Field performance of travelling sprinkler with controlled rotation speed

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ABSTRACT

A new mechanical device, designed and manufactured by SIME Idromeccanica for varying the rotation speed of travelling sprinklers, was tested under no wind conditions on September 2012, according to *ISO 8224-1 n. 584, Traveller Irrigation Machines: operational characteristics and laboratory and field test methods*. Test was repeated three times. Field assessment was made using the uniformity indicators CU and DUlq, performed by two identical sprinklers, *Uniform* and *Explorer*, operating simultaneously and under the same setting (e.g., working pressure, nozzle diameter, discharge, jet throw). Each value of the uniformity parameters is originated by 78 measured values of collected water. Only *Uniform* was equipped with the speed rotation controller. Since radial distribution pattern of *Uniform* is quite flat, better performance were achieved with minimal overlapping of the wetted areas in all comparisons. On average, and under test conditions, DUlq ranges from 0.85 to 0.88 when adjacent towpath lanes are spaced from about 75% to 90% the wetted diameter. In the same spacing interval, CU varies from 88% to 92%. With respect to Explorer, the advantage is evident when spacing exceeds 75% the wetted diameter. Minimal thresholds of DUlq (0.75) and CU (80%) are allowed by *Uniform* for spacing up to 92% and 97% the wetted diameter, respectively. Under *Explorer*, spacing is reduced by about 5% on average. As a consequence, the area irrigated by *Uniform* is 5% greater given the same uniformity. Compared to *Explorer*, potential water saving due to uniformity is about 15%. Mechanical control of rotation speed proved to be effective under minimal overlapping of wetted areas, resulting in better working capacity. Water and energy saving can be expected. Test results show that good performance is non synonym of complexity and expense. Moreover, any amelioration of the regulating device must be a further step towards better water use and farm economy.

Key words: travelling sprinkler, rotation speed control, uniformity, DUlq, CU, hose reel machine

INTRODUCTION

Modern hose reel machines benefit from technological evolution of each constituting element, resulting in irrigation performance no longer comparable with past models. Efficiency is a performance indicator defined as the ratio between the volume of irrigation water beneficially used and the volume of irrigation water applied (Burt,1997). It takes advantage from system uniformity (Pereira, 1997), described either by Christiansen's uniformity coefficient, CU, (Christiansen, 1942) or by the low-quarter distribution uniformity, DUlq (Burt, 1992). For travelling gun systems, minimum threshold values of CU and DUlq are 80% and 0.75 respectively (ARC,

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2010; Reinders, 2011). According to field test (Smith et al., 2003; Ghinassi, 2010), old travelling sprinklers hardly allow adequate distribution of water, unless large wetted areas are overlapped. In general, travelling guns supply much more water along the middle of the wetted area, due to the typical bell-shaped distribution pattern. Recent sprinkler models take advantage from improved hydraulic and mechanical characteristics, resulting in little depression of the cross distribution curve. In no wind conditions, overlapping of wetted areas is reduced up to 10-15% of the jet throw (Taglioli, 2007). The more the curve is flat, the more uniformity is high and the working capacity increases. This condition can be achieved by increasing the rotation speed of the travelling gun when approaching the towpath lane direction, and decreasing towards the lateral ends. Moving from this assumption, *SIME Idromeccanica* (Guastalla, Italy) manufactured a speed regulation device characterized by a cam-shaped ring, over which a pulley runs (Figure 1). Rotating speed results from the combination of pulley position on the cam and the braking degree adjusted by the external screw pin. Currently, the regulation device is mounted only on *Uniform* sprinkler model.

Figure 1. Device regulating rotation speed of the travelling gun

The device was assessed according to the uniformity parameters CU and DUlq in a farm located in North Italy, 40 km NE from Bologna, through a field test replicated three times. Testing activity was carried out during September 2012, and included comparison with *Explorer* sprinkler model, identical to *Uniform* except for the speed rotation controller.

MATERIALS AND METHODS

Data collection

Two identical testing areas, 227 m long and 121 m wide, separated by a strip of land 70 m wide, were arranged in parallel on a 10 ha field. Each field was equipped with 3 lines of catch cans (L1, L2, L3), 60 m spaced, perpendicular to the towpath lane and placed according to *ISO 8224-1 n. 584, Traveller Irrigation Machines: operational characteristics and laboratory and field test methods*. Stop position of sprinkler trolleys was set 74 m far from the last line of catch cans (L3). Collector spacing was 4.5 m, and 28 catch cans were placed along each line, covering a wetted diameter (WD) of 121 m. A meteo station for wind measurement (intensity and direction) at 10' time interval was positioned between the fields. Due to the specific feature of the innovative device, and the comparative scope of the test, both irrigators were set for 180° irrigation sector.

Collector lines were wetted in pair (e.g., L1-L1, L2-L2, L3-L3), since travelling guns worked simultaneously being coupled to two identical hose reel machines, each one equipped with pressure gauge and water meter. Rewind speed was set equal to 20 m/h, resulting in 11h15' irrigation time. Diameter of sprinklers nozzle was 28 mm Ø. Under 500 kPa pressure at the inlet, jet throw measured from the raiser was 56 m. Irrigations started round 8.00 p.m., and measurement of collected water finished before the rising of the sun. Water supplied during each event was measured.

Average values for *Explorer* and *Uniform* are 674 m^3 and 673 m^3 respectively. Average depths of water collected by each collector line during individual events are reported in Table 1.

Table 1. Water depths (mm) measured during each event

Collector line	8 Sept		10 Sept		17 Sept	
	Sprinkler model		Sprinkler model		Sprinkler model	
	Explorer	*Uniform*	*Explorer*	*Uniform*	*Explorer*	*Uniform*
L1	28.9	30.1	29.4	29.9	31.7	33.3
L2	30.3	29.6	27.8	29.3	28.8	28.8
L3	30.7	28.1	30.4	30.5	30.8	29.2
h avg	30.0	29.2	29.2	29.9	30.4	30.4
h max	50.4	40.5	51.6	45.9	48.3	45.5
h min	1.0	0.3	1.5	1.5	1.0	1.0

Max depth supplied by Explorer exceeds max depth of Uniform also in all pair of lines (e.g., L1, L2, L3), in spite of average depths are coincident.

Example of water distribution of *Uniform* and *Explorer* is given in Figure 2.

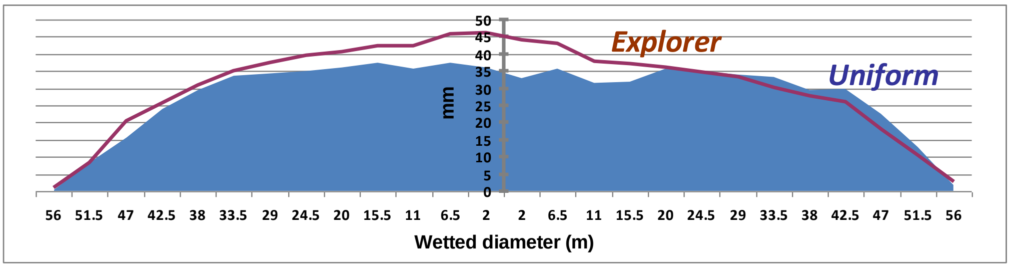

Figure 2. Water distribution of *Uniform* and *Explorer*

DUlq and CU

Measured water depths were used to assess DUlq and CU parameters according to progressive overlapping (4.5 m each step), from 112 m to 58 m (e.g., the distance between two subsequent towpath lanes). DUlq and CU values related to first, second and third irrigation event (from left to right), are reported in Figure 3 and Figure 4 respectively. Each value is obtained from 78 measured water depths (L1+L2+L3) using *ISO 8224-1 n. 584* calculation procedure.

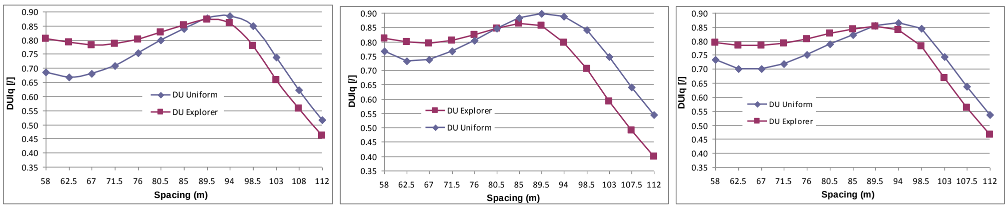

Figure 3. DUlq values originated by different overlapping

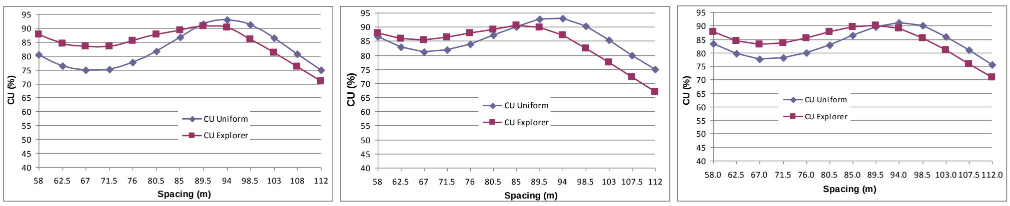

Figure 4. CU values originated by different overlapping

DUlq and CU patterns look quite similar. *Explorer* performs better than *Uniform* when overlap increases (spacing less than about 75% of WD), while effectiveness of the speed rotation controller increases with spacing. Figure 5 and Figure 6 illustrates average values of DUlq and CU respectively.

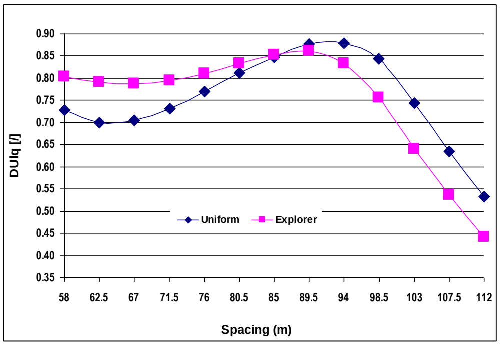

Figure 5. Average values of DUlq

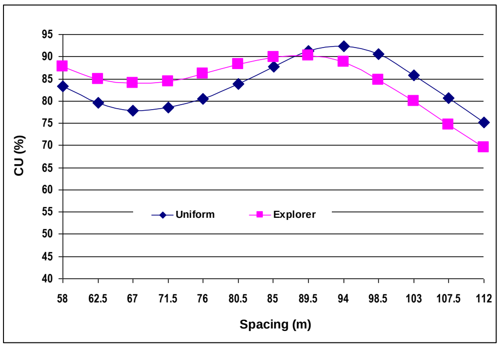

Figure 6. Average values of CU

For spacing exceeding 85 m (76% WD), advantage of *Uniform* under the same uniformity value is about 5% the irrigated width. Under the same spacing, difference of DUlq and CU increases up to about 10% and 5% respectively. Both *Explorer* and *Uniform* stand over the minimal threshold of DUlq and CU in a wide range of spacing.

CONCLUSIONS

Test results show that speed rotation controller is effective to flatten the radial distribution pattern, resulting in some practical advantages. The first is that uniformity values are higher than those performed by the normal model, and achieved under minimal overlapping. This condition means both potential higher irrigation efficiency and increased working capacity. In terms of water saving, potential allowed by the controller is from 6% to 14% when spacing increases from 94 m to 103 m, that is from 69 m^3 to 212 m^3 of water saved every 1000 m^3 of net irrigation requirement. Working capacity is expected to increase up to 5%. It should be noticed that water and energy saving is allowed by a quite simple mechanical device, proving that irrigation performance can take appreciable advantage from not expensive investments. Improvements on the rotating speed controller are in progress, and benefits on water use and farm economy can be reasonably expected.

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