DRIPPER IRRIGATION EFFICIENCY IN THE SOD-PODZOL SOILS AT STRAWBERRY CULTIVATION IN THE MOSCOW DISTRICT

EFFICIENCE DE L'IRRIGATION GOUTTE À GOUTTE DANS LA CULTIVATION DE LA FRAISE SUR LES MOTTES DE GAZON-PODZOLS DANS LA RÉGION DE MOSCOU

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ABSTRACT

Leading countries of the world give preference to the low-capacity irrigation techniques which provides water and nutrition management for soil according to plants' requirements; dripper irrigation being one of them. Dipper irrigation permits water application in small rates over short time periods simultaneously with fertilizers and pesticides application. The later is important for the garden strawberry cultivation, as its productivity has been decreasing both in the case of water shortage and water excess as the result of gray rot and other diseases. In wet years productivity loss equals 40-50% and the commercial value of harvested strawberry also reduces. A field experiment on strawberry cultivation using dripper irrigation began in the Moscow district in Russia in 2007.

Different schemes of drip hoses fittings as well as spacing between drippers were studied. Soil moister, evapotranspiration (consumptive water use), strawberry productivity were analyzed during the experiment. Research was carried out during the vegetation periods in 2008 and 2009 having different air temperatures and soil moisture. As far as the roots of strawberry are located in the topsoil 30cm layer, water application rates taking into account root zone watering were calculated. The depth of drip hoses fitting and drip spacing were recommended to obtain the most favorable soil moisture values in the root zone as well as to facilitate farming techniques.

Based on the experimental results, a new technique of the dripper irrigation for strawberry

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has been developed that gave productivity increase by 1.7-1.8 times; water saving of 3.5 times; eliminated surface runoff and infiltration losses, minimized adverse impacts to the environment and facilitated farming techniques.

Key words: *Drip irrigation efficiency, Sod-podzol soil, water shortage, Lenin farm, Moscow, soil moisture distribution.*

RESUME

Les pays principaux du monde préfèrent les techniques d'irrigation de basse capacité pour gérer l'eau et la nutrition du sol selon les exigences, l'irrigation goutte à goutte étant l'une de ces techniques. Cette méthode permet à l'application d'eau en petite quantité sur les durées courtes simultanément avec l'application des pesticides et des engrais. L'application de ces derniers est important pour la cultivation de la fraise car sa productivité diminue en raison des maladies autant dans le cas de pénurie d'eau que dans le cas de l'eau excédentaire. Dans les années humides, les pertes de productivité sont estimées à 40-50%. Cela réduit la valeur commerciale de la fraise. Une expérimentation sur le terrain a commencé en 2007 utilisant le système d'irrigation goutte à goutte dans le quartier de Moscou (Russie) pour la cultivation de la fraise.

Les différents installations de tuyaux ainsi que l'espacement entre les goutteurs ont été étudiés. Les facteurs tels que la teneur en eau du sol, l'évapotranspiration (eau consommée), la productivité de la fraise ont été analysés lors de l'expérimentation. La recherche a été effectuée en 2008 et 2009 lors des périodes de cultivation ayant des différentes températures de l'air et la teneur en eau du sol. Les racines des fraises se trouvent à 30cm dans la couche de terre. La quantité d'eau appliquée est calculée compte tenu de l'arrosage de zone de racine. Il a été recommandé de placer les tuyaux et l'espacement des goutteurs de telle manière qu'il donne les valeurs les plus favorables de la teneur en eau du sol et de faciliter les techniques agricoles.

Compte tenu des résultats d'expérimentation, une nouvelle technique d'irrigation goutte à goutte a été développée qui a donné lieu à l'augmentation de productivité de 1,7-1,8 fois; d'économie d'eau de 3,5 fois. Elle a également éliminé le ruissellement de surface, les pertes d'infiltration, a réduit les impacts adverses sur l'environnement et a facilité les techniques agricoles.

Mots clés: *Efficience d'irrigation goutte à goutte, mottes de gazon-podzols, pénurie d'eau, ferme Lenin, Moscou, distribution de la teneur en eau du sol.*

1. INTRODUCTION

Under conditions of water shortages, the appropriate irrigation technique should economize on water use and permit nutrient management in soil according to plants' requirements. Drip irrigation is one such technique.

Drip irrigation allows crops watering in small water application rates with short intervals and allows simultaneous fertilizers and pesticides application together with irrigation water. The

later is important for the garden strawberry cultivation because its productivity declines both in the case of water shortage and water excess due to gray rot and other diseases. In wet years productivity loss equals 40-50% and a reduced commercial value of the harvested strawberry due to its poor quality. To address this probem, a field experiment on dripper irrigation to strawberry was started in 2007 in the Moscow didtrict of Russia, with a view to studying the efficiency and standardizing the parameters of dripper irrigation in garden strawberry.

2. MATERIALS AND METHODS

The experiment was conducted in the state farm: "Lenin" in the Moscow district in the sod-podzol loamy soils in 2007. Humus content in the topsoil was 2.2%; water-soluble nitrogen content was 45 mg/kg; mobile phosphorus and exchangeable potassium contents were 83 and 142 mg/kg, respectively. Soils were low water permeable with neutral pH. The depth to water was 2-3 m.

Drip irrigation system GALLILEO having computer-aided water application rate was used in the field experiment. Three drip lateral placements (on the soil surface, at a depth of 5 and 15 cm from the soil surface) and two dripper spacing (33 and 66 cm) with a buffer strip 2 m wide were studied. Sprinkling was used in the control plot. High-yielding variety of the garden strawberry Red Gonlet was cultivated using single-line (33 cm) scheme of planting (4 plants per 1 m of the line length. Row spacing was 1 m. The dripper discharge was 1.0 l/h.

Water discharge pattern and soil moister (A.A.Rode technique) were studied during the experiment. Soil moisture was maintained in the range of 80-85% and was measured at the depth of 15 and 30 cm with the help of tensiometer every day. Dripper discharge was measured at the beginning, at the middle and at the end of the irrigation season with the help of 9 volumetric glasses. Evapotranspiration was determined using balance method. Yield was considered for the period of biological ripeness of the garden strawberry. Dispersion theory was used for processing the experimental results. Field experiment was carried out during the vegetation period in 2008, 2009 and 2010. Vegetation periods were characterized as warm and wet in 2008 and 2009, where as it was extremely dry in 2010.

3. RESULTS AND DISCUSSION

Irrigation was provided at low rates to wet the top 30 cm root zone depth only. The duration of water application was 20…60 minutes. As a rule mineral fertilizers were applied simultaneously. In the wet weather conditions water was applied 41 times at the rate of 25-30 m^3 /ha. Water application duration was not more than 1 hour. Intervals between water application were 1 - 5 days. When it rained and soil moisture content was high there was no water application. However mineral fertilizers were applied every 2 - 3 days according to recommended rates. Weather conditions were characterized as medium considering temperature and water probability in 2009. Water was applied 10 times during the period from the 20th - 31st of May in 2009, 9 of them at the rate of 12.8 m^3 /ha for fertilizers application and 1 at the rate of 30.3 m^3 /hectare – water application without fertilizers. In June there were 24 water applications, 6 of them at the rate of 30.3 m^3/ha (for soil moisture optimization) and 18 at the rate of 18 m^3/ha (fertilizers application together with irrigation water). In August 2009 there were 22 water

applications to provide necessary moisture and nutrient regime in soil, 11 water applications for root zone wetting and 11 for applying nutrients. Water application rates were 28-30 m^3/ha and 12- 13 m^3/ha, respectively. In 2009 water was applied 79 times during the vegetation period (29 of them – root zone wetting and 50 for fertilizer application). The sprinkler water application rates varied in the range of 300 - 500 m^3/ha.

In 2010 dry weather conditions there were 66 water applications under dripper irrigation and 23 water applications under sprinkler irrigation. Water application rates are given in the table 1.

Table 1. Actual water application rates under drip and sprinkle irrigation in 2008 and 2009, m^3 /ha Les significations réeles des besoins en eau d'irrigation à l'irrigation goutte à goutte et l'aspersion en 2008 et 2009, m^3 /hectare

Drip irrigation		Sprinkle irrigation (Control plot)
Dripper spacing 33 cm	Dripper spacing 66 cm	
Vegetation period in 2008		
1072	567.5	3800
Vegetation period in 2009		
1480	7 74047477407	4380
Vegetation period in 2010		
3865	4284	5280

As it is shown in the Table, application rates under drip irrigation were lower in 3.5 - 6.7 times as compared to the Control plot (sprinkle irrigation).

Soil moister management in the root zone is one of the major issues of the land reclamation measures. Tensiometeres were used to measure soil moisture at the depth of 15 cm. Water was applied when soil moisture potential value did not exceed 20 bars which corresponds to soil moisture 85% of the minimal soil moisture capacity.

In 2008 soil moisture was not less than 75% of the minimum soil moisture capacity (MSMC). Soil moisture value varied in the range of 80 - 89% under sprinkler irrigation. Under drip irrigation when dripper laterals were located on the soil surface with drip spacing of 33 cm, soil moisture varied in the range of 82.0 – 93.9% MSMC. At drip spacing 66 cm soil moisture varied between 8 0 -93.6% MSMC, which agree with optimum values. When dripper laterals were laid at the depth of 5 and 15 cm with the dripper spacing 33 and 66 cm, soil moisture values were close to the optimum. So under wet weather conditions in 2008 favourable soil moisture values were provided for all variants of the field experiment.

Soil moisture contours in the case of dripper spacing 33cm are shown on the Figure 1. Uniform wettingg zone having soil moisture content of more than 95% was created along the row.

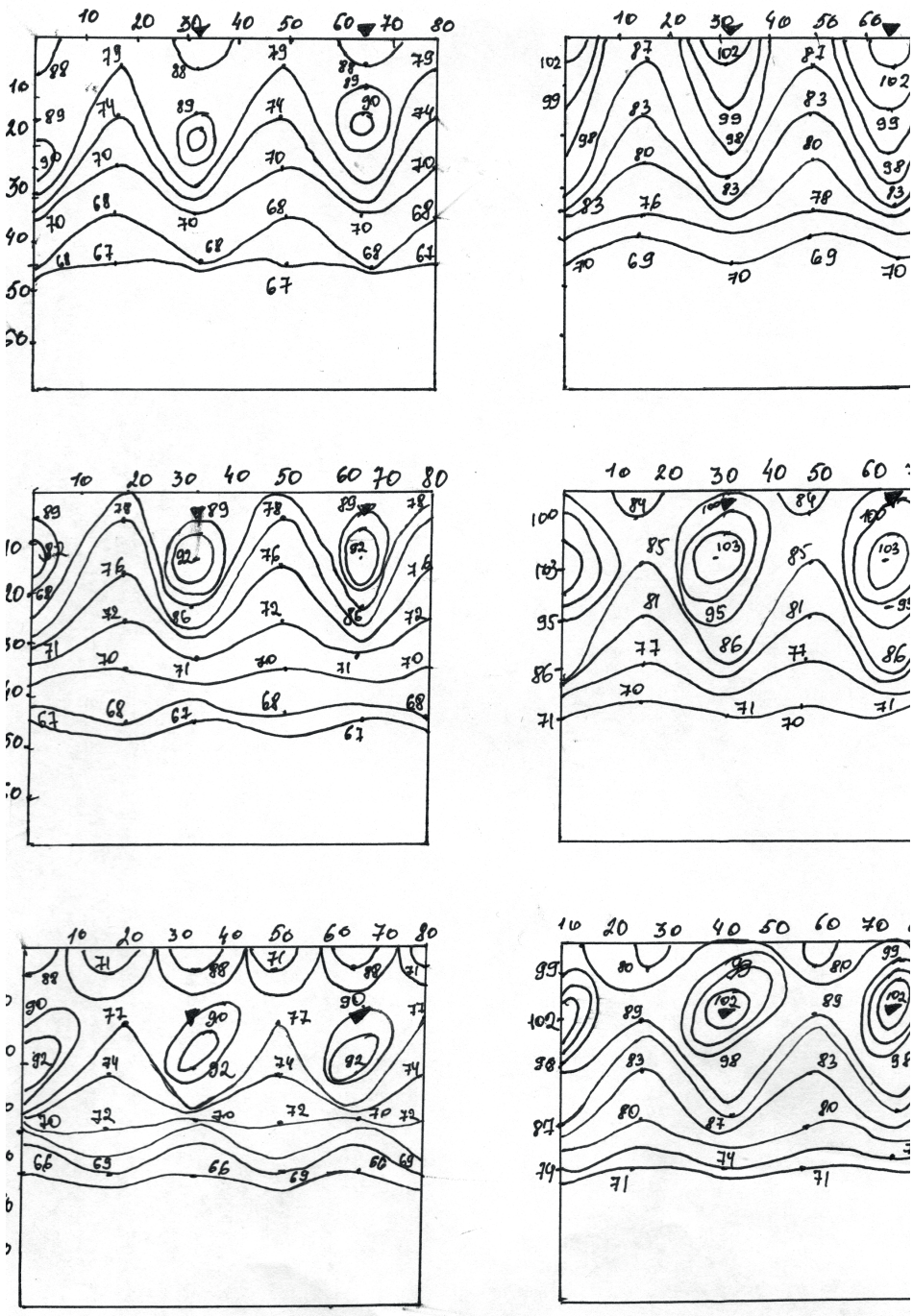

Fig. 1. Soil moisture distribution in the affected zone of the dripper (discharge 1.25 l/h, dripper spacing 33cm, water application period 60 min.) La distribution de l'umidité du sol à la zone des goutteures (débit d'eau – 1,25 l/h, la distance entre les goutteures - 33 sm, la durée de l'arrosage – 60 min/)

For the dripper spacing of 66 cm soil moisture contours were not linked, which may cause productivity decrease in the dry year. In 2009 soil moisture pattern was characterized as follows:

Under sprinkle irrigation soil moisture varied in the required range during the vegetation period.

When drippers were located on the soil surface with the spacing of 33 cm average soil moisture varied in the range of 0.85 – 0.9 MSMC.

When drippers spacing was 66 cm soil moisture in the root zone was lower than in the previous case.

When dripper lateral was laid at the depth of 5 cm optimum soil moisture was observed in the top soil 0.3 m layer. Components of water balance for water consumption of strawberry are shown in Table 2.

Table 2. Components of water of strawberry in 2008-2010 m^3/ha Les elements du bilan d'eau et la consummation d'eau de la fraise en 2008-2010, m^3/hectare

Year	Soil moisture	Precipitation	Irrigation rate	Ground-water income	Water onsumption during vegetation	Average daily consumption
Sprinkle irrigation						
2008	122.4	3301	1780	163	5366.4	49.2
2009	204	3512	1360	71.5	5147.5	41.8
2010	720.8	1480	5280	30	7510.8	61.1
Mean value	349.1	2764	2807	88.1	6008.2	54.3
Drip irrigation (dripper spacing 33 cm)						
2008	101.9	3301	960	167.4	4530.3	41.6
2009	181.4	3512	872	76.8	4642.2	37.7
2010	802.3	1480	3865	29.6	6176.9	50.2
Mean value	361.9	2764	1899	91.3	5116.2	43.4
Drip irrigation (dripper spacing 66 cm)						
2008	145.1	3301	569	171.4	4186.5	38.4
2009	217.6	3512	521	78	4328.6	35.2
2010	897.6	1480	4284	31.9	6693.5	54.4
Mean value	420.1	2764	1791.3	93.8	5069.2	42.8

Indicators of the irrigation project efficiency is crop productivity. Strawberry productivity values are shown on the Figure 2. It should be noted that strawberry was planted in 2008, commercial yield was not obtained this year. Therefore the mean productivity was calculated for 2009 and 2010.

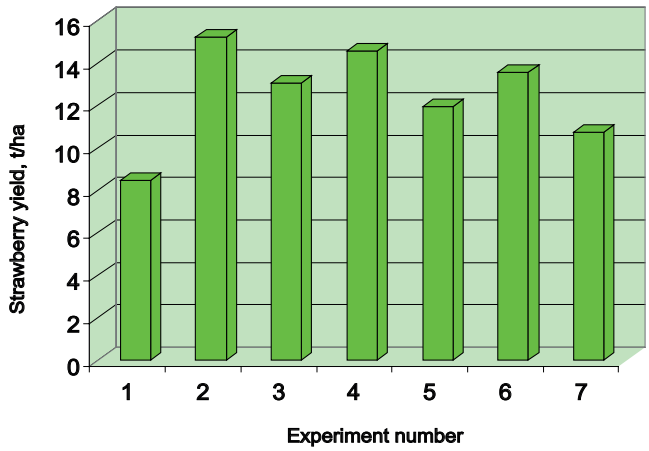

Fig. 2. Garden strawberry productivity for the different variants of the field experiment (mean values for 2009 – 2010), t/hectare

La productivité de la fraise du jardin pour des differentes variantes (moyen pour 2009-2010), t/hectare

Variants of the experiment: **1** – sprinkler irrigation (control plot), **2** – drip laterals are on the soil surface, drip spacing - 33 cm; **3** - drip laterals are on the soil surface, drip spacing - 66 cm; **4** - drip laterals are at the depth of 5 cm, drip spacing - 33 cm; **5** - drip laterals are at the depth of 5 cm, drip spacing - 66 cm; **6** - drip laterals are at the depth of 15 cm, drip spacing - 33 cm; **7** - drip laterals are at the depth of 15 cm, drip spacing - 66 cm.

The best results were obtained when drip laterals were laid on the soil surface with drip spacing 33 cm.

Such scheme provides uniform soil moisture distribution as well as optimum watering and nutrition for plants. When drip lateral was laid at the depth of 5 cm at drip spacing of 33 cm, favorable water regime was provided in soil too. Productivity losses were negligible (< 7%), however plant raising technology becomes easier to fulfill. The deeper lateral location requires special works.

Besides productivity increase the quality of strawberry was higher under drip irrigation, it contains more sugar and vitamins as compared to sprinkler irrigation.

Economic efficiency of drip irrigation was estimated using the standard procedure. Additional net profit was used as the major index. The highest additional net profit was obtained when the drip laterals were located on the soil surface and at the depth of 5 cm with drip spacing of 33 cm; exceeding the additional net profit under sprinkler irrigation by 3.0 – 3.6 times. Capital expenditures are repaid in the first year of strawberry fruiting.

Thus it was concluded that drip irrigation technique was more efficient for strawberry irrigation as compared to sprinkle irrigation. The developed technique provides strawberry productivity

increase by 1.7 – 1.8 times, as well as irrigation water economy by 3.5 times. This technique prevents surface runoff and seepage and at the same time facilitates technologies of plant raising and harvesting.

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