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Optimization of Nutrients for Hybrid Maize Under Drip Fertigation System

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Field experiments were conducted at Agricultural College and Research Institute, Madurai during *kharif* 2008-2009 and summer 2009-2010 to study the effect of drip fertigation on growth, yield and quality of maize. The experiment was laid out in randomized block design with four replications. The treatments tried were two irrigation methods (drip irrigation and surface irrigation), three fertilizer levels viz., 75, 100 and 125 percent and three fertilizer combinations viz., fully water soluble fertilizers with 100 percent P as basal, 50 percent commercial fertilizers and 50 percent water soluble fertilizers with 50 percent P and K as basal, and fully water soluble fertilizers. Drip irrigation was scheduled at 100 % PE once in three days and fertigation was given once in six days as per the treatment schedule. Surface irrigation was scheduled at 0.8 IW/CPE ratio with 5 cm depth of irrigation with recommended dose of fertilizers. Drip fertigated maize exhibited better plant height and dry matter production in drip fertigation with 125 per cent RDF as water soluble fertilizer. The yield attributes *viz.,* cob length, cob girth and cob weight was higher in drip fertigation of 125 per cent RDF as water soluble fertilizer. As a consequence of better growth, drip fertigation of 125 per cent RDF as water soluble fertilizer recorded higher yield of hybrid maize. In addition to better crop growth, higher yield attributes and substantial quantity of water saving (23 per cent) indicated the feasibility of drip fertigation for higher productivity and sustainable yield from maize.

Key words: Drip fertigation, water soluble fertilizers, yield, quality, hybrid maize

Maize (*Zea mays* L.) is one of the most important cereal crops in the global agricultural economy both as a food for man and feed for animal and the crop is with immense potentiality and therefore called queen of cereals. Maize ranks fifth among the cereals in area and production and has high nutritive value as compared to wheat and sorghum, but considerably above rice. The area under maize is expected to increase in future due to ever increasing demand for maize grain in poultry and animal feed industries. At present, there exists a gap of about 10 lakh tonnes of maize grain between production and demand. One of the possible ways to bridge the gap between demand and supply is to increase the productivity per unit area by adopting appropriate production and management technologies. Drip fertigation offers the scope to increase the productivity of crops per unit land, time and all inputs in crop production strategies. With these ideas in view, an experiment was planned to study the effect of drip fertigation on growth, yield and quality of maize

Materials and Methods

Field experiments were conducted at Agricultural College and Research Institute, Madurai during *kharif* 2008 and summer 2009 to study the effect of drip fertigation on growth, yield and quality of maize. The experiment was laid out in randomized block design with four replications. The treatments included were two irrigation methods (drip irrigation and surface irrigation), three fertilizers levels viz., 75, 100 and 125 percent and three fertilizer combinations viz., fully water soluble fertilizers with 100 percent P as basal, 50 percent commercial fertilizers and 50 percent water soluble fertilizers with 50 percent P and K as basal, and fully water soluble fertilizers. The treatments adopted are T_1-Surface irrigation with RDF ; T_2 - Drip fertigation with 75% RDF (P as basal, N&K through drip) ; T_3- Drip fertigation with 100% RDF (P as basal N&K through drip); T_4 - Drip fertigation with 125% RDF (P as basal N&K through drip); T_5 - Drip fertigation with 75% RDF (50% P&K as basal, remaining NPK as WSF); T_6 - Drip fertigation with 100% RDF (50% P&K as basal, remaining NPK as WSF) ; T_7 - Drip fertigation with 125% RDF (50% P&K as basal, remaining NPK as WSF) ; T_8 - Drip fertigation with 75% RDF as WSF(Urea, Polyfeed, MAP,KNO_3) ; T_9 - Drip fertigation with 100% RDF as WSF (Urea, Polyfeed, MAP, KNO_3) ; T_{10} - Drip fertigation with 125% RDF as WSF(Urea, Polyfeed, MAP, KNO_3). Maize hybrid CO H (M) 5 was used as the test crop. The recommended dose of fertilizer of 150:75:75 kg NPK ha^{-1} was followed.

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Drip irrigation was scheduled at 100 % PE once in three days and fertigation was given once in six days as per the treatment schedule. Surface irrigation was scheduled at 0.8 IW/CPE ratio with 5 cm depth of irrigation with recommended dose of fertilizers. Observations were recorded on growth, yield attributes, yield and estimates of total water use were made.

Results and Discussion

Growth characters

Plant growth is a reflection of utilization of the available resources by the crop. Plant growth in terms of growth rate, vigour and stand of the crop provide an index of productivity of the crop. In the present study, 125 per cent of the recommended dose of fertilizers as water soluble fertilizers through drip fertigation registered higher plant height as compared to surface irrigation with soil application of fertilizer. Higher frequency of irrigation and increased availability of soil moisture under drip irrigation might have led to effective absorption and utilization of available nutrients and better proliferation of roots resulting in quick canopy growth (Sivanappan *et al.,* 1988). The enhancement of growth parameters might be due to the restricted wetting area and root zone application of nutrients through drip system coupled with constant and continuous availability of optimum soil moisture, which provided the plants more nutrients to absorb (Patel *et al.,* 1999 and Aruna *et al.,* 2007)). These results are in agreement with the findings of Archana *et al*. (2012) who also reported that increased availability and uptake of nutrients in hybrid maize increased the plant height.

Dry matter production was favorably influenced by drip fertigation levels as compared to soil application of fertilizers with surface irrigation. Due to excess irrigation in surface irrigation methods, fertilizer nutrients might have been leached beyond the root zone. Whereas, in drip fertigation, fertilizers applied through drip irrigation in desired split doses throughout the growing period according to crop requirements, so that the losses were minimized and opportunity was provided to take up more nutrients, which reflected on the plant growth rate

Table 1. Effect drip fertigation on growth and DMP of hybrid maize

Treatment	Plant height at harvest (cm)		Dry matter at harvest (t/ha)	
	2008	2009	2008	2009
I_1 - Surface irrigation with RDF	207.3	200.1	12.7	11.8
T_2 - Drip fertigation with 75% RDF (P as basal, N&K through drip)	228.8	221.2	13.3	13.0
T_3 - Drip fertigation with 100% RDF (P as basal N&K through drip)	246.6	238.9	14.3	13.5
T_4 - Drip fertigation with 125% RDF (P as basal N&K through drip)	260.9	254.0	14.4	13.8
T_5 - Drip fertigation with 75% RDF (50% P&K as basal, remaining NPK as WSF)	225.3	218.4	13.8	13.0
T_6 - Drip fertigation with 100% RDF (50% P&K as basal, remaining NPK as WSF)	249.8	242.8	14.7	14.5
T_7 - Drip fertigation with 125% RDF (50% P&K as basal, remaining NPK as WSF)	256.1	248.1	17.1	17.8
I_8 - Drip fertigation with 75% RDF as WSF(Urea, Polyfeed, MAP,KNO_3)	232.5	225.3	14.0	13.9
T_9 - Drip fertigation with 100% RDF as WSF (Urea, Polyfeed, MAP, KNO_3)	247.8	241.7	16.7	17.0
I_{10} - Drip fertigation with 125% RDF as WSF(Urea, Polyfeed, MAP, KNO_3)	268.5	260.4	18.1	18.5
SEd	8.0	10.1	0.5	0.5
CD (P-0.05)	16.4	21.2	1.0	1.1

and higher DMP in the present study. Similar results were reported by Ananthi (2010) and Amanullah (2008) in maize. Rajasekaran (2007) also reported higher dry matter production under 125 per cent RDF followed by 100 per cent in drip irrigated sugar beet.

Yield attributes and yield

The yield attributing characters of maize (cob length, cob girth and cob weight) were significantly influenced by drip fertigation levels (Table 2). The yield attributing characters of maize crop were higher under drip fertigation with 125 per cent RDF as water soluble fertilizer in both the seasons. This might be due to the fact that adequate nutrients supplied from these treatments created more conducive environment for the roots to absorb the nutrients more effectively, when compared to surface irrigation treatments. The growth parameters were also higher under drip fertigation treatments, which might have contributed to higher yield parameters. The increase in yield attributes was due to increased NPK availability and uptake at higher levels of NPK application through drip irrigation in cotton (Bharmbe *et al.*, 1997). Better crop growth at higher nutrient levels might have influenced the yield attributes favourably (Patel *et al.,* 2009).

The yield data showed the favorable effect of drip fertigation on the grain yield of maize. Drip fertigation of 125 percent RDF through WSF excelled other treatments by recording significantly higher grain yield in both the seasons. The increase in maize grain yield with drip fertigation was mainly attributed by greater and consistent availability of soil moisture and nutrients which resulted in the better crop growth, yield components, and ultimately reflected on the grain yield of hybrid maize.

Table 2. Effect of drip fertigation on yield attributes of hybrid maize

Treatment	Cob length (cm)		Cob girth (cm)		Cob weight (gm)		Grain yield (kg/ha)	
	2008	2009	2008	2009	2008	2009	2008	2009
T_1 - Surface irrigation with RDF	17.0	16.0	14.7	13.9	149.0	140.2	4050	5012
T_2 - Drip fertigation with 75% RDF (P as basal, N&K through drip)	18.8	17.8	15.1	14.5	161.0	155.4	5560	5475
T_3 - Drip fertigation with 100% RDF (P as basal N&K through drip)	19.6	18.2	15.8	15.0	169.7	163.4	6252	6160
T_4 - Drip fertigation with 125% RDF (P as basal N&K through drip)	20.3	19.0	16.2	15.5	171.0	165.6	6460	6380
T_5 - Drip fertigation with 75% RDF (50% P&K as basal, remaining NPK as WSF)	19.1	18.1	15.4	14.8	166.0	160.0	6530	6425
T_6 - Drip fertigation with 100% RDF (50% P&K as basal, remaining NPK as WSF)	19.4	19.5	16.5	16.1	159.3	153.7	7508	7420
T_7 - Drip fertigation with 125% RDF (50% P&K as basal, remaining NPK as WSF)	20.9	21.0	16.9	17.3	173.3	168.8	8525	8325
T_8 - Drip fertigation with 75% RDF as WSF(Urea, Polyfeed, MAP,KNO_3)	19.6	19.7	16.3	16.6	165.7	159.9	6353	6270
T_9 - Drip fertigation with 100% RDF as WSF (Urea, Polyfeed, MAP, KNO_3)	20.1	20.3	15.9	15.2	170.3	166.3	7870	7785
T_{10} - Drip fertigation with 125% RDF as WSF(Urea, Polyfeed, MAP, KNO_3)	21.9	22.3	17.6	18.0	184.7	175.0	8851	8700
SEd	0.6	2.1	0.5	1.6	5.5	13.9	226	298
CD(P-0.05)	1.3	4.4	1.1	3.4	11.2	29.3	463	627

Under drip fertigation, the water soluble fertilizers were applied at frequent intervals i.e. once in seven days up to 90 DAS which might have resulted in higher availability and higher uptake by the roots and ultimately resulted in better growth and yield whereas in the surface irrigated band application plots, the fertilizers were dumped on the soil with minimum number of splits (i.e) one basal and two top dressings so the availability of nutrient would be very high during first 20 to 30 days, which have resulted in higher growth parameters during initial stage of the crop. At reproductive stage the applied nutrients would have been depleted or leached off and not available to the crops which might have resulted in lower yield attributing characters and yield of the crop. These findings are in conformity with the findings of Ramu and Reddy (2007) in maize.

The results obtained by Sundar Raman *et al.* (2000) also indicated that fertigation with soluble fertilizers like urea, MAP and Multi-K can increase the yield and quality of gherkins and 25 per cent of the fertilizer can be saved without affecting the yield.

Table 3. Effect drip fertigation on water use and economics of hybrid maize

Treatment	Water used (mm)		WUE kg/ha-mm		Net income (Rs./ ha)		B : C Ratio	
	2008	2009	2008	2009	2008	2009	2008	2009
T_1 - Surface irrigation with RDF	685	567.7	5.9	8.8	16322	25400	1.8	2.1
T_2 - Drip fertigation with 75% RDF (P as basal, N&K through drip)	529	481.1	10.5	11.4	23656	25265	1.9	1.9
T_3 - Drip fertigation with 100% RDF (P as basal N&K through drip)	529	481.1	11.8	12.8	29257	31384	2.1	2.1
T_4 - Drip fertigation with 125% RDF (P as basal N&K through drip)	529	481.1	12.2	13.3	29921	32307	2.1	2.1
T_5 - Drip fertigation with 75% RDF (50% P&K as basal, remaining NPK as WSF)	529	481.1	12.3	13.4	29177	31695	1.9	1.9
T_6 - Drip fertigation with 100% RDF (50% P&K as basal, remaining NPK as WSF)	529	481.1	14.2	15.4	35356	38561	2.1	2.1
T_7 - Drip fertigation with 125% RDF (50% P&K as basal, remaining NPK as WSF)	529	481.1	16.1	17.3	41360	44525	2.1	2.2
T_8 - Drip fertigation with 75% RDF as WSF(Urea, Polyfeed, MAP,KNO_3)	529	481.1	12.1	13.1	23132	25550	1.7	1.7
T_9 - Drip fertigation with 100% RDF as WSF (Urea, Polyfeed, MAP, KNO_3)	529	481.1	14.9	16.2	31490	35322	1.8	1.8
T_{10} - Drip fertigation with 125% RDF as WSF(Urea, Polyfeed, MAP, KNO_3)	529	481.1	16.7	18.1	34987	39091	1.8	1.8

Water use and economics

Water use efficiency can be increased either by increasing the yield (or) by reducing the quantity of water applied. In the present study, drip irrigation method had influenced the water use efficiency of hybrid maize in both the seasons.

Among the fertilizer levels, 125 per cent RDF as water soluble fertilizer through drip resulted in higher WUE as compared to surface irrigation. Fertigation at the rate of 75 per cent RDF recorded lower WUE compared to 100 and 125 per cent RDF. The increased WUE obtained under drip irrigation was due to increased grain yield and reduced water consumption when compared to surface method of irrigation. This is in conformation with the finding of Hodgson *et al.* (1990) and Cetin and Bilgel (2002) in cotton crop.

Though the cost of drip fertigation unit was high, considering longer life period of drip fertigation system (10 years), the benefit out of drip fertigation will be for longer period. Higher net income was observed under 125 per cent drip fertigation as against surface irrigation with soil application of fertilizers, due to higher cost of water soluble fertilizers attain lesser net income compared to drip fertigation with 125 per cent RDF as WSF. Kavitha *et al.* (2007) also reported that though the yield was higher with water soluble fertilizers, the benefit cost ratio was less mainly due to high cost of special fertilizer in drip fertigated tomato. However, the yield and gross income was high in the fertigated plots, due to higher uptake and nutrient use efficiencies from the costly fertilizers, which obtained a very meager difference of B: C ratio when compared to surface irrigation with soil application of fertilizer. Thus, the additional expenditure towards the drip fertigation system and water soluble fertilizers was well compensated through greater additional income.

Conclusion

Thus, from the forgoing discussion, in addition to higher yield and income, higher quantity of irrigation water saving coupled with higher water and nutrient use efficiencies indicate the practical feasibility of drip fertigation for sustainable maize production.

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