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Study on the impact of various irrigation methods on soil properties in maize

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ABSTRACT

A field experiment was conducted to find out the changes in soil physical and chemical properties and soil fertility under various irrigation methods in maize-groundnut cropping system at Agricultural Research Station, Bhavanisagar, Tamil Nadu. The experiment was laid out in strip plot design in a plot size of 15 m^2 with 6 main plot treatments viz drip irrigation, drip fertigation, sub-surface drip irrigation, sub-surface drip fertigation, sprinkler irrigation and conventional method of irrigation and 3 sub-plot treatments viz absolute control (no fertilizer), recommended dose of NPK fertilizers through normal fertilizers/recommended dose of NPK fertilizers through water soluble fertilizers (according to the irrigation treatment) and recommended dose of NPK fertilizers through normal fertilizers/recommended dose of NPK fertilizers through water soluble fertilizers (according to the irrigation treatment) + vermicompost @ 5 tonnes/ha and treatments replicated thrice. The results of the study revealed that sub-surface drip fertigation with the application of recommended dose of NPK fertilizers along with vermicompost @ 5 tonnes/ha was superior in enhancing the soil physical, chemical and post-harvest soil fertility status.

Keywords: Maize; irrigation methods; fertigation; soil; fertility; properties

INTRODUCTION

Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 Mha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices and contributes 36 per cent (782 MT) in the global grain production (Kumar et al 2005).

Among the maize growing countries, India ranks 4th in area and 7th in production representing around 4 per cent of the world maize area and 2 per cent of total production. During 2018-19 in India, the maize area has reached to 9.2 million ha (https://iimr.icar.gov.in/india-maze-scenario/). Among Indian states, Madhya Pradesh and Karnataka have the highest area under maize (15% each) followed by Maharashtra (10%), Rajasthan (9%), Uttar Pradesh (8%) and others. After Karnataka and Madhya Pradesh, Bihar is the highest maize producer.

Maize in India, contributes nearly 9 per cent in the national food basket and more than Rs 100 billion to the agricultural GDP at current prices apart from generating employment to over 100 million man days at the farm and downstream agricultural and industrial sectors. In addition to staple food for human beings and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc (Kumar and Jat 2018).

Water is a crucial input for augmenting agricultural production towards sustainability in agriculture. Scientific water management aims to provide suitable soil moisture environment to the crop to obtain optimum yield commensurate with maximum economy in irrigation water and maintenance of soil productivity. During the winter season less water is required at early stage of crop while at later crop growth stages water requirement increases due to rapid increase in evapo-transpiration demand (Kadasidappa and Rao 2018).

The long term effect of irrigation on soil chemical and physical properties that affect soil productivity requires quantification. Irrigation encourages continuous cropping of land which can have beneficial effects on soil properties. Improved yield and increased organic matter levels have been observed under long term irrigated rotations. Irrigated production has also been shown to increase the total nitrogen and carbon content of soil in cases where these values were low in the native condition.

The aim of this work was to study the impact of various irrigation methods on soil fertility status of maize under maize-groundnut cropping system.

MATERIAL and METHODS

A field experiment was conducted at Agricultural Research Station, Bhavanisagar, Erode district, Tamil Nadu. Before sowing of maize, the initial soil samples were collected from the experimental field and analysed for physical properties viz bulk density, particle density and pore space and chemical properties viz pH, EC, CEC and organic carbon and fertility parameters (available nutrients). The soil of the experimental site was neutral in reaction (pH 6.8), free from soluble salts (EC 0.15 dS/m), low in organic carbon content (0.12%), low in available nitrogen (252 kg/ha), medium in available P (13 kg/ha) and high in available K (535 kg/ha). The bulk density, particle density and pore space of the experimental site were 1.12 Mg/m^3, 2.0 Mg/m^3 and 50 per cent respectively.

The experiment was laid out in strip plot design in a plot size of 15 m^2 with 6 main plot treatments viz I_1– Drip irrigation, I_2– Drip fertigation, I_3– Sub-surface drip irrigation, I_4– Sub-surface drip fertigation, I_5– Sprinkler irrigation and I_6– Conventional method of irrigation and 3 sub-plot treatments viz S_1– Absolute control (no fertilizer), S_2– Recommended dose of NPK fertilizers through normal fertilizers/recommended dose of NPK fertilizers through water soluble fertilizers (according to the irrigation treatment) and S_3– S_2 + vermicompost @ 5 tonnes/ha, treatments replicated thrice. The maize (COHM 5) was the test crop. Regular crop production and protection measures were followed. The irrigation and fertilizer applications were carried out as per treatment schedule. The plot-wise soil samples (0-15 cm) were collected after the harvest of maize crop. These samples were analyzed for pH (by 1:2.5 soil:water suspension), electrical conductivity by conductivity meter (Jackson 1967), organic carbon by rapid titration method (Walkley and Black 1934), available N by alkaline permanganate method (Subbiah and Asija 1956), available P by Olsen's method (Olsen and Sommers 1982), available K by ammonium acetate extraction method (Jackson 1967) and CEC by neutral normal ammonium acetate method (Jackson 1967).

RESULTS and DISCUSSION

Effect of various irrigation methods on soil properties

The plot-wise soil samples collected (0-15 cm) after the harvest of maize crop were processed and analysed for post-harvest soil properties. Data on analysis of soil samples for bulk density, particle density, pore space, pH, EC, organic carbon, CEC, available nitrogen, phosphorus and potassium are given in Table 1.

The bulk density and pore space were significantly influenced by the main plot treatments and their interaction effect and there was no significant difference among the sub-plot treatments. The particle density was not significantly influenced by both main plot and sub-plot treatments. Similar observations were made by Salgado et al (2004).

In case of pH and EC, the data indicated that among the main plot treatments, I_4 (sub-surface drip fertigation) recorded the lowest pH (6.8) and EC (0.15 dS/m) and there was no significant difference between the main plot treatments in case of pH. The pH and EC were significantly influenced by sub-plot treatments. Among the sub-plot treatments the lowest pH of 6.8 and EC (0.15 dS/m) were recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 tonnes/ha). Among the interactions, sub-surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 tonnes/ha (I_4S_3) recorded the lowest pH and EC as also reported by Malik et al (1994). The findings are also in line with

Table 1. Effect of irrigation treatments on soil properties in maize

Treatment	Bulk density (Mg/m^3)				Particle density (Mg/m^3)				Pore space (%)				pH				EC (dS/m)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
I_1	1.32	1.27	1.24	1.27	2.48	2.48	2.27	2.41	51	51	48	49.9	7.1	7.1	6.9	7.0	0.18	0.18	0.16	0.17
I_2	1.24	1.32	1.24	1.27	2.29	2.48	2.27	2.35	48	51	47	48.4	6.9	6.9	6.8	6.9	0.16	0.16	0.15	0.16
I_3	1.37	1.32	1.26	1.36	2.10	2.27	2.13	2.16	43	47	45	44.7	6.8	6.8	6.7	6.8	0.15	0.15	0.14	0.15
I_4	1.37	1.29	1.37	1.32	2.10	2.10	2.48	2.21	45	43	49	45.6	6.9	6.8	6.7	6.8	0.16	0.15	0.14	0.15
I_5	1.32	1.29	1.29	1.31	2.48	2.42	2.48	2.46	51	46	46	47.9	7.2	7.0	6.8	7.0	0.19	0.17	0.15	0.17
I_6	1.29	1.29	1.32	1.32	2.37	2.37	2.37	2.37	47	50	52	49.7	7.2	7.1	6.9	7.1	0.19	0.18	0.16	0.18
Mean	1.32	1.30	1.31	1.31	2.29	2.35	2.33	2.22	47	48	48	48	7.0	7.0	6.8	7.0	0.17	0.17	0.15	0.16

I_1– Drip irrigation, I_2– Drip fertigation, I_3– Sub-surface drip irrigation, I_4– Sub-surface drip fertigation, I_5– Sprinkler irrigation, I_6– Conventional method of irrigation, S_1– Absolute control (no fertilizer), S_2– Recommended dose of NPK fertilizers through normal fertilizers/ Recommended dose of NPK fertilizers through water soluble fertilizers (according to the irrigation treatment)

	Bulk density		Particle density		Pore space		pH		EC	
	SED	$CD_{0.05}$	SED	$CD_{0.05}$	SED	$CD_{0.05}$	SED	$CD_{0.05}$	SED	$CD_{0.05}$
I	0.020	0.44	1.22	NS	1.25	2.8	0.51	NS	0.021	0.046
S	0.009	NS	0.92	NS	0.82	NS	0.36	0.65	0.008	0.017
I at S	0.028	0.06	2.20	NS	2.1	4.4	0.21	0.53	0.023	0.058
S at I	0.024	0.05	2.25	NS	2.01	4.2	0.17	NS	0.020	0.042

Table 1. Contd…..

Treatment	Organic C (%)				CEC [cmol (P$^+$)/kg]				Average N (kg/ha)				Average P (kg/ha)				Average K (kg/ha)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
I_1	0.11	0.12	0.13	0.12	16.3	16.4	16.6	16.4	143	182	188	171	4.8	7.0	7.0	6.3	266	334	406	335
I_2	0.11	0.12	0.14	0.12	16.4	16.5	16.7	16.5	160	183	199	181	5.0	7.2	7.8	6.7	274	352	414	347
I_3	0.12	0.14	0.15	0.14	16.5	16.6	16.8	16.6	160	186	208	185	5.0	7.5	8.0	6.8	288	368	428	361
I_4	0.12	0.14	0.15	0.14	16.5	16.6	16.9	16.7	162	192	215	190	5.5	7.5	9.0	7.3	294	372	434	367
I_5	0.11	0.11	0.13	0.13	16.3	16.4	16.5	16.3	132	180	180	164	4.5	6.8	7.0	6.1	250	325	390	322
I_6	0.10	0.11	0.12	0.12	16.2	16.4	16.5	16.4	126	180	166	157	4.5	6.5	6.5	5.8	241	318	381	313
Mean	0.11	0.12	0.14	0.12	16.4	16.5	16.6	16.5	147	184	193	175	4.9	7.1	7.6	16.5	269	345	409	341

I_1– Drip irrigation, I_2– Drip fertigation, I_3– Sub-surface drip irrigation, I_4– Sub-surface drip fertigation, I_5– Sprinkler irrigation, I_6– Conventional method of irrigation, S_1– Absolute control (no fertilizer), S_2– Recommended dose of NPK fertilizers through normal fertilizers/ Recommended dose of NPK fertilizers through water soluble fertilizers (according to the irrigation treatment)

	Organic C		CEC		Average N		Average P		Average K	
	SED	$CD_{0.05}$	SED	$CD_{0.05}$	SED	$CD_{0.05}$	SED	$CD_{0.05}$	SED	$CD_{0.05}$
I	0.047	0.105	0.11	0.25	2.05	4.57	0.54	1.03	12.12	27.01
S	0.024	0.50	0.060	0.105	1.68	3.47	0.48	1.00	8.08	16.68
I at S	0.068	0.15	0.15	0.33	3.94	8.31	1.07	2.24	20.21	42.9
S at I	0.06	0.12	0.12	0.26	4.12	8.50	1.19	2.45	19.8	40.9

the results reported by Singh et al (1980) and Halemani et al (2004).

The data on organic carbon and CEC indicated that among the main plot treatments I_4 (sub- surface drip fertigation) recorded the highest organic carbon (0.14%) and CEC (16.7 cmol (P^+)/kg) and the parameters were significantly influenced by the main plot treatments. Among the sub-plot treatments the highest organic carbon (0.14%) and CEC (16.6 cmol ((P^+)/kg) were recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 tonnes/ha) followed by S_2. Among the interactions, sub-surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 tonnes/ha (I_4S_3) recorded the highest organic carbon (0.15%) and CEC (16.9 cmol (P^+)/kg).

The main plot treatments significantly influenced available N. Among the main plot treatments, the highest value of 190 kg/ha was recorded by I_4 (sub-surface drip fertigation) and the treatments I_2 and I_3 were on par with each other. Among the sub-plot treatments the highest available nitrogen status (193 kg/ha) was recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 tonnes/ha) followed by S_2.

Among the interactions, sub-surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 tonnes/ha (I_4S_3) recorded the highest available nitrogen (215 kg/ha) and the treatment combination I_3S_3 (sub-surface drip irrigation with recommended dose of NPK fertilizers + vermicompost @ 5 tonnes/ha) was on par with I_4S_3. The lowest available nitrogen content of 126 kg/ha was noticed with conventional method of irrigation with no fertilizer (I_6S_1) and this was on par with I_5S_1 (sprinkler irrigation with no fertilizer).

The available phosphorus content of post-harvest soil was significantly influenced by the treatments. Among the main plot treatments the highest value of 7.3 kg/ha was recorded by I_4 (sub-surface drip fertigation) followed by I_2 and I_3. Among the sub-plot treatments, the highest available phosphorus content of 7.6 kg/ha was recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 tonnes/ha) followed by S_2. Among the interactions, I_4S_3 recorded the highest available phosphorus (9.0 kg/ha) and the treatment I_3S_3 and I_2S_3 behaved similarly. The lowest available phosphorus content of 4.5 kg/ha was noticed with conventional method of irrigation with no fertilizer (I_6S_1) and this was on par with I_5S_1 (sprinkler irrigation with no fertilizer).

With regard to available potassium status, the main plot treatments significantly influenced the available potassium. Among the main plot treatments the highest value of 367 kg/ha was recorded by I_4 (sub-surface drip fertigation) which was on par with I_2 and I_3.

Among the sub-plot treatments, the highest available potassium (409 kg/ha) was recorded in S_3 followed by S_2. Among the interactions, I_4S_3 recorded the highest available potassium (434 kg/ha) which was similar to I_3S_3 and the lowest available potassium content of 269 kg/ha was noticed with conventional method of irrigation with no fertilizer (I_6S_1).

The results are in line with those of Magare et al (2018). They reported that the availability and distribution of nutrients in the soil depend on their solubility, moisture and difference. The higher available N, P, and K in the soil after plant harvesting when using drip fertigation system could be attributed to the minimal losses in minerals via leaching and the enhancement of nutrients movement in the soil comparing to surface and/or sub-surface drip irrigation system. Slight improvement in the post-harvest soil fertility levels of N, P and K was noticed in fertigation plots.

This confirms that fertilizers solubilize the unavailable phosphorus to available P form and increase the P use efficiency. Supply of water and N fertilizers at shorter intervals increased the nutrients availability in the soil. Malik et al (1994) and Bharambe et al (1997) reported that there was increase in the availability of soil nutrients under drip fertigation system compared to the direct application to the soil.

Conventional method of irrigation with no fertilizer (I_6S_1) recorded less available nitrogen due to low nutrient use efficiency. Similar trend was noticed in case of available P and K.

CONCLUSION

Present study indicated that in the post-harvest soil properties of maize, the application of recommended dose of fertilizers + vermicompost @ 5 tonnes/ha with sub-surface drip fertigation significantly influenced the physical and chemical properties and also soil fertility status than rest of the treatments.

REFERENCES

Bharambe PR, Narwade SK, Oza SR, Vaishnava VA, Shelke DK and Jadhav GS 1997. Nitrogen management in cotton through drip irrigation. Journal of the Indian Society of Soil Science **45:** 705-709.

Halemani HL, Hallikeri SS, Nandagavi RA, Nooli SS and Kumar GM 2004. Influence of organics, inorganics and their combinations on soil properties and crop productivity in cotton-based cropping system. In: Proceedings of the International Symposium on Strategies for Sustainable Cotton Production- a Global Vision, 2. Crop Production, 23-25 November 2004, UAS, Dharwad, Karnataka, India, pp 174-180.

https://iimr.icar.gov.in/india-maze-scenario/ (Retrieved: 05.01.2022)

Jackson ML 1967. Soil chemical analysis. Prentice Hall of India Pvt Ltd, New Delhi, India, 498p.

Kadasidappa MM and Rao VP 2018. Irrigation scheduling through drip and surface methods– a critical review on growth, yield, nutrient uptake and water use studies of rabi maize. Agricultural Reviews **39:** 300-306.

Kumar A, Guatam RC, Singh R and Rana KS 2005. Growth, yield and economics of maize (*Zea mays*)–wheat (*Triticum aestivum*) cropping sequence as influenced by integrated nutrient management. Indian Journal of Agricultural Sciences **75(11):** 709-711.

Kumar R and Jat R 2018. Water requirements and irrigation scheduling of maize in northern Gangetic plains. International Journal of Agricultural Engineering **11(1):** 210-215.

Magare PN, Katkar RN and Jadhao SD 2018. Effect of fertigation on yield, quality and soil fertility status under cotton grown in Vertisol. International Journal of Chemical Studies **6(2):** 42-46.

Malik RS, Kumar KA and Bhandar I 1994. Influence of nitrogen application by drip irrigation on nutrients availability in soil and uptake by pea. Journal of the Indian Society of Soil Science **44:** 508-509.

Olsen SR and Sommers LE 1982. Phosphorus. In: Methods of soil analysis (AL Page, RH Miller and DR Keeney, eds), Part 2: Chemical and microbiological properties, American Society of Agronomy, Inc, Madison, pp 403-427.

Salgado E, Ahumada R, Ribbe L and Gaese H 2004 Soil physical properties under two irrigation systems in the upper Aconcagua valley of Chile. Zeitschrift fur Bewasserungwirtschaft **39:** 93-102.

Singh L, Verma RNS and Lohia SS 1980. Effects of continuous application of farmyard manure and chemical fertilizers on some soil properties. Journal of Indian Society of Soil Science **28:** 171-172.

Subbiah BV and Asija GV 1956. A rapid procedure for determination of available N in soils. Current Science **25:** 264-265.

Walkley AJ and Black IA 1934. Estimation of soil organic carbon by the chromic acid titration method. Soil Science **37:** 29-38.