AATCC Review

12 March 2023: Received
03 July 2023: Revised
08 September 2023: Accepted
10 November 2023: Available Online

www.aatcc.peerjournals.net

Research Article Open Access

Influence of methods of irrigation and fertilizer application on Physical and Physico-Chemical properties and available nutrient status of soil in Groundnut

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ABSTRACT

Groundnut is an important food legume and oilseed crop of tropical and subtropical areas and cultivated on about 25 million hectare of land in more than 90 countries in the world, under different agro-climatic regions where rainfall during the growing season exceeds 500 mm. Though, nutritionally groundnut is an energy rich crop, it is grown mainly on energy-starved conditions of poor fertility soils and about 70% of the its production in the world occurs in the semi-arid tropics with average yield is around 800 kg ha. In past the combination of improved varieties and nutrient management practices have contributed significantly to increase in production and productivity. However, India could not maintain the required growth rate of the productivity and became a decade behind of China mainly because, in India, the groundnut crop is mostly grown as rainfed in dry lands, on problem soils under low fertility, and low input management. Long term use of fertilizers like acidic or basic or neutral may affect the physico chemical properties of soil which may be long term or short term. Therefore, it is imperative to study the Influence of methods of irrigation and fertilizer application on Physical and Physico - Chemical properties and available nutrient status of soil under Groundnut cultivation. Hence the field experiment was conducted at Agricultural Research Station, Bhavanisagar, Erode district of Tamil Nadu to study the influence of various methods of irrigation and fertilizer application on Physical properties viz., bulk density, particle density, pore space and Physico - Chemical properties viz., pH, EC, organic carbon and CEC and available nutrient status (Nitrogen, Phosphorus and Potassium) of post harvest soil in Groundnut under maize – groundnut cropping system. The various irrigation methods (main plot treatments) followed were 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 the various methods of application of fertilizers were imposed as subplot treatments, ie., 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 t ha^{-1} and the treatments were replicated thrice. The experiment was laid out in strip plot design in a plot size of 15 M^2. The crop rotation followed was maize – groundnut. The second crop in the cropping system i.e., groundnut was sown by following a spacing of 30 cm between rows and 10 cm between plants. The intercultural were followed as per crop production guide. The irrigation and fertilizer application were followed as per the treatment schedule. The crop was harvested at maturity. After the harvest of the crop, the post harvest soil samples were collected, processed and analysed for their physical and physico – chemical properties and available nutrient status. The results of the study indicated that there was a slight increase in the bulk density, particle density and EC, but the increase was not significant. There was no improvement in the pH of the soil. With respect to organic carbon, CEC and available nutrient status viz., available N, available P and available K also there was no improvement when compared to the initial soil properties. With regard to various irrigation methods and fertilizer applications, the sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) is superior in enhancing post harvest soil physical and physico – chemical properties and available nutrient status of groundnut when compared to other treatment combinations.

Keywords: *Groundnut, Irrigation methods, Fertilizers, Fertilizer application methods, Initial soil characteristics, Physical properties, Physico – chemical properties, Available nutrient status*

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DOI: https://doi.org/10.58321/AATCCReview.2023.11.04.304

Introduction

Groundnut (*Arachis hypogaea L.*) is commonly branded as poor man's nut also important food crop frequently used as edible oil and vegetable protein. India is the second largest producer of groundnut after China. Groundnut ranks first in the production among major oilseeds of India accounting for 42 per cent of the oil seeds production in the country during 2014 – 15 [17]. The major groundnut production states are Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra. These five states contribute 86 percent of groundnut production in India [14]. Gujarat is the largest producer contributing 25 per cent of the total production of groundnut followed by Andhra Pradesh, Tamil Nadu and Karnataka [16]. Tamil Nadu, occupies 3,38,300 hectares with a production of 7,83,200 tonnes [15]. The major groundnut producing districts are Vellore, Cuddalore, Thiruvannamalai, Dharmapuri, Salem, Erode, Theni, Trichy, Madurai, Perambalur, Ariyalur, Pudukkottai and Kancheepuram district [1].

In India, peanut is one of the important oilseed crops and occupies an area of 5.86 M ha with the production of 8.27 M tonnes and productivity of 1411 kg ha^{-1} (2010–11) which is quite low as compared to other countries. Among the various factors that limit the productivity of peanut, efficient use of available water and fertilizer is highly critical for improving the crop productivity. It has been reported that the loss of applied irrigation water from the reservoir to the field under unlined irrigation system is 71% in furrow and border irrigation systems. Such huge amounts of water loss cause abundant nutrient loss through seepage/percolation. However, drip irrigation reduces deep percolation and evaporation and controls soil water status more precisely within the crop root zone. Similarly, during fertigation, fertilizers are applied through emitters directly in the zone of maximum root activity, and consequently, fertilizer-use efficiency can be improved over conventional broadcasting/furrow placement method of fertilizer application. It has been scientifically recognized that adoption of drip fertigation method is an option for efficient use of water and nutrients through improvement in crop yield per unit volume of water and nutrients used. There is a reduction in water consumption by 30–70% by use of drip system over surface method with a concomitant gain in productivity by 20–30% for different crops [8] and [2].

With course of time and crop cultivations, soil continually receives inputs of external energy, water, gases and dissolved constituents. Losses of these same components are equally possible through radiation of heat, leaching and biological activities. These changes disturb the soil system and as well as their equilibrium that may be present. The effect of fertigation on soil chemical properties is more diffuse because fertilizers are spread in a larger area than the application of conventional fertilization [19]. Long term use of fertilizers like acidic or basic or neutral may affect the physico chemical properties of soil which may be long term or short term. Therefore, it is imperative to study the Influence of methods of irrigation and fertilizer application on Physical and Physico - Chemical properties and available nutrient status of soil under Groundnut cultivation.

Materials and Methods

The field experiment was conducted at Agricultural Research Station, Bhavanisagar, Erode district of Tamil Nadu. The initial soil sample was collected, processed and analysed for physical properties *viz.,* bulk density, particle density and pore space, chemical properties *viz.,* pH, EC,CEC and organic carbon and fertility parameters (available nutrients) (Table 1). 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 subplot treatments, *i.e.,* 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 t ha^{-1} and replicated thrice. The crop rotation followed was maize – groundnut. The second crop in the cropping system *i.e.,* groundnut was sown by following a spacing of 30 cm between rows and 10 cm between plants. The intercultural operations like spraying herbicides, gap filling, hand weeding, gypsum application, earthing up and plant protection measures were followed as per crop production guide. The irrigation and fertilizer application were followed as per the treatment schedule. The crop was harvested at maturity.

Soil sampling and physico-chemical analysis

Post harvest soil samples were drawn from 0-15 cm depth from each plot. The collected samples were air-dried and ground to pass through 2-mm sieve. Soil pH was determined from soil-water suspension in 1:2.5 ratio with the help of pH meter as described by [7]. The electrical conductivity (EC) of soil-water suspension (1:2.5) was estimated with the help of a conductivity meter outlined by ([7]. The electrical conductivity was measured at room temperature (25°C) after the soil particles have been settled down. Organic carbon of soil was estimated by following the wet digestion method of [20]. Available N by alkaline permanganate method [18], available P by Olsen's method [12], available K by ammonium acetate extraction method [7] and CEC by Neutral Normal Ammonium acetate method [7].

To compare the effect of irrigation and fertilizer levels on the soil properties was statistically analyzed by Factorial Experiment (FRBD) given by [6]. Six levels of irrigation were considered as Factor-1 and three levels of fertilizer were considered as Factor-2, making total of 18 treatments with three replications. The standard error of means (SEm±) and critical difference (CD) at 5% level of significance were calculated to compare the treatment means.

Results and Discussion

The results of the field experiment are as follows:

Table. 1. Characteristics of experimental soil

Particulars	Value
pH	6.80
EC (dSm^{-1})	0.15
Bulk density (Mg/m^3)	1.12
Particle density (Mg/m^3)	2.00
Pore space	50 %
Organic carbon (%)	0.12
Cation Exchange Capacity (cmol (P^+) kg^{-1})	16.5
Available Nitrogen (Kg ha^{-1})	252
Available Phosphorus (Kg ha^{-1})	13
Available Potassium (Kg ha^{-1})	535

The initial soil physical, physico-chemical and available nutrient status of the experimental field are presented in the Table 1. The bulk density, particle density and pore space of the soil are 1.12 Mg/m^3, 2.0 Mg/m^3 and 50 per cent respectively. The soil is having a pH of 6.8 and EC of 0.15 dS/m. The organic carbon content and CEC are 0.12 per cent and 16.5 cmol (P^+) kg^{-1} and the available nitrogen, phosphors and potassium are 252 kg ha^{-1}, 13 kg ha^{-1} and 535 kg ha^{-1} *i.e.,* the soil of the experimental field is low, medium and high in available nitrogen, phosphors and potassium status respectively.

Result and Discussion

The post harvest soil properties *viz.,* bulk density, particle density, pore space, pH, EC, organic carbon, CEC, available nitrogen, phosphorus and potassium were analysed and reported in table 2 and 3. With regard to bulk density, particle density and pore space, the bulk density was significantly influenced by the main plot treatments and not significantly influenced by the sub plot treatments. The particle density and pore space were not significantly influenced by both main plot and the sub plot treatments.

In case of pH and EC, the data indicated that among the various irrigation methods the sub surface drip irrigation (I_3) recorded the lowest pH (6.7), and sub surface drip fertigation (I_4) recorded the lowest EC (0.16 dSm^{-1}) and there was a significant difference between the irrigation methods. The pH and EC were significantly influenced by the fertilizer application. The data indicated that the lowest pH of 6.7 and and EC (0.15 dSm^{-1}) were recorded by S_2 (recommended dose of NPK fertilizers through normal fertilizers / recommended dose of NPK fertilizers through water soluble fertilizers) and S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}) respectively. Among the interactions, sub surface drip fertigation with recommended dose of NPK fertilizers (I_4S_2) recorded the lowest pH and I_4S_3 (sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}) recorded the lowest EC. Soil pH decreased with decrease in quantity of irrigation water as apparent from the results and the variation among treatments was significant in this respect (Table 2). Similarly, pH decreased slightly with increasing fertilizer levels and their difference was also significant. Reduction in soil pH under decreasing irrigation quantity might be due to increase in organic carbon and increased rate of nitrification. But, it may be noted that organic carbon could not be the sole factor in controlling the soil pH. The slight decrease in pH with increasing fertilizer levels might be due to formation of nitrates from the urea in the soil by virtue of nitrification. Similar findings have been reported from N fertigation experiments conducted by [5]) and [13]. The soil pH under fertigation treatments seemed to be slightly lower than surface and conventional method of irrigation. Under conventional irrigation, the pH might be increased in surface and sub-surface soils as stated by [9]. Results also showed that there was a slight increase in the soil electrical conductivity (Table 2). This might be due to the fact that some amounts of basic materials might have accumulated in the soil layer. Similar findings have been reported by [4]. Increased EC was observed under conventional irrigation in as reported earlier by [9] in pea on a gravelly loam soil.

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 (0.15 %) and CEC (16.6 cmol (P^+) kg^{-1}) and the parameters were significantly influenced by the main plot treatments. Among the subplot treatments the highest organic carbon (0.16 %) and CEC (16.7 cmol (P^+) kg^{-1}) were recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}) followed by S_2. Among the interactions, sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) recorded the highest organic carbon (0.18 %) and CEC (16.8 cmol (P^+) kg^{-1}). Irrespective of irrigation methods and fertilizer application, there was slight increase in the oxidizable soil organic carbon (0-15 cm depth) when compared with the initial content. The increase in the soil organic carbon might be due to gradual accumulation of root exudates, decaying dead roots in soil under regular and optimal supply of water and nutrients under drip fertigation. It is also universally accepted fact that, under regular supply of soil moisture, more percentage of roots proliferates laterally and concentrates near the surface, thus increasing the OC in soil. In comparison, the organic carbon in soils was higher under drip fertigation, than that of conventional method. This might be due to the sudden, fluctuating and disturbing the soil equilibrium after heavy surface irrigation Kumaravelu *et al.,* [10]). In comparison, the soils under drip fertigation, the organic carbon was higher than that of conventional method.

With respect to available nitrogen status, the main plot treatments were significantly influenced the parameter. Among the main plot treatments the highest value of 194 kg ha^{-1} was recorded by I_4 (sub surface drip fertigation) and the treatments followed by I_3. Among the subplot treatments the highest available nitrogen status (194 kg ha^{-1}) was recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}) followed by S_2. Among the interactions, sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) recorded the highest available nitrogen (219 kg ha^{-1}) followed by I_3S_3 (sub surface drip irrigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}). The lowest available nitrogen content of 132 kg ha^{-1} was noticed with conventional method of irrigation with no fertilizer (I_6S_1).

The available phosphorus content of post harvest soil was significantly influenced by the treatments. Among the main plot treatments the highest value of 9.4 kg ha^{-1} was recorded by I_4 (sub surface drip fertigation) followed by I_3. Among the subplot treatments the highest available phosphorus content of 9.6 kg ha^{-1} was recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}) followed by S_2. Among the interactions, sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) recorded the highest available phosphorus (11.0 kg ha^{-1}) and this treatment is similar in line with I_3S_3 (sub surface drip irrigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}). The lowest available phosphorus content of 5.2 kg ha^{-1} was noticed with conventional method of irrigation with no fertilizer (I_6S_1) and this is on par with I_5S_1 (sprinkler irrigation with no fertilizer).

With regard to available potassium status, the main plot treatments were significantly influenced the parameter. Among the main plot treatments the highest value of 386 kg ha^{-1} was recorded by I_4 (sub surface drip fertigation) followed by I_3. Among the subplot treatments the highest available potassium status (428 kg ha^{-1}) was recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}) and there was no significant difference between the subplot treatments. Among the interactions, sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) recorded the highest available potassium (452 kg ha^{-1}). The lowest available potassium content of 254 kg ha^{-1} was noticed with conventional method of irrigation with no fertilizer (I_6S_1). In general a decrease in soil available NPK at post harvest was noticed as compared with initial soil nutrient status. The treatments showed significant influence on post harvest soil available nutrient status and the highest NPK values were noticed under drip fertigation with recommended dose of NPK fertilizers and application of vermicompost @ 5 t ha^{-1}. Conventional irrigation with absolute control recorded the lowest values of post harvest soil nutrient [8]. The distribution and availability of nutrients in the soil depends upon their solubility, moisture and its variation. The reason for higher post harvest available N, P and K in soil under drip fertigation could be due to reduction in leaching loss and better movement of nutrients in the soil under drip fertigation as compared with surface irrigation. Slight improvement in the post harvest soil fertility levels of N, P and K were noticed in vermicompost applied plots. This confirmed that vermicompost solubilise the unavailable phosphorus to available P form and increase the P use efficiency. Increasing the soil nutrient availability with drip fertigation as compared with soil application was reported by [11] and [13].

Conclusion

The initial soil analysis indicated that soil was low in available nitrogen, medium in available phosphorus and high in potassium. So various irrigation methods and fertilizers give quick response. Sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) is superior in enhancing the soil fertility status of groundnut when compared to the rest of the treatments.

Table 2: Effect of treatments on soil properties

Treatments	Bulk density (Mg / m³)				Particle density (Mg / m³)				Pore space (%)				pH				EC (dSm⁻¹)			
	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	1.23	1.29	**1.28**	2.45	2.21	2.37	**2.13**	46	49	47	**47**	7.0	6.9	6.7	**6.9**	0.18	0.18	0.17	**0.18**
I_2	1.34	1.29	1.34	**1.33**	2.37	2.48	2.27	**2.38**	46	47	49	**47**	6.9	6.9	6.6	**6.8**	0.17	0.17	0.16	**0.17**
I_3	1.29	1.32	1.32	**1.31**	2.27	2.42	2.21	**2.30**	44	46	43	**44**	6.8	6.7	6.6	**6.7**	0.17	0.16	0.16	**0.16**
I_4	1.37	1.32	1.37	**1.36**	2.21	2.42	2.37	**2.33**	44	46	49	**46**	6.8	6.7	6.5	**6.7**	0.16	0.16	0.15	**0.16**
I_5	1.32	1.35	1.32	**1.33**	2.21	2.21	2.27	**2.23**	43	43	44	**43**	7.0	7.0	6.7	**6.8**	0.18	0.17	0.18	**0.18**
I_6	1.32	1.29	1.34	**1.32**	2.48	2.13	2.13	**2.25**	46	49	42	**46**	7.1	7.1	6.8	**7.0**	0.19	0.18	0.17	**0.18**
Mean	**1.33**	**1.30**	**1.33**	**1.32**	**2.33**	**2.31**	**2.27**	**2.30**	**45**	**47**	**46**	**46**	**6.9**	**6.7**	**6.8**	**6.8**	**0.18**	**0.17**	**0.17**	**0.17**
	SED		CD (0.05)		SED		CD (0.05)		SED		CD (0.05)		SED		CD (0.05)		SED		CD (0.05)	
I	0.019		0.042		0.047		0.106		3.02		NS		0.018		0.04		0.006		0.012	
S	0.12		NS		0.061		0.126		2.37		NS		0.011		0.024		0.003		NS	
I at S	0.031		0.066		0.131		0.273		5.64		NS		0.029		0.062		0.008		0.017	
S at I	0.030		0.061		0.150		0.309		5.84		NS		0.028		0.058		0.006		0.013	

Table 3: Effect of treatments on soil properties

Treatments	Organic carbon (%)				CEC (cmol (P⁺) kg⁻¹)				Av. Nitrogen (Kg/ha)				Av. Phosphorus (Kg/ha)				Av. potassium (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	0.16	**0.13**	16.1	16.3	16.6	**16.3**	151	185	192	**170**	5.5	8.2	9.0	**7.6**	275	354	416	**348**
I_2	0.12	0.12	0.17	**0.14**	16.2	16.3	16.7	**16.4**	160	193	207	**180**	6.8	8.5	9.8	**7.7**	284	363	434	**360**
I_3	0.12	0.13	0.17	**0.14**	16.3	16.4	16.8	**16.5**	168	196	218	**188**	7.0	9.0	10.5	**8.8**	295	376	448	**373**
I_4	0.13	0.13	0.18	**0.15**	16.5	16.5	16.8	**16.6**	171	204	226	**194**	7.6	9.5	11.0	**9.4**	314	398	452	**386**
I_5	0.10	0.11	0.15	**0.12**	16.2	16.1	16.6	**16.3**	144	182	187	**165**	5.5	7.5	8.5	**7.2**	261	345	410	**339**
I_6	0.11	0.10	0.15	**0.12**	16.1	16.2	16.5	**16.3**	136	180	174	**158**	5.2	7.1	8.5	**6.9**	254	338	409	**334**
Mean	**0.12**	**0.12**	**0.16**	**0.13**	**16.2**	**16.3**	**16.7**	**16.4**	**150**	**184**	**194**	**176**	**6.3**	**8.0**	**9.6**	**8.0**	**281**	**362**	**428**	**357**
	SED		CD (0.05)		SED		CD (0.05)		SED		CD (0.05)		SED		CD (0.05)		SED		CD (0.05)	
I	0.008		0.020		0.21		0.47		1.82		4.05		0.16		0.35		1.66		3.71	
S	0.009		0.019		0.16		0.33		1.25		2.57		0.12		0.24		2.47		NS	
I at S	0.020		0.042		0.38		0.81		3.08		6.54		0.28		0.59		5.21		10.8	
S at I	0.022		0.046		0.39		0.81		3.05		6.30		0.28		0.59		6.04		12.5	

Acknowledgement
This research work was carried out under All India Coordinated Research Project on Irrigation Water Management, Bhavanisagar centre, Tamil Nadu, India.

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