, the intensity of which decreases continuously. Thus, the injection dose is different and the time to dissolve the fertilizer is not always known. The concentration of the fertilizer solution is higher at the beginning of the fertilization and is lower at the end. At each change of fertilizer station, the container must be emptied and reloaded with fertilizer. The volume of the container (from 50 to 300 liters) limits the use of the diluent to fertilize the position of large areas (serving less than half a hectare of vegetables and one hectare in trees).

The container must be tight, not allow air to enter the enclosure or liquid loss during the process. When using a valve for injection control, the concentration of the fertilizer solution is less varied but

requires manual intervention; the loss of pressure / flow generated by the valve is high, influencing in the negative sense the parameters of the water distribution devices.
There is a risk of environmental pollution due to the increased fertilizer injection dose at the start of the injection, the uneven distribution of the solution in the crop and the lack of the anti-retardant valve.
When using corrosive substances there is a risk of damage to components of the injection equipment and the watering system.
Administration of fertilizer mixtures is possible only if they are compatible and if they permit the obtaining of homogeneous fertilizing solutions; it is necessary to know the way in which the different chemicals in the fertilizers used in the mixture react, to prevent accidents at work. **Vacuum injection** is based on the principle of the Venturi tube and the equipment is called Venturi injector. Venturi liquid chemical fertilizer injectors are based on the Venturi effect, illustrated in fig. 2, according to which, when a pressurized liquid flows through a given section with sudden constriction and progressive decomposition, the suction phenomenon occurs.

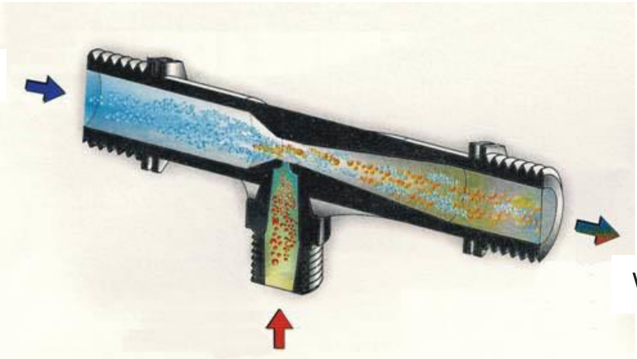

Fig. 2. The operating principle of the Venturi injector

Venturi injectors, made within 3/ 4”-2” limits, require operating pressures higher than 4.5 bar, the ratio between the flow rate of the primary solution and the flow rate of the fertilizer solution being 1/5- 1/50 in the 3/4" model and 1/ 5- 1/100 in the 2” model. The fertilizer solution flow rates, depending on the size type (3/4” -2”), vary between 193-2640 l/h.
The absorption of the fertilizer solution depends on the type of fertilizer, the inlet pressure and the water flow rate. It operates with a minimum pressure difference that interferes between the input and output segments.
Venturi Injectors can be installed either on the main pipe of the irrigation plant (full flow) for the 3/4 "and 1" constructive dimensions or on a parallel bypass circuit for the 1¼ ", 1½" and 2", fig. 3.
The advantage of connecting the injector to the main column of the irrigation installation, fig. 3, is the realization of a relatively large flow of primary injection solution for small type (3/4 "and 1") sizes. The disadvantage of the connection technical solution is the loss of the hydraulic load created in the injector body, with implications for the sizing of the distribution network of the irrigation system.
The connection of the bypass injector, fig.4, eliminates the disadvantage of creating a hydraulic load loss on the main column of the irrigation installation, but in turn the disadvantage of lower injected primary solution flows compared to the full-flow connection, for the same type of injector size.

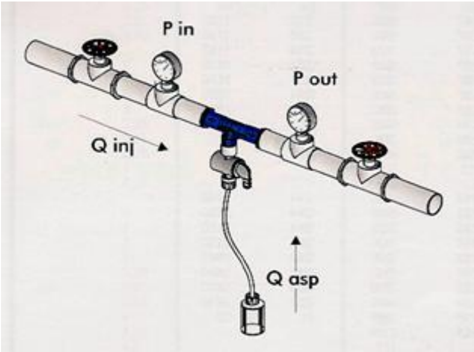

Fig. 3. Connecting the Venturi injector to main pipe

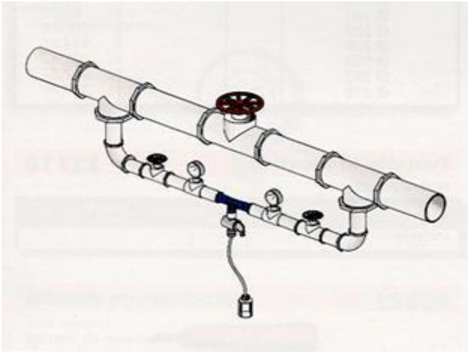

Fig. 4. Connecting the Venturi injector on by-pass

Advantages. The Venturi Injector is simple to construct, does not require large investment for purchase and has high operating reliability. It achieves a good proportional flow rate of the pump / plant and the injection dose is constant.

Disadvantages. The pressure loss on the plant circuit is about 1 bar, and the flow and the working capacity of the plant are reduced. This situation is specific to installations with large diameters and flows, to which Venturi injectors cannot be used; there is a risk of air absorption at the end of the injection or clogging of the nozzle with sedimentary impurities in the fertilization process; the quantitative regulation of the injected fertilizer solution is difficult to achieve and is therefore not suitable for automation.

Injection by fertilizer absorption, fig. 5, is accomplished by connecting a liquid fertilizer tank to the absorption circuit of a pump (or a gravitational water supply source with falling water), and to facilitate the process, the vessel must be at a higher rate.

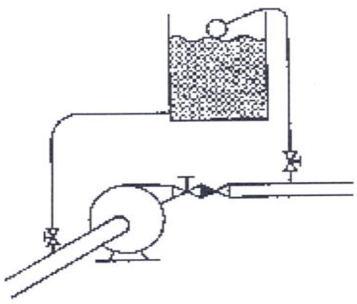

Fig. 5. Injection through absorption scheme

The vessel can be supplied with water from the pump discharge circuit for the primary solution, and at the end of the fertilization, the valves are closed to prevent the introduction of air, which causes the cavitation phenomenon.

Advantages: the construction solution is very simple; does not use additional energy.

Disadvantages: the pump is worn because of the fertilizer solution it is driving; the rotor of the pump can be destroyed by the cavitation phenomenon, the air absorption in the primary solution container at the end of the administration process; does not allow concentration variation in a large range.

The fertigation equipment to which the injection is made by pumping, consists of injection devices of the **volumetric pumps** with membrane type or piston pumps type, hydraulically, pneumatically or electrical actuated.

These pumps can perform active strokes on a moving direction of the mobile injection assembly (single effect pumps), respectively, on both moving directions (double-effect pumps).

Depending on the mounting position of the system, the pumps are mounted in series, on the main flow circuit of a full flow or on a bypass circuit.

4. INOE 2000-IHP contribution to the development of the fertigation equipment field

Injection device of double pump with membranes type, developed by INOE 2000-IHP during the collaborative project Innovative Technologies and Equipment for the Implementation in Irrigated Agriculture of the Modern Fertigation Concept (FERTIRIG) – Contract no.: 158/2014 [10] was made in a compact construction, the piston-membrane movable assembly, the hydraulic directional control valve, the drive of hydraulic directional control valve , the throttles of the control chambers of directional control valve, the primary solution suction / discharge valve block are incorporated in the body. The connection between the functional elements is achieved through holes in the body of the device and the piston of the mobile assembly, been eliminated the external connections, with the exception of those associated to the control chambers of the directional control valve.
The schematic diagram of the fertilization equipment is shown in fig. 6.
The mobile assembly, fig. 6 sect. D-D consists of piston, membranes, outer and inner flanges, special bolts for fixing the piston diaphragms.

Primary solution suction / discharge valve assembly; each injection chamber is connected to an intake and discharge valve. The suction / discharge valves of the two injection chambers are interconnected and connected to the primary and discharge solutions.

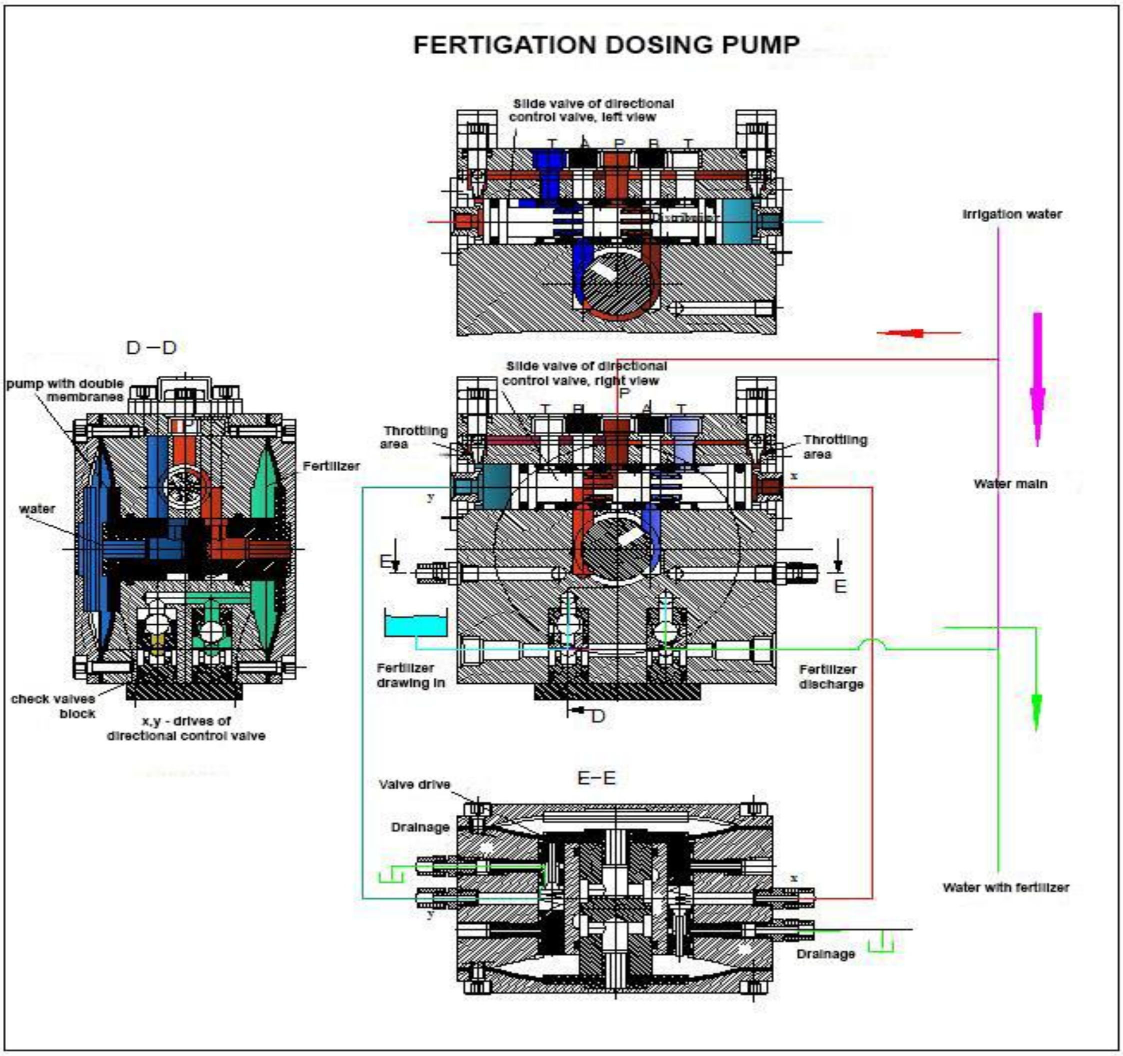

Fig. 6. The principle scheme of fertigation equipment

In the construction of the two-positions and four-orifices type directional control valve, the alternative with slide valve, with O-rings seal was chosen to allow the components to be executed in H8 / f7 tolerance fields, thus avoiding the extremely precise execution of the hydraulic directional control valve with classic slide valve, where the lost motions between the slide valve and the body are of the micron order. The constructive version of the directional control valve allows operation with irrigation water with a low level of filtration.
The seals have been designed and made with tightening as low as possible, so that the friction forces of the mobile elements are as small as possible.
The slide valve of the directional control valve has a positive coating, the switching is done without loss of pressure.
The control valve of the hydraulic directional control valve, fig. 6 sect. E-E are unblocking valves located in the water tank discharge holes in the control chambers operated in the pump body, to ensure hard closure and opening and to reduce the switching time of the directional control valve. The drive chambers are delimited by the outer surfaces of the membranes and the lids, and the injection chambers by the inner surfaces of the membranes and the body.
Depending on the position occupied by **the slide valve of the directional control valve**, the orifice P is connected with the orifices A or B, from which, through internal holes in the body and the piston, the pressurized water supply of the drive chambers is provided. Outside, holes A and B are plugged with technological plugs.
The T-holes alternately drain the water from the drive chambers (A to T or B to T) during the withdrawal phase of the membrane assembly (reducing the volume of the drive chambers). The water discharged from the drive chambers is distributed to the plants through an assignment tube with dropper built-in.
Also, from the P port, the Ccs-Ccd control chamber of the hydraulic directional control valve are continuously supplied with pressurized water. The mobile assembly alternately operates through the internal flanges the unblocking valves, which shortly before reaching the end of the stroke, connect one of the control chambers to the atmosphere, causing the switching of the slide valve of the directional control valve from the control chamber under pressure to the pressure discharge chamber.
The throttles, which regulate the flow of water that arrives into the control chambers, keep the slide valve of the directional control valve in an equilibrium position and dictate the frequency of the pump mobile assembly.

5. Worldwide top achievements in the fertigation equipment field

The most advanced fertilizer equipment with differential piston displacement pump is DOSATRON-France. The pump can be located both on the main circuit of the irrigation system and on a circuit parallel to it, and uses as the moving fluid the irrigating water that transits its feed line. The operating principle of the pump, illustrated in fig. 7 is the following:

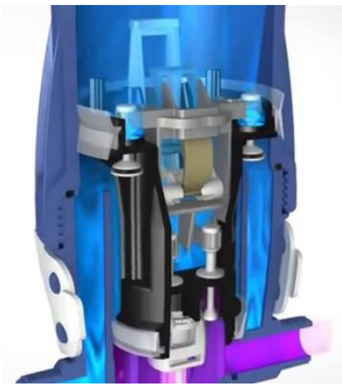

Fig. 7. Operation principle of the DOSATRON metering pump with differential piston

The water acts on the movable assembly of the pump, consisting of the driving piston and metering piston, that moves together.
The shift of the moving direction of the pump mobile assembly is controlled by the flanged arc-tilting mechanism located on the driving piston and which, by actuating some valves, allows access to the water as a moving fluid underneath or above the piston.
The metering piston is provided with a translation sealing type sliding cuff which, in the upward stroke, rests on the lower seat, seals against the metering cylinder and creates the depression required to raise the seat valve, the access of the primary solution under the piston and the drive of the volume of the overhead primary solution, existing inside it from the previous stroke, inside the moving fluid - primary solution mixing chamber (the cylinder of the drive piston).
In the downward stroke, the seal cuff of the metering piston is placed on the upper seat of the piston, which put on the seat or intake valve of the primary solution and allows the access to the primary solution volume already introduced into the metering cylinder at the previous stroke above it, through the longitudinal slots practiced on the external generators.
By continuously varying the volume of the mixing chamber in order to reduce it, the fertilizer solution is injected through the pump discharge connection into the irrigation installation.
DOSATRON equipment is designed so that the volume of injected fertilizer solution is always strictly proportional to the volume of water entering the unit, regardless of the variations in flow or pressure that may occur in the main pipeline. The high dosing accuracy of DOSATRON equipment eliminates the risk of over-cropping, thus contributing to plant protection, consumer health and the environment.

6. Objectives of the complex project on fertigation of agricultural crops

During the project Innovative technologies for irrigation of agricultural crops in arid, semiarid and dry sub-humid climate, project number PN-III-P1-1.2-PCCDI-2017-0254, Contract no. 27PCCDI / 2018, within PNCDI III, a fertigation equipment will be developed for operation in aggregate with drip irrigation, micro-sprinkling and underground systems.
The injection device, of injection pump with differential piston type, will have to operate at values of the hydraulic parameters flow-pressure specific to the mentioned watering methods.
Critical parameters for the injection device of the fertigation equipment component, which work in a dynamic regime, are the flows and pressures specific to underground irrigation systems, lower than drip irrigation and micro-sprinkling.
Fertigation equipment will be designed to allow for primary solutions of concentrations and different dosages depending on the chemical (macro or micro elements) they are prepared from.
The mixture of the irrigation water used as the moving fluid and the primary solution will be made inside the injection device, which will result in higher hydraulic yields.

7. Conclusions

• Project PN-III-P1-1.2-PCCDI-2017-0254, Contract no. 27PCCDI / 2018 within PNCDI III proposes the development of innovative technologies for irrigation of agricultural crops on sandy soils in arid, semiarid and dry sub-humid climate, applicable to project partners SCDCPN Dabuleni and SCDP Constanta, in the context in which the extension and the intensity of extreme meteorological phenomena decreases annual agricultural output by at least 30-50%.
• Sandy soils fall into the soil group with a more pronounced manifestation of extreme phenomena (atmospheric, pedological and agricultural drought, strong burning and a major shortage of rainfall, unevenly distributed throughout the vegetation period).
• On sandy soils, in arid, semiarid or dry sub-humid climate, the plants have specific water and fertilizer needs, which are administered with low norms and times of return, to satisfy optimally the soil-water-plant -atmosphere interrelationship.

• The contribution of INOE 2000-IHP to the development of the field of fertigation equipment resulted in the development of an injection device with technical-functional performance, of double pump with membrane type, validated in real exploitation conditions for the fertilization of horticultural crops from protected areas and of fruit crops at Vasile Adamache didactic farm within USAMV Iasi, ICDP Pitesti Maracineni

• During of the project Innovative technologies for irrigation of agricultural crops in arid, semiarid and dry sub-humid climate, project number PN-III-P1-1.2-PCCDI-2017-0254, Contract no. 27PCCDI / 2018, within PNCDI III, a fertigation equipment will be made whose injection device will be of pump with differential piston type , with the mixture of the irrigation water (the moving fluid) - the primary solution inside it; the equipment will work in aggregate with drip irrigation, micro sprinkling and underground irrigation systems for the administration of liquid fertilizers of different concentrations, obtained from chemical compounds with macro and micro elements.

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References

[1] "Technological solutions of plant cultivation on sandy soils in the context of climate change". Opening speech at symposium Manifestation of drought phenomenon in agricultural crops in the area of sandy soils, Dabuleni, 11 July 2012.
[2] Lăcătus, Victor. ”Orcharding in the "triangle" of sandy soils”. *Ferma magazine*, May 25, 2016.
[3] Păltineanu, Cr, I.F. Mihăilescu and I. Seceleanu. *Dobrogea: Pedoclimatic conditions, consumption and irrigation water requirements of the main agricultural crops – General climatic conditions in Dobrogea*. Constanta, Ex Ponto Publishing House, 2000.
[4] Topor, Nicolae. *Rainy and Dry Years in the Romanian People's Republic*, 1964.
[5] Paltineanu, Cristian, Emil Chitu, Leinar Septar, Corina Gavat, and Alexandru Oprita. *Peach and apricot in the system soil - plant - atmosphere, in Dobrogea*. Bucharest, Estfalia Publishing House, 2015.
[6] Păltinean, Cr., I.F Mihailescu, I.Seceleanu. *The general climatic conditions in Dobrogea*. Printed analytical text, Constanţa, 2000, p. 69-114.
[7] Canarache, Andrei. *Agricultural Soil Physics*. Ceres Publishing House,1990.
[8] Fideghelli, C., M.G. Devreux, Della Strada, F. Grassi. *Il miglioramento genetico delle drupacee L'Italia Agricola*, 1991.
[9] Scott, R.S., and K, Uriu. *Mineral nutrition in peach, plums and nectarine*. 1989.
[10] Sovaiala, Gh. Collaborative project ”Innovative technologies and equipment for the Implementation in the irrigated agriculture of the modern fertigation concept (FERTIRIG)”,Contract no.: 158/2014, Scientific Technical Report Phase III, 2016.