

**Original Research Article**  
**A study on soil nutrient status and nutrient uptake of summer groundnut under pressurized irrigation**

**Comment [h1]:** 1.The title of the manuscript needs to be modified. The term 'A study on' is not look good. Authors have used three methods of irrigation but mentioned only two in the title i.e. pressurized irrigation, which is again not logical. I suggest to modify the title as: "Experimental evaluation of irrigation methods on soil nutrient status and nutrient uptake of summer groundnut"

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1 | **ABSTRACT**

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**Aims:** To study the nutrient uptake and status of available nutrients in soil after harvest of groundnut as affected by different irrigation levels and methods.

**Study design:**The experiment was laid out in randomized block design with different irrigation levels and methods replicated thrice.

**Place and Duration of Study:**AICRP on Groundnut, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during summer ~~season of~~ 2021.

**Methodology:**We took 11 treatments involving different level and methods of irrigation using eight micro-sprinkler treatments, one drip fertigation treatment and two flood irrigation treatments. ~~We carried out laboratory analysis of the soil samples for soil nutrient status and nutrient uptake of the crop after harvest.~~

**Results:**Significantly higher total nitrogen, phosphorus and potassium uptake were recorded with drip irrigation applied at 0.6 ET<sub>0</sub> at Seedling, 1.0 ET<sub>0</sub> at Flowering, 1.25 ET<sub>0</sub> at Pegging, 0.8 ET<sub>0</sub> at Pod formation stages along with fertigation of N and P [3 splits at NF on 3rd, 4th and 5th week] and CaNO<sub>3</sub> and S nutrients [3 splits at PGF on 7th, 8th and 9th week] (164.0, 27.6 and 129.3 kg ha<sup>-1</sup>, respectively) and was 40.0, 55.43 and 25.91 per cent higher compared to control (Flood FAO). Same treatment enhanced the soil chemical properties like pH, EC and organic carbon by 1.04, 16.12 and 7.40 per cent compared to control.

**Conclusion:**Drip irrigation and fertigation enhanced nutrient uptake of groundnut and available soil nutrient status and also improved soil chemical properties as compared to control (Flood irrigation). So, this method can be proved beneficial in reducing the nutrient requirement of the crop under cultivation in the Northern Transitional Zone of Karnataka.

**Comment [h2]:** Complete the sentence by adding line given below after word 'method'

at Northern Transitional Zone of Karnataka.

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After harvesting soil nutrient status and nutrient uptake from the soil were analyzed.

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**Keywords:** Drip, micro-sprinkler, groundnut, nutrient uptake

## 7 1. INTRODUCTION

8

9 Oilseed crops are the second most important determinant of agricultural economy, next only  
10 to cereals within the segment of field crops. In India, groundnut (*Arachishypogaea* L.) is a  
11 significant oilseed and supplemental food crop. When it comes to sources of vegetable  
12 protein (26%) and edible oil (46–51%), groundnut is the third most significant crop. On an  
13 equivalent basis, groundnuts have 2.5 times more protein than eggs and 2 times more than  
14 beef. Groundnut also has a good supply of calcium, phosphorus, iron, zinc, and boron. In  
15 addition to being high in calories, groundnuts also provide minor levels of vitamin B complex  
16 and vitamin E. Because of these qualities, groundnut is referred to as the "King of Oilseeds".  
17 Globally, Groundnut covers 32.7 million hectares with the production of 53.9 million tonnes  
18 with the productivity of 1648 kg per hectare (FAOSTAT, 2021) [1]. India produced 87 lakh  
19 tons of groundnut from an area of 57.05 lakh hectares with an average productivity of 1500  
20 kg per hectare during 2021-22 (USDA, 2023) [2].

Comment [h4]: Add appropriate reference.

21 Soil moisture is the key limiting factor for the higher yield of groundnut during dry seasons.  
22 Therefore, there is need for effective strategies to maximize the water use efficiency from the  
23 limited water utilized for the crop growth. Among the other issues, indiscriminate use of  
24 water and chemical fertilizers has led to environmental issues, such as groundwater  
25 contamination and atmospheric nitrous oxide release. So, proper management of water and  
26 nutrients in essential in dry arid and semi-arid regions.

27 Micro-irrigation has been widely investigated as a valuable and sustainable production  
28 strategy in dry regions. Drip or trickle irrigation is a type of micro irrigation system that has  
29 the potential to save water and nutrients by allowing water to drip slowly to the roots of plant.  
30 At various crop growth phases, drip-based fertigation offers a range of diverse nutrient  
31 treatments. Additionally, periodic fertigation applications of the nutrients ensure continual  
32 nutritional availability. The potential yield of groundnuts can be increased while conserving

33 water and nutrients by strategically applying water at important physiological growth phases  
34 in response to moisture constraint throughout the summer (Patra *et al.*, 1998)[3].

35 So, keeping in view the above facts, the present experiment was planned and carried out to  
36 study the nutrient uptake and available soil nutrient status after crop harvest under different  
37 irrigation treatments.

## 38 2. MATERIAL AND METHODS

39 The experiment was carried out at AICRP on Groundnut, University of Agricultural Sciences,  
40 Dharwad. The experimental site is located at 15029'47.4" N latitude and 74059'32.1" E  
41 longitude and at an altitude of 678 m above mean sea level. Dharwad comes under Northern  
42 Transition Zone (Zone-VIII) of Karnataka which lies between the Western Hilly Zone (Zone-  
43 IX) and Northern Dry Zone (Zone-III).

44 Monthly maximum (35.4<sup>o</sup>C) and minimum temperature (15.2<sup>o</sup>C) was noticed during April  
45 and February months, respectively. Rainfall received during the cropping period of  
46 groundnut (28<sup>th</sup> Jan 2021 to 30<sup>th</sup> May, 2021) was 245.6 mm and effective rainfall was 115.2  
47 mm during different phenological stages. Maximum evaporation during the cropping period  
48 was in the month of March (205.6 mm) and minimum evaporation was in the month of (120.1  
49 mm).

50 Soil was clay in texture with basic pH (7.62), electrical conductivity of 0.30 dS m<sup>-1</sup>, low in  
51 available nitrogen (258.7 kg ha<sup>-1</sup>), medium in available P<sub>2</sub>O<sub>5</sub> (29.8 kg ha<sup>-1</sup>) and high  
52 available K<sub>2</sub>O (334.9 kg ha<sup>-1</sup>).

53 The experiment was laid out in randomized block design having eight micro-sprinkler  
54 irrigation treatments viz. T1- Sprinkler method (50 mm depth of irrigation at all stages except  
55 60 mm depth at 50 and 60 DAS), T2- 80% of T1 Treatment, T3- 70% of T1 Treatment, T4-  
56 60% of T1 Treatment, T5- 50% of T1 Treatment, T6- 70% of T1 Treatment + Foliar

**Comment [h5]:** Introduction is well written yet it lacks focus on the problem, its approach adopted for the solution and its justification. Slight revision in the last part of it would improve the interpretation.

1. Add some results/refrences of yield data of groundnuts under sprinkler and flood irrigation.
2. its better to citepapers of last 10-15 years.

**Comment [h6]:** Correctly write latitude and logitude N 15° 29' 44.23", E 74° 58' 57.28"

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**Comment [h7]:** Complete the sentence.

**Comment [h8]:** Add word 'Phosphorous'

**Comment [h9]:** Add word 'Potassium'

57 application of 0.5% KNO<sub>3</sub> at 50 DAS, T7- 60% of T1 Treatment + Foliar application of 0.5%  
 58 KNO<sub>3</sub> at 40 and 60 DAS, T8- 50% of T1 Treatment + Foliar application of 0.5% KNO<sub>3</sub> at 30,  
 59 50 and 70 DAS, one drip irrigation treatment viz. Drip method of irrigation at 0.6 ET<sub>0</sub>  
 60 (Seedling), 1.0 ET<sub>0</sub> (Flowering), 1.25 ET<sub>0</sub> (Pegging) and 0.8 ET<sub>0</sub> (Pod formation) +  
 61 fertigation of N and P [3 splits at nodule formation on 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> week] + CaNO<sub>3</sub> and S  
 62 nutrients [3 splits at peg formation on 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> week] and two flood irrigation treatments  
 63 viz. Flood irrigation at 0.45 ET<sub>0</sub> (Seedling), 0.75 ET<sub>0</sub> (Flowering), 1.05 ET<sub>0</sub> (Pegging), 0.70  
 64 ET<sub>0</sub> (Pod Formation) (FAO) and irrigation as per UAS POP (Irrigating at 25,40,55,70,and 85  
 65 DAS at 60 mm depth) replicated thrice. Irrigation in drip plots was done based on actual  
 66 evapotranspiration at 4 days interval. Irrigation was applied as per treatments based on  
 67 deficit water supply at 15, 30, 40, 50, 60, 70, 80 and 90 days after emergence (DAE) in  
 68 micro-sprinkler irrigated plots. In flood irrigation as per FAO recommendation, irrigation was  
 69 provided based on actual evapotranspiration depending on growth stage and in flood  
 70 irrigation as per UAS package of practice, irrigation was provided at 25, 40, 55, 70 and 85  
 71 DAS with 60 mm depth at each irrigation. The irrigation provided uniformly to all treatments  
 72 up to establishment. There was continuous rainfall from 10<sup>th</sup> April till harvest, so, irrigation  
 73 was either skipped or adjusted as per treatment requirement.  
 74 The actual evapotranspiration was calculated by using the following formula given by  
 75 Choudhary and Kadam (2006) [4] as, ET<sub>0</sub> = K<sub>p</sub> × E<sub>p</sub>, where, ET<sub>0</sub>= Actual evapotranspiration,  
 76 K<sub>p</sub>= Pan coefficient (0.70) and E<sub>p</sub>= Daily pan evaporation (mm)  
 77 Groundnut variety 'KadiriLepakshi' was sown using 125 kg/ha seed rate sown at a spacing  
 78 of 30 cm x 10 cm (Row to row: 30 cm and plant to plant: 10 cm). Two weeks prior to sowing,  
 79 farm yard manure at 7.5 t ha<sup>-1</sup> was administered to all treatments. According to the  
 80 recommended package of practice (RPP), all the treatment plots received a basal  
 81 application of N, P, and K (25 kg N, 46 kg P<sub>2</sub>O<sub>5</sub> and 25 kg K<sub>2</sub>O ha<sup>-1</sup>) as well as gypsum at  
 82 flowering and pegging stages with 500 kg ha<sup>-1</sup>. Fertigation of fertigation of N and P [3 splits  
 83 at NF on 3rd, 4th, and 5th week] and 3 splits of Calcium and Sulphur at peg formation stage

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Comment [h10]: Add complete reference in reference section

Comment [h11]: Add complete reference in reference section

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Comment [h12]: In section Material Methods, Line number 46, you have told that there is 115 mm effective rainfall has happend in total cropping period, here you are saying that there is a continuous rainfall from April till harvest.

Check both of the statements and revise accordingly.

I suggest you to either mention here the data of effective rainfall from 10th April to till harvest or delete this line.

Comment [h13]: Replace the word 'administered, with 'applied'

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Comment [h14]: ?

84 (on 7th, 8th, and 9th week) in the form of water soluble forms of  $\text{Ca}(\text{NO}_3)_2$  and sulphur  
 85 granules by hand application are used for drip plots.

## 86 2.1. Nutrient uptake

87 Dried plant samples were powdered in a Willey mill and passed through 40-mesh sieve to  
 88 considerable fineness before storing them in polythene bags for further analysis. The  
 89 nutrient uptake was calculated using the following formula and expressed in kilogram per  
 90 hectare.

**Comment [h15]:** Write in two three lines of sampling process of plant.

**Comment [h16]:** Add appropriate refence of given formula.

$$91 \text{ Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%)} \times \text{Total biomass (kg ha}^{-1}\text{)}}{100}$$

93 **Table 1. Methods of soil analysis in laboratory:**

Parameters	Methods	References
pH	pH meter	Piper, 1962 [5]
EC ( $\text{dSm}^{-1}$ )	Conductivity method	Jackson, 1973 [6]
Soil organic carbon (%)	Wet oxidation method	Walkley and Black (Jackson, 1973) [6]
Available N ( $\text{kg ha}^{-1}$ )	Alkaline $\text{KMnO}_4$ distillation method	Saharawat and Buford (1982) [7]
Available $\text{P}_2\text{O}_5$ ( $\text{kg ha}^{-1}$ )	Olsen's method ( <del>Sparks, 1996</del> )	Jackson, 1973[6]
Available $\text{K}_2\text{O}$ ( $\text{kg ha}^{-1}$ )	Flame photometer method ( <del>Sparks, 1996</del> )	Jackson, 1973 [6]

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## 95 2.2. Statistical analysis

96 Plant and soil samples were analyzed in laboratory and plant nutrient uptake and soil  
97 nutrient status were estimated and subjected to statistical analysis by adopting Fischer's  
98 method of analysis of variance and the mean values of treatments were then subjected to  
99 Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) [8]. The critical difference  
100 values given in the table at 5 per cent level of significance were used.

**Comment [h17]:** Plant and soil sampling play a very important role in calculation of nutrient status, as your paper mainly focusing on nutrient status and nutrient uptake, so i suggest you to describe in detail of sampling timing and process for better understanding.

### 3. RESULTS AND DISCUSSION

#### 3.1. NUTRIENT UPTAKE

The results on nutrient uptake presented in ~~table~~ Table 2 reveal that significantly higher total nitrogen, phosphorus and potassium uptake were recorded with drip irrigation applied at 0.6 ET<sub>0</sub> at seedling, 1.0 ET<sub>0</sub> at flowering, 1.25 ET<sub>0</sub> at pegging, 0.8 ET<sub>0</sub> at pod formation stages along with fertigation of N and P [3 splits at NF on 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> week] and CANO<sub>3</sub> and s nutrients [3 splits at PGF on 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> week] (164.0, 27.6 and 129.3 kg ha<sup>-1</sup>, respectively) and was 40.0, 55.43 and 25.91 per cent higher compared to control (flood FAO) and 22.26, 24.27 and 13.53 per cent higher compared to sprinkler with 50 mm irrigation depth (Table 2). Similarly, providing irrigation at 100 % ET<sub>0</sub> to groundnut significantly increased the total nitrogen uptake (232.84 kg ha<sup>-1</sup>), total phosphorus uptake (23.66 kg ha<sup>-1</sup>) and total potassium uptake (87.79 kg ha<sup>-1</sup>) by the crop was reported by Shinde (2020) [9]. Similar results were reported by Chandini *et al.* (2022) [10] who found that significantly higher N, P and K uptake of plant (104.2, 11.8 and 54.3 kg ha<sup>-1</sup>, respectively) was recorded with irrigation scheduled at IW/CPE ratio of 1.0 along with KadiriLepakshi compared to the other treatments. This was in conformity with the results reported by Sanjuet *et al.* (2014) [11], Maurya *et al.* (2017) [12] Jain *et al.* (2018) [13].

**Comment [h18]:** Correct spelling 'that'

**Comment [h19]:** Put in a bracket (T9)

**Comment [h20]:** Rewrite the lines

The results on nutrient uptake presented in Table 2. It has been observed that significantly higher uptake of total nitrogen, phosphorus and potassium uptake under drip irrigation treatment, T<sub>3</sub> [i.e irrigation applied on 0.6 ET<sub>0</sub> at seedling, 1.0 ET<sub>0</sub> at flowering, 1.25 ET<sub>0</sub> at pegging, 0.8 ET<sub>0</sub> at pod formation stages along with fertigation of N and P (3 splits at NF on 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> week) and CANO<sub>3</sub> and s nutrients (3 splits at PGF on 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> week)] as 164.0, 27.6 and 129.3 kg ha<sup>-1</sup>, respectively.

**Comment [h21]:** Check the calculation

And rewrite the line as

It was 66.67, 122.58 and 34.97 per cent higher compared to control treatment T<sub>10</sub> (flood FAO) and 28.63, 32.06 and 15.65 per cent higher compared to treatment T<sub>1</sub> (sprinkler with 50 mm irrigation depth)

**Comment [h22]:** As your paper is comparing three irrigation methods, so i suggest you to put irrigation method name along with Etc %.

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**TABLE 2. EFFECT OF DIFFERENT IRRIGATION LEVELS AND METHODS ON MAJOR NUTRIENT UPTAKE OF GROUNDNUT AT HARVEST**

Treatments	Major nutrient uptake (kg ha <sup>-1</sup> )			Total nutrient (NPK) uptake (kg ha <sup>-1</sup> )
	N	P	K	
T <sub>1</sub>	127.5 <sup>b</sup>	20.9 <sup>b</sup>	111.8 <sup>b</sup>	260.2 <sup>b</sup>
T <sub>2</sub>	121.3 <sup>bc</sup>	19.0 <sup>bc</sup>	108.6 <sup>b</sup>	248.9 <sup>bc</sup>
T <sub>3</sub>	115.2 <sup>bcde</sup>	16.9 <sup>cd</sup>	104.2 <sup>bc</sup>	236.3 <sup>cde</sup>
T <sub>4</sub>	105.9 <sup>def</sup>	15.5 <sup>d</sup>	101.8 <sup>bc</sup>	223.2 <sup>ef</sup>
T <sub>5</sub>	97.4 <sup>f</sup>	12.2 <sup>e</sup>	93.4 <sup>c</sup>	203.0 <sup>g</sup>
T <sub>6</sub>	119.5 <sup>bcd</sup>	19.1 <sup>bc</sup>	109.7 <sup>b</sup>	248.3 <sup>bc</sup>
T <sub>7</sub>	114.8 <sup>bcde</sup>	18.2 <sup>c</sup>	107 <sup>b</sup>	240.0 <sup>cd</sup>
T <sub>8</sub>	109.7 <sup>cdef</sup>	17.1 <sup>cd</sup>	101.5 <sup>bc</sup>	228.3 <sup>de</sup>
T <sub>9</sub>	164 <sup>a</sup>	27.6 <sup>a</sup>	129.3 <sup>a</sup>	320.9 <sup>a</sup>
T <sub>10</sub>	98.4 <sup>f</sup>	12.4 <sup>e</sup>	95.8 <sup>c</sup>	206.6 <sup>g</sup>
T <sub>11</sub>	100.4 <sup>ef</sup>	12.3 <sup>e</sup>	96.2 <sup>c</sup>	208.9 <sup>fg</sup>
S.Em±	4.6	0.7	3.3	5.2

T<sub>1</sub>-Sprinkler irrigation (SI) (50 mm except 60 mm at 50 and 60 DAS)

T<sub>2</sub>-SI (40 mm except 48 mm at 50 and 60 DAS) i.e. 80 % of T<sub>1</sub>

T<sub>3</sub>-SI (35 mm except 42 mm at 50 and 60 DAS) i.e. 70 % of T<sub>1</sub>

T<sub>4</sub>-SI (30 mm except 35 mm at 50 and 60 DAS) i.e. 60 % of T<sub>1</sub>

T<sub>5</sub>-SI (25 mm except 30 mm at 50 and 60 DAS) i.e. 50 % of T<sub>1</sub>

T<sub>6</sub>-SI (35 mm except 42 mm at 50 and 60 DAS) + FA of 0.5 % KNO<sub>3</sub> at 50 DAS

T<sub>7</sub>-SI (30 mm except 25 mm at 50 and 60 DAS)+ FA of 0.5 % KNO<sub>3</sub> at 40 and 60 DAS

T<sub>8</sub>-SI (25 mm except 30 mm at 50 and 60 DAS)+ FA of 0.5 % KNO<sub>3</sub> at 30, 50 and 70 DAS

T<sub>9</sub>-DI at 0.6 ET<sub>0</sub> (S), 1.0 ET<sub>0</sub> (F), 1.25 ET<sub>0</sub> (P) and 0.8 ET<sub>0</sub> (PF) + fertigation of N and P [ 3 splits at NF on 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> week] + CaNO<sub>3</sub> and S nutrients [3 splits at PGF on 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> week]

T<sub>10</sub>-Flood irrigation at 0.45 ET<sub>0</sub> (S), 0.75 ET<sub>0</sub> (F), 1.05 ET<sub>0</sub> (P), 0.70 ET<sub>0</sub> (PF) (FAO recommendation)

T<sub>11</sub>-Irrigation as per UAS POP (Irrigating at 25, 40, 55, 70 and 85 DAE at 60mm depth)

SI= Sprinkler Irrigation; FA= Foliar Application; DI= Drip Irrigation; S = Seedling; F = Flowering; P= Pегging; PF = Pod Formation; NF = Nodule formation; PGF= Peg formation

Higher nutrient uptake in drip irrigation with fertigation was mainly due to application of controlled water near the crop root zone thus providing conditions for vigorous root development which helped in better water and nutrient uptake by the crop and higher root initiation with three equal splits caused significant differences in nutrient uptake pattern. This is due to the split application of nutrients, which may have improved the solubility of nutrients, leading to better nutrient availability in the crop root zone and resulted in higher root activity and thus improving nutrient uptake.

Among the sprinkler treatments, nutrient uptake was significantly lower in case of treatment receiving 25 mm irrigation depth (97.4, 12.2 and 93.4 kg ha<sup>-1</sup> nitrogen, phosphorus and potassium uptake, respectively) and the per cent decrease from sprinkler irrigation with 50 mm irrigation depth was 23.6, 41.6 and 16.5 per cent for nitrogen, phosphorus and potassium uptake. Similarly, Metiet *et al.* (2004) [14] reported that nitrogen, phosphorus, potassium and sulphur uptake increased from 88.64 to 191.17 kg N ha<sup>-1</sup>, 8.34 to 9.05 kg P ha<sup>-1</sup>, 60.59 to 65.34 kg K ha<sup>-1</sup> and 8.86 to 10.01 kg S ha<sup>-1</sup>, respectively by increasing water application rate through irrigation scheduling at 0.8 to 1.0 IW/CPE ratio. This was due to lower water availability in crop root zone reducing nutrient mobility and uptake by the crop plant. However, sprinkler treatments with foliar spray of KNO<sub>3</sub> performed better in terms of nutrient uptake.

### 3.2. Soil chemical properties and available nutrient status after harvest of groundnut

#### 3.2.1. Soil chemical properties

The soil pH, electrical conductivity (EC) and organic carbon content did not differ significantly under different irrigation levels at harvest of groundnut. However, pH ranged from 7.63 to 7.71, EC from 0.26 to 0.31 dS m<sup>-1</sup> and soil organic carbon content from 5.0 to 5.4 mg kg<sup>-1</sup> (Table 3). However, ~~treatment T<sub>4</sub> drip irrigation applied at 0.6 ET<sub>0</sub> at Seedling, 1.0 ET<sub>0</sub> at Flowering, 1.25 ET<sub>0</sub> at Pegging, 0.8 ET<sub>0</sub> at Pod formation stages along with fertigation of N and P [3 splits at NF on 3rd, 4th and 5th week] and CaNO<sub>3</sub> and S nutrients [3 splits at PGF on 7th, 8th and 9th~~

**Comment [h23]:** Note among the sprinkler treatments from T<sub>1</sub> to T<sub>8</sub>, T<sub>5</sub> is not significantly lower in individual uptake of N, P and K.

Statement of significantly lower of treatment T<sub>5</sub> among all sprinkler irrigated treatment is valid in case of (total nutrient uptake values)

So I suggest to rewrite the line in form of total nutrient uptake as

Among the sprinkler treatments, total nutrient uptake was significantly lower in case of treatment T<sub>5</sub> (25 mm irrigation depth) as 203 kg ha<sup>-1</sup>, and it was 21.98% lower as compared to the treatment T<sub>1</sub> (50 mm irrigation depth) as 260.2 kg ha<sup>-1</sup>.

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~~week~~ recorded numerically higher soil chemical properties and enhanced the pH, EC and organic carbon by 1.04, 16.12 and 7.40 per cent respectively compared to ~~control~~ treatment T<sub>10</sub> which indicated the role of drip fertigation in enhancing chemical properties of soil. Higher soil organic carbon in the drip fertigation treatment was due to the increasing availability of N, P and K in soil with congenial soil moisture regime as a result of drip fertigation which might have increased the soil microbial activity leading to increased levels of soil organic carbon (Salvin, 1999 [15]; Kavino *et al.*, 2004 [16]).

#### 3.2.4 Available nutrient status in soil (kg ha<sup>-1</sup>)

The data pertaining to available major nutrients (nitrogen, phosphorus and potassium) in soil after ~~at~~ harvest of groundnut as influenced by different levels of irrigation are given in Table 4.

The influence of different irrigation levels had failed to show significant difference on soil available nitrogen, phosphorus and potassium after harvest. However, it ranged from 255.73 to 283.62 kg ha<sup>-1</sup> for nitrogen. Whereas, it ranged from 28.47 to 29.84 kg ha<sup>-1</sup> for available phosphorus and range of soil available potassium was 350.39 to 355.49 kg ha<sup>-1</sup> for different treatments after harvest of the crop. Similarly, Saha and Gunri (2014) [17] noticed that irrigation scheduling at 1.0 IW/CPE ratio in summer groundnut recorded significantly higher available soil nitrogen (445.38 kg ha<sup>-1</sup>) compared to irrigation regimes of 0.8 and 0.6 IW/CPE ratio.

Available nitrogen, phosphorus and potassium in soil at harvest of groundnut did not differ significantly due to different irrigation levels. However, major nutrient availability was numerically higher with drip ~~irrigation-irrigated treatment T<sub>4</sub>~~ applied at 0.6 ET<sub>0</sub> (S), 1.0 ET<sub>0</sub> (F), 1.25 ET<sub>0</sub> (P), 0.8 ET<sub>0</sub> (PF) stages i.e., 7.87, 4.26 and 1.35 per cent higher compared to control treatment T<sub>10</sub> (Flood FAO) (Table 4). This was mainly due to split of application of nitrogen, phosphorus and potassium in drip fertigation treatment.

**Comment [h24]:** You have only one drip irrigated treatment i.e. T9, there is no need to write every time a treatment detail, it creates a confusion. Just simply write treatment number as T9 .....likewise

**Comment [h25]:** Check the calculation  
It should be 1.04, 19.23 and 8.0 respectively.

**Comment [h26]:** What is your control treatment? Is it T10 or T11.

Write clearly

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**Comment [h27]:** Your data showed non significant results of available NPK after harvest.

Here your cross reference showed different results. Please check and correct accordingly.

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**Comment [h28]:** Check the calculation it should be

8.54, 4.45, 1.37%

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**TABLE 3. EFFECT OF DIFFERENT IRRIGATION LEVELS AND METHODS ON SOIL PH, ELECTRICAL CONDUCTIVITY (EC) AND ORGANIC CARBON (OC) AFTER HARVEST OF GROUNDNUT**

Treatments	pH	EC (d Sm <sup>-1</sup> )	OC (mg kg <sup>-1</sup> )
T <sub>1</sub>	7.70 <sup>a</sup>	0.31 <sup>a</sup>	5.3 <sup>a</sup>
T <sub>2</sub>	7.68 <sup>a</sup>	0.30 <sup>a</sup>	5.2 <sup>a</sup>
T <sub>3</sub>	7.67 <sup>a</sup>	0.28 <sup>a</sup>	5.1 <sup>a</sup>
T <sub>4</sub>	7.66 <sup>a</sup>	0.27 <sup>a</sup>	5.0 <sup>a</sup>
T <sub>5</sub>	7.64 <sup>a</sup>	0.27 <sup>a</sup>	5.0 <sup>a</sup>
T <sub>6</sub>	7.67 <sup>a</sup>	0.28 <sup>a</sup>	5.2 <sup>a</sup>
T <sub>7</sub>	7.66 <sup>a</sup>	0.28 <sup>a</sup>	5.2 <sup>a</sup>
T <sub>8</sub>	7.64 <sup>a</sup>	0.28 <sup>a</sup>	5.0 <sup>a</sup>
T <sub>9</sub>	7.71 <sup>a</sup>	0.31 <sup>a</sup>	5.4 <sup>a</sup>
T <sub>10</sub>	7.63 <sup>a</sup>	0.26 <sup>a</sup>	5.0 <sup>a</sup>
T <sub>11</sub>	7.64 <sup>a</sup>	0.26 <sup>a</sup>	5.0 <sup>a</sup>
<b>S.Em±</b>	<b>0.13</b>	<b>0.02</b>	<b>0.32</b>

T<sub>1</sub>- Sprinkler irrigation (SI) (50 mm except 60 mm at 50 and 60 DAS)

T<sub>2</sub>- SI (40 mm except 48 mm at 50 and 60 DAS) i.e. 80 % of T<sub>1</sub>

T<sub>3</sub>-SI (35 mm except 42 mm at 50 and 60 DAS) i.e. 70 % of T<sub>1</sub>

T<sub>4</sub>-SI (30 mm except 35 mm at 50 and 60 DAS) i.e. 60 % of T<sub>1</sub>

T<sub>5</sub>-SI (25 mm except 30 mm at 50 and 60 DAS) i.e. 50 % of T<sub>1</sub>

T<sub>6</sub>-SI (35 mm except 42 mm at 50 and 60 DAS) + FA of 0.5 % KNO<sub>3</sub> at 50 DAS

T<sub>7</sub>-SI (30 mm except 25 mm at 50 and 60 DAS)+ FA of 0.5 % KNO<sub>3</sub> at 40 and 60 DAS

T<sub>8</sub>-SI (25 mm except 30 mm at 50 and 60 DAS)+ FA of 0.5 % KNO<sub>3</sub> at 30, 50 and 70 DAS

T<sub>9</sub>-DI at 0.6 ET<sub>0</sub> (S), 1.0 ET<sub>0</sub> (F), 1.25 ET<sub>0</sub> (P) and 0.8 ET<sub>0</sub> (PF) + fertigation of N and P [3 splits at NF on 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> week] + CaNO<sub>3</sub> and S nutrients [3 splits at PGF on 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> week]

T<sub>10</sub>-Flood irrigation at 0.45 ET<sub>0</sub> (S), 0.75 ET<sub>0</sub> (F), 1.05 ET<sub>0</sub> (P), 0.70 ET<sub>0</sub> (PF) (FAO recommendation)

T<sub>11</sub>-Irrigation as per UAS POP (Irrigating at 25, 40, 55, 70 and 85 DAE at 60mm depth)

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~~SI= Sprinkler Irrigation; FA= Foliar Application; DI= Drip Irrigation; S = Seedling; F = Flowering; P= Pegging; PF = Pod Formation; NF = Nodule formation; PGF= Peg formation~~

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**TABLE 4. EFFECT OF DIFFERENT IRRIGATION LEVELS AND METHODS ON AVAILABLE NUTRIENTS AFTER HARVEST OF GROUNDNUT**

Treatments	N (kg ha <sup>-1</sup> )	P (kg ha <sup>-1</sup> )	K (kg ha <sup>-1</sup> )
T <sub>1</sub>	280.82 <sup>ab</sup>	29.74 <sup>a</sup>	354.83 <sup>a</sup>
T <sub>2</sub>	278.33 <sup>ab</sup>	29.37 <sup>a</sup>	353.79 <sup>a</sup>
T <sub>3</sub>	269.67 <sup>ab</sup>	29.07 <sup>a</sup>	352.73 <sup>a</sup>
T <sub>4</sub>	264.10 <sup>ab</sup>	28.64 <sup>a</sup>	351.85 <sup>a</sup>
T <sub>5</sub>	255.73 <sup>b</sup>	28.47 <sup>a</sup>	350.39 <sup>a</sup>
T <sub>6</sub>	272.46 <sup>ab</sup>	29.20 <sup>a</sup>	352.79 <sup>a</sup>
T <sub>7</sub>	269.67 <sup>ab</sup>	28.98 <sup>a</sup>	351.86 <sup>a</sup>
T <sub>8</sub>	264.09 <sup>ab</sup>	28.57 <sup>a</sup>	350.86 <sup>a</sup>
T <sub>9</sub>	283.62 <sup>a</sup>	29.84 <sup>a</sup>	355.49 <sup>a</sup>
T <sub>10</sub>	261.30 <sup>ab</sup>	28.57 <sup>a</sup>	350.69 <sup>a</sup>
T <sub>11</sub>	264.09 <sup>ab</sup>	28.74 <sup>a</sup>	351.00 <sup>a</sup>
<b>S.Em±</b>	<b>7.36</b>	<b>0.78</b>	<b>5.55</b>

T<sub>1</sub> -Sprinkler irrigation (SI) (50 mm except 60 mm at 50 and 60 DAS)

T<sub>2</sub> -SI (40 mm except 48 mm at 50 and 60 DAS) i.e. 80 % of T<sub>1</sub>

T<sub>3</sub> -SI (35 mm except 42 mm at 50 and 60 DAS) i.e. 70 % of T<sub>1</sub>

T<sub>4</sub> -SI (30 mm except 35 mm at 50 and 60 DAS) i.e. 60 % of T<sub>1</sub>

T<sub>5</sub> -SI (25 mm except 30 mm at 50 and 60 DAS) i.e. 50 % of T<sub>1</sub>

T<sub>6</sub> -SI (35 mm except 42 mm at 50 and 60 DAS) + FA of 0.5 % KNO<sub>3</sub> at 50 DAS

T<sub>7</sub> -SI (30 mm except 25 mm at 50 and 60 DAS)+ FA of 0.5 % KNO<sub>3</sub> at 40 and 60 DAS

T<sub>8</sub> -SI (25 mm except 30 mm at 50 and 60 DAS)+ FA of 0.5 % KNO<sub>3</sub> at 30, 50 and 70 DAS

T<sub>9</sub> -DI at 0.6 ET<sub>0</sub> (S), 1.0 ET<sub>0</sub> (F), 1.25 ET<sub>0</sub> (P) and 0.8 ET<sub>0</sub> (PF) + fertigation of N and P [3 splits at NF on 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> week] + CaNO<sub>3</sub> and S nutrients [3 splits at PGF on 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> week]

T<sub>10</sub> -Flood irrigation at 0.45 ET<sub>0</sub> (S), 0.75 ET<sub>0</sub> (F), 1.05 ET<sub>0</sub> (P), 0.70 ET<sub>0</sub> (PF) (FAO recommendation)

T<sub>11</sub> - Irrigation as per UAS POP (Irrigating at 25, 40, 55, 70 and 85 DAE at 60mm depth)

SI= Sprinkler Irrigation; FA= Foliar Application; DI= Drip Irrigation; S = Seedling; F = Flowering; P= Pegging; PF = Pod Formation; NF = Nodule Formation; PGF= Peg Formation

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#### 4. CONCLUSION

From the present investigation, it can be concluded that highest nutrient uptake was recorded in drip irrigation and fertigation treatment and it was significantly higher than control flood irrigation. There was no significant differences among the treatments for soil chemical properties and available major nutrients in soil at harvest of groundnut but the values were numerically higher in drip fertigation treatment. So, micro-irrigation strategies, particularly, drip irrigation and fertigation can be a solution for improving crop nutrient uptake and improved nutrient status in soil thus reducing the use of excessive amount of water and nutrients in crops and help in improving crop productivity through optimized supply of resources in the crop root zone.

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**Comment [h31]:** Few references have not been written following the style of the journal. References should be corrected accordingly. Few references are missing while few are written but not cited in the MS. Authors may be suggested to update reference section according to journal guidelines.

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