VARIATION OF CULTURE PRODUCTIVITY IN THE FUNCTION OF WATER DISTRIBUTION OF EMITORS

A. J. Farias[1], J. de O. Costa[1], A. N. de Almeida[1], I. A. Almeida[2], F. H. Campos[3], R. D. Coelho[4]

ABSTRACT: The application of water by an irrigation system always shows a degree of unevenness. Uniformity in conventional sprinkler systems depends on factors such as: the type of sprinkler and its operating conditions, the arrangement and spacing between sprinklers in the field, and the speed and direction of the wind during the period of application of water. The variation in soil moisture is dependent on the distribution and amount of water applied. The effect of irrigation uniformity on crop productivity is a significant factor to be considered in sprinkler irrigation projects. The objective of this work was to evaluate the effect of water application uniformity on the productivity of potato, beet and bean crops. For the three cultures, conditions of different spacings between the emitters (6 x 6m, 12 x 12m, 12 x 18m and 12 x 24m) were simulated resulting in different water application uniformity coefficients. Next, production functions were developed by other authors. The results indicated the spatial variability of productivity as a function of the distribution uniformity of the emitters. The productivity of potato, beet and bean crops were affected by the high disuniformities of water application via sprinklers.

KEY WORDS: sprinkling; distribution; production.

VARIAÇÃO DA PRODUTIVIDADE DE CULTURAS EM FUNÇÃO DA DISTRIBUIÇÃO DE ÁGUA DE EMISSORES

RESUMO: A aplicação de água por um sistema de irrigação sempre apresenta grau de desuniformidade. A uniformidade em sistemas convencionais de aspersão depende de fatores como: o tipo de aspersor e suas condições operacionais, a disposição e o espaçamento entre aspersores no campo, e a velocidade e a direção do vento durante o período de aplicação de

[1] PhD Student, University of São Paulo, College of Agriculture “Luiz de Queiroz” (ESALQ/USP), Biosystems Engineering Dept., Piracicaba, SP.
[2] Master Student, ESALQ/USP, Biosystems Engineering Dept. Av. Pádua Dias, 11, Postal Code 9, Piracicaba, SP. Phone:(35)991477661.e-mail: isabelaa@usp.br
[3] Master Student, Biosystems Engineering Dept., ESALQ/USP, Piracicaba, SP.
[4] PhD, Full Professor, Biosystems Engineering Dept., ESALQ/USP, Piracicaba, SP.

água. A variação na umidade do solo é dependente da distribuição e da quantidade de água aplicada. O efeito da uniformidade de irrigação na produtividade das culturas é fator significativo a ser considerado em projetos de irrigação por aspersão. O presente trabalho teve como objetivo avaliar o efeito da uniformidade de aplicação de água na produtividade das culturas da batata, beterraba e feijão. Para as três culturas foram simuladas condições de diferentes espaçamentos entre emissores (6 x 6m, 12 x 12m, 12 x 18m e 12 x 24m) resultando em diferentes coeficientes de uniformidade de aplicação de água. Em seguida foram aplicadas funções de produção desenvolvidas por outros autores. Os resultados indicaram a variabilidade espacial da produtividade em função da uniformidade de distribuição dos emissores. A produtividade das culturas da batata, beterraba e feijão foram afetadas pelas altas desuniformidades de aplicação de água via aspersores.

PALAVRAS-CHAVE: aspersão; distribuição; produção.

INTRODUCTION

Sprinkler irrigation has contributed greatly to the increase of the irrigated area in Brazil, improving crop productivity and making the exploitation of available land more intensive. In this method of irrigation, many factors can interfere in the level of uniformity of water distribution, such as sprinkler spacing, wind speed and direction, sprinkler operating pressure, sprinkler speed and uniformity, among others (Coelho et al., 1998).

Given the scenario in which environmental protection and water conservation are emphasized, uniformity of water application is a growing concern for equipment manufacturers, designers and users of irrigation systems. The application of water to irrigation systems has effects on the production characteristics of irrigated crops (Frizzone et al., 2007).

According to Frizzone et al. (2007), irrigation leads to considerable increases in crop productivity in regions where there are water deficits, provided that it is well-sized and managed. However, poorly planned irrigation systems with poor water application uniformity can lead to declines in production as well as excessive water, energy and fertilizer losses.

For the different irrigation methods, the uniformity of water application is a factor that reflects the quality of the irrigation system, being this parameter represented by a coefficient of statistical uniformity, which is assigned, for each irrigation system, a minimum value acceptable. In the case of spraying it is advisable that the uniformity values (Christiansen Uniformity Coefficient - CUC) are greater than 80% (Frizzone, 1992).

Among cultural practices, irrigation is a viable alternative for substantial productivity improvement. The basic purpose of irrigation is to provide water to the crop in order to meet all water requirements during the cultural cycle. However, irrigations and poorly sized systems, with excess or deficit applications, may compromise this productivity (Santana et al., 2009).

There is a lack of information and research on various topics related to the water-soil-plant relationship in certain situations. Work should be carried out to study some aspects such as the amount of water to be applied according to the cultivar and the soil, the crop response to the deficit and to the excess water and economic optimal blade, among others.

In this work the objective was to evaluate the effect of water application uniformity on the productivity of potato, beet and bean crops and verify the spatial variability of the production in function of the distribution uniformity of the emitters.

MATERIAL AND METHODS

The work was carried out in the laboratory of tests of irrigation material of the School of Agriculture "Luiz de Queiroz" (ESALQ), located in Piracicaba, SP. This unit is one of the divisions of the National Institute of Science and Technology in Irrigation Engineering (INCT-EI), whose responsibility is the evaluation of irrigation equipment following international norms and standards of quality.

A radial test of the MV / 360L-Agropolo sprinkler was carried out at the operating pressure of the equipment (196 kPa) and controlling the flow rate of the system. The time of the test was timed and the volumes of water applied by the sprinkler were collected in containers with a diameter of 0.08 meters and distributed in a spacing of 0.5 meters.

After the test, the water collectors were weighed in a precision scale and these values were converted to millimeters of water or irrigation blade applied at the different measured points. With these data, the radial distribution curve of the evaluated sprinkler was elaborated.

From the radial distribution of the sprinkler, different water distribution grids were elaborated using the data interpolation method known as the inverse of the distance. These grids were created considering the spacings 6 x 6m, 12 x 12m, 12 x 18m and 12 x 24m.Com os valores interpolados e sobrepostos, calculou-se um CUC para cada ponto considerado e em seguida foi feito o cálculo do CUC médio para cada espaçamento adotado, utilizando a Equação 1:

$$CUC = 1 - \frac{\sum_{i=1}^{n} \left| X_i - \overline{X} \right|}{n.\overline{X}} \qquad (1)$$

on what,

CUC – Christiansen Uniformity Coefficient, in decimal;

n – número de observações;

Xi – water slide applied at the i-th point on the soil surface, mm;

$\overline{X}$ – average applied blade, mm.

In order to evaluate the effect of water application unevenness on the productivity of different crops, we used three production functions suggested by other authors. The production function adopted for potato cultivation (Duarte, 1989) can be seen in Equation 2:

$$Y\ Potato = -28{,}31978 + 0{,}1818hi - 0{,}00014517hi^2 \qquad (2)$$

on what,

Y – Total yield, t ha^{-1};

hi – Applied water blade, mm.

The average water blade value adopted for the potato cycle was 626 mm. The production functions adopted for beet (Oliveira Neto, 2009) and for bean culture (Tagliaferre et al., 2013) can be seen in Equations 3 and 4.

$$Y\ Bett = -14{,}818 + 0{,}5177hi - 0{,}0014hi^2 \qquad (3)$$

on what,

Y – Total yield, t ha^{-1};

hi – Applied water blade, mm.

$$Y\ Bean = -1444{,}6 + 15{,}375hi - 0{,}01274hi^2 \qquad (4)$$

on what,

Y – Total yield, kg ha^{-1};

hi – Applied water blade, mm.

The average water blade values adopted for the beet and bean cycle were 185 and 606 mm, respectively. Using the production functions cited, the coefficient of production uniformity (CUPduction) was calculated for each point evaluated in all the spacing considered. The mean CUPduction was obtained from the calculation of the average of the values found for each point of the evaluation.

RESULTS AND DISCUSSION

In Figure 1 the radial distribution profile of the MV / 360L-Agropolo emitter can be seen. The blade applied to the collectors that were positioned near the sprinkler was above 6 mm. Meanwhile, in the collectors positioned at a distance greater than 15 meters, the applied blade was close to zero. The variation found, considering most of the collectors, was of 2 to 6 mm of applied blade.

Table 1 shows the total potato production values for a mean lamina of 626 mm, CUC and CUPduction for the different spacings between sprinklers adopted. The CUC varied as a function of the spacing between sprinklers that was adopted, consequently, the CUPduction also varied. The total production that was reached in the 6 x 6m, 12 x 12m, 12 x 18m and 12 x 24m spacings was 28.47, 28.13, 22.93 and 26.30 t ha-1, respectively. There was a variation of up to 19.5% in the total potato productivity due to the uneven application of water from the sprinkler.

Coelho et al. (1998) simulated potato productivity as a function of sprinkler regulation in a portable system and concluded that at the small sprinkler spacings (6 x 12m and 12 x 12m) the highest pressures (300 and 400kPa) had higher CUC values while (12 x 18m and 18 x 18m) the pressures of 200, 300 and 400kPa did not differ significantly in relation to the CUC values presented.

According to Azevedo et al. (2000), the uniformity of distribution decreases when sprinkler spacing increases, however, the combination of other factors should be considered in selecting the best spacing, such as operating pressure, nozzle diameter, jet range, and so on.

Table 2 shows the total beet production values for a mean application blade of 185 mm, CUC and CUPduction for the different sprinkler spacings adopted. The CUC varied as a function of the spacing between sprinklers that was adopted, consequently, the CUPduction also varied. The total production that was reached in the 6 x 6m, 12 x 12m, 12 x 18m and 12 x 24m spacings was 32.97, 32.68, 28.31 and 31.14 t ha-1, respectively. There was a variation of up to 14.1% in beet productivity due to the uneven application of water from the sprinkler.

Oliveira Neto (2009) determined the yield of the beet crop under the application of six different irrigation slides and verified that for every 10 mm of water applied over, within the range of 95 to 274 mm of total irrigation depth, there is an increase Of 280 kg of fresh root mass per hectare to a maximum point, when it begins to decline in the same proportion. They also verified that 72% of the variations occurred for the accumulation of fresh root mass is explained by a quadratic polynomial regression.

In Table 3 the total bean production values for a mean application blade of 185 mm, CUC and CUPduction for the different spacings between sprinklers can be seen. The CUC varied as a function of the spacing between sprinklers that was adopted, consequently, the CUPduction also varied. The total production that was reached in the 6 x 6m, 12 x 12m, 12 x 18m and 12 x 24m spacings was 3201.97, 3173.97, 2748.88 and 3023.83 kg ha-1, respectively. There was a variation of up to 14.1% in bean productivity due to the uneven application of water from the sprinkler.

Andrade Júnior et al. (2002), studying the cowpea cv. Gurgueia, under different irrigation slides, verified that the increase of the irrigation blade, from an optimum point, caused a decrease of the productivity, being the maximum production was obtained with application of the blade of 449.1mm. These results confirm that the excess of water in the soil, as well as the deficit, also impairs the production of grains.

CONCLUSIONS

- The productivity of potato, beet and beans varied up to 19.5%, 14.1% and 14.1%, respectively, due to the uneven application of water from the sprinkler in question;
- The spacing that resulted in the greatest productivity losses in the three crops was 12 x 18m, and the application unevenness in this situation reached up to 73.78%, causing losses of up to 19.5% of the total production.

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Table 1. Total potato yield for a given average application blade, CUC and CUPduction due to different spacings between sprinklers

	Spacing 6x6 m	Spacing 12x12 m	Spacing 12x18 m	Spacing 12x24 m
Middle blade (mm)	626	626	626	626
Total production (t ha^{-1})	28.47	28.13	22.93	26.30
CUProduction (%)	99.69	98.64	78.28	90.61
CUC (%)	97.02	93.03	73.78	84.98

Table 2. Total beet production for a given average application blade, CUC and CUPduction due to different spacings between sprinklers

	Spacing 6x6 m	Spacing 12x12 m	Spacing 12x18 m	Spacing 12x24 m
Middle blade (mm)	185	185	185	185
Total production (t ha^{-1})	32.97	32.68	28.31	31.14
CUProduction (%)	99.78	99.01	85.21	93.33
CUC (%)	97.02	93.03	73.78	84.98

Table 3. Total bean production for a given average application blade, CUC and CUPduction due to different spacings between sprinkler

	Spacing 6x6 m	Spacing 12x12 m	Spacing 12x18 m	Spacing 12x24 m
Middle blade (mm)	606	606	606	606
Total production (kg ha^{-1})	3201.97	3173.97	2748.88	3023.83
CUProduction (%)	99.78	99.01	85.18	93.32
CUC (%)	97.02	93.03	73.78	84.98

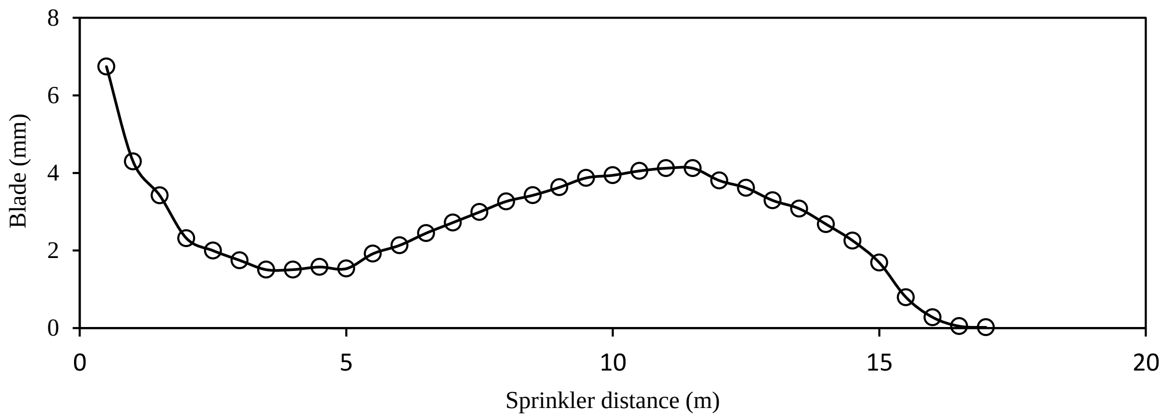

Figure 1. Radial distribution profile of the emitter MV / 360L-Agropolo