Effect of drip-fertigated and soil-drenched liquid organic manures on growth and yield of maize intercropped with vegetable amaranth

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 Received: 8.1.2019/Accepted: 26.1.2019

ABSTRACT

A field experiment was carried out at the Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu to assess the effect of irrigation methods on growth and yield of maize in comparison to drip irrigation and surface irrigation systems during 2016-17. The treatment comprised two irrigation methods with seven fertilization methods viz humic acid 3 kg/ha, fulvic acid 3 kg/ha, vermiwash 5 per cent, Jeevamiritham 5 per cent and their combinations and inorganic fertilizers were the fertilization treatments. The drip irrigation showed superiority in growth characters and yield of the crop. Among fertilization methods inorganic fertilizers registered significant influence on the crop yield ie 7298 and 7384 kg grain yield/ha that was comparable with humic acid 3 kg/ha + fulvic acid 3 kg/ha treatment ie 6250 and 6184 kg/ha during first and second year respectively. In case of amaranth higher fresh green yield was due to the inorganic fertilizer application treatment followed by Jeevamiritham.

Keywords : Humic acid; fulvic acid; maize; amaranth; vermiwash; Jeevamiritham

INTRODUCTION

Maize (*Zea mays* L) is the most adaptable food crop of universal importance. In India it occupied an area of 10.2 Mha with a production of 26.3 MT and productivity of 2574 kg/ha during 2015-16 (https://www.faostat.com). The demand for maize is growing in India day by day with the rising need for poultry and cattle feed. High yield potential of maize is not achieved due to several biotic and abiotic constraints.

The current global scenario firmly emphasizes the need to adopt eco-friendly agricultural practices for sustainable food production. The cost of inorganic fertilizers has been increasing enormously and they are out of reach of small and marginal farmers. The research reports have shown that it is impossible to attain sustainable agricultural production through the use of inorganic fertilizers alone.

The Jeevamirith prepared from cow dung, urine, legume flour and jaggary contains macronutrients, essential micronutrients, many vitamins, essential amino acids, growth promoting factors like IAA, GA and beneficial microorganisms (Gore and Sreenivasa 2011).

Humic substances play a vital role in soil fertility and plant nutrition. Plants grown on soils which contain adequate humin, humic acid (HA) and fulvic acid (FA) are healthier, give higher and better quality yield and are less prone to stress (Ouni et al 2014). Therefore the main objective of the present investigations was to study the effect of soil drenching and drip-fertigated liquid organic manures on the productivity of maize with the vegetable amaranth (*Amaranthus* sp L) as intercrop under drip and conventional irrigated conditions.

MATERIAL and METHODS

The experiment was conducted in the eastern block fields of Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu in 2016 and 2017 to analyze productivity of maize under drip and conventional irrigated conditions due to various liquid organic manures. The experiment consisted of 2 factors namely

irrigation methods and fertilization methods with 3 replications in a factorial randomized block design. The pre-sowing soil samples collected from the experimental site were analysed for physico-chemical characteristics (Table 1).

The treatments included two types of irrigation methods viz I_1: Drip irrigation and I_2: Conventional irrigation and 7 fertilizations viz F_1: Humic acid 3 kg/ha, F_2: Fulvic acid 3 kg/ha, F_3: Vermiwash 5 per cent, F_4: Jeevamiritham 5 per cent, F_5: Humic acid 3 kg/ha + fulvic acid 3 kg/ha, F_6: Vermiwash 5 per cent + Jeevamiritham 5 per cent and F_7: Inorganic fertilizers.

The liquid organic manures were analysed for the nutrient status and microflora present in them (Table 2). Maize hybrid CoH(M)8 was used in the experimentation. Seeds (20 kg/ha) were treated with *Trichoderma viride* (4 g/kg), *Pseudomonas fluorescens* (10 g/kg), *Azospirillum lipoferum* (600 g/kg) and *Phosphobacterium* (600 g/kg) and sown by hand dibbling with specified spacing of 60 × 30 cm. In surface irrigation treatment maize was sown along the sides of the ridges and vegetable amaranth on other side. Paired-row planting system was adopted under drip irrigation (2 rows of maize with 60 cm row spacing and 30 cm between plant to plant spacing). Between the two rows of maize, two rows of amaranth were sown with 30 cm row spacing. The vegetable amaranth seeds were mixed with sand (1:5) and sown.

The height of the plant was measured from ground level to the tip of plant at harvest. For calculating total dry matter production (DMP) sample plants were air-dried and then oven-dried at 65 ± 5°C till a constant weight was reached. The harvested cobs were dried, dehusked, shelled and cleaned separately. After cleaning the grains were sun-dried to 14 per cent moisture content. Grain weight of each treatment plot was recorded. Vegetable amaranth plants from the net plot area were pulled out manually and weighed.

In case of drip-irrigated inorganic fertilization treatment (I_1F_7), the fertilizers (NPK) were applied through drip fertigation (Table 3) using urea as N source, mono ammonuim phosphate (MAP) for P and muriate of potash (white potash/MoP) for K. For conventional irrigation (I_2) treatments soil drenching of organic liquid manures and conventional method of application of fertilizers were done. Recommended dose of fertilizers (RDF) for maize 150:75:75 kg of NPK per ha was given as indicated in Table 3. Further

Table 1. Physico-chemical characteristics of the experimental soil

Parameter	Value	
	I year	II year
Textural class	Sandy clay loam	Sandy clay loam
Bulk density (g/cc)	1.31	1.33
Particle density (g/cc)	2.23	2.31
Porosity (%)	41.25	42.42
pH	8.34	8.10
EC (dS/m)	1.16	0.78
Organic carbon (%)	0.45	0.39
Available nitrogen (kg/ha)	198.0	336.0
Available phosphorus (kg/ha)	19.5	17.5
Available potassium (kg/ha)	648.0	468.0

Table 2. Nutrient status and microbial population of liquid organic manures

Parameter	Humic acid	Fulvic acid	Vermiwash	Jeevamiritham
Total nitrogen (%)	3.75	4.20	0.01	0.32
Total phosphorus (%)	1.04	0.69	0.08	0.26
Total potassium (%)	1.46	6.01	0.13	0.06
Bacteria (cfu/ml)	0	0	82.6×10^6	122.7×10^6
Fungi (cfu/ml)	0	0	10.3×10^4	13.4×10^4
Actinomycetes (cfu/ml)	0	0	5.2×10^2	8.4×10^2

fertilizer sources used for supplying NPK were urea, single super phosphate (SSP) and MoP for inorganic fertilization in the conventional irrigation. All other standard cultural practices of TNAU for field crops were followed uniformly to all the treatments (http://agritech.tnau.ac.in/agricultural_marketing/agrimark_Cooperatives.html).

First irrigation was given immediately after sowing. Life irrigation was given on 3 DAS to saturation level. In conventional method of surface irrigation, scheduling was done to 5.0 cm depth at 0.8 IW/CPE ratio. Subsequent irrigations were given based on the pan evaporation value from USWB Class A open pan evaporimeter. For irrigation through drip, it was scheduled once in three days based on the daily pan evaporation at the same 0.8 IW/CPE ratio. Gap filling was done on 7 DAS and thinning on 10 DAS by leaving one healthy seedling per hill to maintain 100 per cent plant population in the experimental plots. Adequate prophylactic measures were taken to protect the crop from pests and diseases by organic methods. Two hand weedings were given on 20 and 45 DAS. Intercrop vegetable amaranth was harvested at 25 DAS.

RESULTS and DISCUSSION

Effect of irrigation and fertilization methods on growth characters of maize

Plant height is a direct index to assess the growth and vigour of the plant. It was found to be influenced both by irrigation methods and fertilization (Table 4). Among the irrigation methods, drip showed superiority over conventional irrigation in the first year

Table 3. Fertigation and fertilization schedule for maize

Fertigation schedule for drip-irrigated treatment (I_1F_7)				Fertilization schedule for conventional-irrigated treatment (I_2F_7)		
Crop stage (days)	Quantity (%)			Basal	I top dressing (25 DAS)	II top dressing (45 DAS)
	N	P	K			
Vegetative stage (15-30)	25	25	25	25% N	50% N	25% N
Reproductive stage (30-60)	50	50	50	100% P_2O_5	-	-
Maturity stage (60-75)	25	25	25	50% K_2O	-	50% K_2O

Table 4. Plant height of maize at harvest as affected by irrigation and fertilization methods

Treatment	I year			II year		
	I_1 (drip)	I_2 (conventional)	Mean	I_1 (drip)	I_2 (conventional)	Mean
F_1: Humic acid 3 kg/ha	183.89	173.99	178.94	202.37	196.93	199.65
F_2: Fulvic acid 3 kg/ha	175.29	174.43	174.86	201.23	201.67	201.45
F_3: Vermiwash 5%	168.37	165.11	166.74	191.53	182.10	186.82
F_4: Jeevamiritham 5%	172.04	167.91	169.98	190.53	184.90	187.72
F_5: Humic acid kg/ha + fulvic acid 3 kg/ha	202.14	193.34	197.74	223.43	210.87	217.15
F_6: Vermiwash 5% + Jeevamiritham 5%	195.98	185.98	190.98	211.23	214.47	212.85
F_7: Inorganic fertilizers	207.43	204.11	205.77	254.77	230.70	242.73
Mean	186.45	180.70	183.57	210.73	203.09	206.91

	I year			II year		
	I	F	I x F	I	F	I x F
SEd	2.6	5.0	7.1	3.65	6.82	9.65
$CD_{0.05}$	5.5	10.3	NS	7.50	14.03	NS

of experimentation but it was comparable in the second year. In case of fertilization, all the sources of nutrients exerted marked influence on the plant height at harvest and superiority was observed under inorganic fertilization (F_7) in both the years. It was comparable with humic acid 3 kg/ha + fulvic acid 3 kg/ha (F_5) in the second year. Increased plant height due to humic substances application has also been reported in maize by Eyheraguibel et al (2008). The interaction effect of irrigation method with fertilization was absent on the plant height. The effect of variables on the total dry matter production (kg/ha) is furnished in Table 5. During advancement of crop growth a steady and steep increase in dry matter was noticed from vegetative to flowering phase that reached the maximum at harvest during both the years. During first year among the two irrigation methods, drip irrigation (I_1) observed significantly higher dry matter of 15826 kg/ha at harvest. Conventional irrigation (I_2) recorded comparatively lower dry matter of 15139 kg/ha.

Table 5. Dry matter production of maize at harvest as affected by irrigation and fertilization methods

Treatment	I year			II year		
	I_1 (drip)	I_2 (conventional)	Mean	I_1 (drip)	I_2 (conventional)	Mean
F_1: Humic acid 3 kg/ha	15509	15129	15319	17674	16652	17163
F_2: Fulvic acid 3 kg/ha	15539	14967	15253	17768	16990	17379
F_3: Vermiwash 5%	13930	12808	13369	16599	13733	15166
F_4: Jeevamiritham 5%	14377	13325	13851	16966	15720	16343
F_5: Humic acid kg/ha + fulvic acid 3 kg/ha	16922	16349	16635	19430	18447	18938
F_6:Vermiwash 5% + Jeevamiritham 5%	16495	15668	16082	18468	18029	18248
F_7: Inorganic fertilizers	18011	17728	17869	21425	20955	21190
Mean	15826	15139	15483	18333	17218	17775

	I year			II year		
	I	F	I x F	I	F	I x F
SEd	214.81	401.87	568.33	288.19	539.17	762.50
$CD_{0.05}$	436.06	815.80	NS	585.04	1094.51	NS

With regard to fertilization methods significant influence was noted among all the treatments. Application of inorganic fertilizers (F_7) recorded higher dry matter of 17869 kg/ha followed by F_5 (16635 kg/ha) and F_6 (16082 kg/ha). The lower dry matter production (13369 kg/ha) was obtained when vermiwash was applied (F_3). There was no significant interaction effect of irrigation and fertilization methods noticed on dry matter production at all stages of the crop. During II year also F_7 produced the highest dry matter which was on par with F_5. Invariably at all stages of maize growth F_3 produced the lowest dry matter. The addition of 200 g/ha HA applied as soil spray caused significant increases of 23 per cent in total dry matter yield (10793 kg/ha) as compared to control Sarir et al (2006).

Effect of irrigation and fertilization methods on yield of vegetable amaranth

The data recorded on vegetable green yield of amaranth are given in Table 6. Drip-irrigated treatment recorded significantly higher yield (4140 and 2982 kg/ha during first and second year respectively) over the conventional irrigation (3787 and 2685 kg/ha). Regarding fertilization methods, inorganic fertilizers showed superiority (4501 and 3645 kg/ha during first and second year respectively) and it was followed by the treatment Jeevamiritham @ 5 per cent (4253 and 3221 kg/ha during first and second year respectively). The interaction between the irrigation methods and fertilization was significant in the first year only. According to Gore Sreenivasa (2011) Jeevamiritham promotes biological activity in soil and as a result the nutrient availability to the crop is enhanced.

Table 6. Fresh green weight (kg/ha) of vegetable amaranth as affected by irrigation and fertilization methods

Treatment	I year			II year		
	I_1 (drip)	I_2 (conventional)	Mean	I_1 (drip)	I_2 (conventional)	Mean
F_1: Humic acid 3 kg/ha	4015	3343	3679	2574	2367	2471
F_2: Fulvic acid 3 kg/ha	4162	4002	4082	2601	2352	2477
F_3: Vermiwash 5%	3800	2386	3093	2458	2426	2442
F_4: Jeevamiritham 5%	4030	4476	4253	3253	3190	3221
F_5: Humic acid kg/ha + fulvic acid 3 kg/ha	4319	3931	4125	3086	2260	2673
F_6: Vermiwash 5% + Jeevamiritham 5%	4160	3865	4012	3240	2574	2907
F_7: Inorganic fertilizers	4495	4506	4501	3663	3628	3645
Mean	4140	3787	3964	2982	2685	2834

	I year			II year		
	I	F	I x F	I	F	I x F
SEd	150.3	281.2	397.6	81.6	152.7	215.9
$CD_{0.05}$	308.9	578.0	817.4	167.7	313.9	NS

Effect of irrigation and fertilization methods on yield of maize

Grain yield of maize was significantly influenced by irrigation methods and fertilization factors during both the years (Table 7). During 2017 and 2018 drip irrigation significantly increased the grain yield (6014 and 6019 kg/ha respectively) over the conventional irrigation (5597 and 5460 kg/ha respectively). Regarding the fertilization factor, inorganic fertilization (F_7) showed prominent impact over all others (7298 and 7384 kg/ha respectively). It was followed by F_5 treatment (6630 and 6227 kg/ha respectively) which was comparable with vermiwash F_6 (5% + Jeevamiritham 5%) treatment (6250 and

Table 7. Grain yield (kg/ha) of maize as affected by irrigation and fertilization methods

Treatment	I year			II year		
	I_1 (drip)	I_2 (conventional)	Mean	I_1 (drip)	I_2 (conventional)	Mean
F_1: Humic acid 3 kg/ha	5440	4936	5188	5643	4973	5308
F_2: Fulvic acid 3 kg/ha	5706	5231	5468	5757	5326	5542
F_3: Vermiwash 5%	5057	4607	4832	5056	3719	4387
F_4: Jeevamiritham 5%	5041	4897	4969	5376	4917	5146
F_5: Humic acid kg/ha + fulvic acid 3 kg/ha	6914	6346	6630	6481	5974	6227
F_6:Vermiwash 5% + Jeevamiritham 5%	6454	6046	6250	6397	5970	6184
F_7: Inorganic fertilizers	7482	7114	7298	7425	7343	7384
Mean	6014	5597	5805	6019	5460	5740

	I year			II year		
	I	F	I x F	I	F	I x F
SEd	169.5	317.1	448.4	244.8	458.0	647.7
$CD_{0.05}$	344.0	643.7	NS	496.9	929.7	NS

6184 kg/ha respectively). Similar findings on humic substances were observed by Sarir et al (2006) who reported that 200 g/ha HA applied as soil spray increased 28 per cent grain yield (4508 kg/ha), 23 per cent total dry matter (10793 kg/ha) and 25 per cent total cob weight (5509 kg/ha) as compared to control. No interaction effect was noticed due to the irrigation methods with fertilization on the grain yield.

CONCLUSION

It can be concluded that drip irrigation performed better in terms of growth and yield of maize and in the fresh green yield of amaranth. Among the fertilization methods though the inorganic fertilizers recorded higher yield, the liquid organic manure especially the combined application of humic acid 3 kg/ha along with fulvic acid 3 kg/ha resulted in higher grain yield among the organic treatments. For vegetable amaranth application of Jeemiritham was beneficial than other liquid organic manures.

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