Effect of Drip Irrigation and Fertigation On Maize Resource-Use Efficiency, Yield and Quality

Massimo Blandino, Eleonora Cordero, Francesca Vanara, Amedeo Reyneri

Dip. di Scienze Agrarie, Forestali e Alimentari, Univ. Torino, TO, massimo.blandino@unito.it

Introduction

In Mediterranean growing area, the need of increasing both productivity and resource-use efficiency of crops is rising, especially for high-demand resource and yield potential crop such as maize (*Zea mays* L.). Drip irrigation can efficiently water maize, then valorizing low water availability. Moreover, this method can be coupled with fertigation, supplying late season and fractionated nitrogen (N) amounts, through the use of soluble fertilizers, in order to better follow the crop needs, then increasing nitrogen use efficiency (NUE). Furthermore, considering the costs of drip irrigation, the economic convenience requires a careful evaluation, determining the effect on maize yield and quality, also considering new cropping systems able to enhance the potential of this irrigation technique.

Materials and Methods

The study was carried out in the North-West Po plain in Italy (Villareggia, TO) over five growing seasons (2014 - 2018), in a shallow, sandy loam soil, by comparing three different treatments:

- CONV, the conventional management of the growing area, consisting in furrow irrigation, N fertilization through granular fertilizer applied at sowing (30% of total) and at 8^{th} leaf stage (70%);
- DI, drip irrigation and N fertilization through granular fertilizer as reported in CONV treatment;
- DI + FERT N, drip irrigation combined with fertigation, in which the cover N fertilization (70% of total) was fractionated in 5 timings from 8^{th} leaf stage to milk ripening growth stage.

A full maturity hybrid (FAO maturity class 600 - 700) was used. Urea (46%) was the granular fertilizer side-dressing applied at 8^{th} leaf stage. Conversely, specific fertilizers characterized by high solubility were used in fertigation. A total of 340 kg N ha^{-1} was applied. Depending on the growing seasons, the irrigation water amount was 2800 – 7000 m^3 ha^{-1} for furrow irrigation and 1225 – 3150 m^3 ha^{-1} for drip irrigation. In 2018 a specific focus compared the treatments previously mentioned with 3 different plant populations (6.5, 7.5 and 8.5 plant m^2), according to a factorial design. A further fertigation treatment with the application of a potassium (K) fertilizer in addition to N was also considered (DI + FERT NK). At maturity grain yield, density per square meter of the fully developed ears (ESQ), number of kernels per square meter (KSQ), grain moisture, test weight (TW) and thousand kernel weight (TKW) were recorded. Moreover, on maize grain, the content of fumonisins (FBs) and deoxynivalenol (DON) was quantified through LC-MS/MS analysis. The irrigation water use efficiency (IWUE) and the NUE were calculated according to Payero et al., (2008) and Ladha et al., (2005), respectively. Data were analyzed through the analysis of variance (ANOVA) in accordance with the REGW-Q test ($P < 0.05$).

Results

On average, drip irrigation (DI) increased IWUE by 2.4 times compared to the furrow one (Fig.1). On the other hand, this treatment did not increase grain yield and NUE compared to CONV. A significant grain yield rise was observed when fertigation was combined to drip irrigation (+11%). leading to a further IWUE increase and a clear NUE enhancement (+16%). As far as the 2018 trial was concerned, the increase of plant population resulted in a clear rise of ESQ and KSQ, although a progressive reduction of TKW was observed (Tab. 1). Fertigation did not impact on ESQ and KSQ, while significantly increased TKW (+6%) as a consequence of a prolonged stay green. The interaction between the nutrition treatment and plant density did not resulted significant, thus grain yield was enhanced by the combination of high plant density and fertigation. However, both high plant density and fertigation significantly increased mycotoxin content.

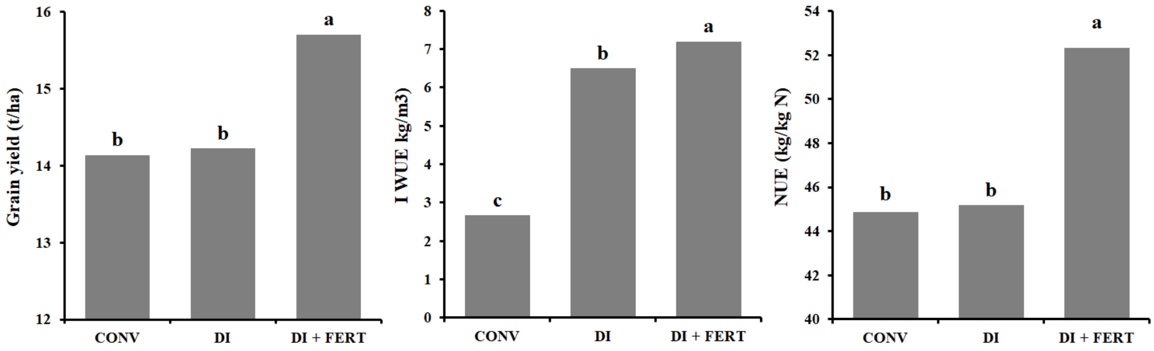

Figure 1. Effect of the different nutrition treatments on maize grain yield, irrigation water use efficiency (IWUE) e nitrogen use efficiency (NUE). Data reported are averaged over 5 growing season and 4 replications. Different letters indicated significant differences according to REGW-Q post hoc test ($P < 0.05$).

Table 1. Productive and qualitative impact of drip irrigation (DI) and drip irrigation combined with N fertigation (DI + FERT N) and NK fertigation (DI + FERT NK) in maize with different plant density.

Factor	**Source of Variation**	**ESQ ear/m2**	**KSQ kernel/m2**	**TKW g**	**FBs µg/kg**	**DON µg/kg**
Nutrition	CONV	7.3 a	4757 a	367 b	24298 ab	81 b
	DI	7.4 a	4669 a	367 b	17972 b	130 b
	DI + FERT N	7.2 a	4576 a	387 a	30939 ab	216 ab
	DI + FERT NK	7.1 a	4435 a	392 a	33794 a	403 a
	P(F)	0.087	0.717	< 0.001	0.14	0.006
Plant density	6.5	6.8 c	4417 b	387 a	23797 a	163 b
	7.5	7.1 b	4509 ab	377 b	24098 a	123 b
	8.5	7.9 a	4903 a	371 b	32356 a	336 a
	P (F)	< 0.001	0.048	< 0.001	0.092	0.019
Nutrition X density	**P (F)**	0.079	0.866	0.971	0.957	0.925

Field experiment carried out in Villareggia, 2018. Means followed by different letters are significantly different (the level of significance P is shown in the table).

Conclusions

Drip irrigation improved IWUE compared to furrow irrigation, without enhancing maize yield, However, the high cost of this system still limits its spread. When combined with fertigation, drip irrigation significantly increased maize yield, then enhancing both IWUE and NUE. The cropping system based on high plant density, fertigation could led to significant increase of grain yield, although their impact on maize sanity and on affordability need to be carefully verified.

References

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