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RESEARCH PAPER

Productivity and economics of summer groundnut (*Arachis hypogaea* L.) under pressurized irrigation

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Abstract: A field experiment was conducted during *summer* -2021 at AICRP on Groundnut, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The experiment was laid out in randomized complete block design having eleven treatments with micro-sprinkler, drip and flood irrigation methods each replicated thrice. Among the different treatments, drip irrigation with fertigation recorded significantly higher pod yield (4103 kg ha^{-1}) and showed 19.03 and 17.33 per cent higher yield over control (Flood irrigation). However, it was on par with sprinkler irrigation receiving 50 and 40 mm water in each irrigation and 35 mm water depth with and without foliar application of KNO_3. Amount of water applied in drip fertigation was 415.93 mm and it saved 10.59 per cent water over control (Flood, UAS recommendation). Maximum water saving of 37.84 per cent was, however, observed in sprinkler irrigation with 25 mm water compared to control. Drip irrigation with fertigation showed a net profit of Rs. 31,475 ha^{-1} and Rs. 27,830 ha^{-1} compared to control (Flood irrigation). However, it was on par with treatment with sprinkler irrigation treatments receiving 50 mm, 40 mm and 35 mm water in each irrigation with and without foliar application of KNO_3 for gross returns and with sprinkler irrigation receiving 50 mm, 40 mm, 35 mm and 30 mm water depth in each irrigation with and without foliar application of KNO_3 for net returns. It was concluded that, in Northern Transitional Zone of Karnataka, drip fertigation and micro-sprinkler irrigation performs better in terms of yield and returns in *summer* groundnut compared to conventional flood irrigation.

Key words: Drip irrigation, Fertigation, Micro-sprinkler, Water productivity

Introduction

Groundnut (*Arachis hypogaea* L.) is a tropical annual legume belonging to the family Fabaceae or Leguminosae, originated in South America. The scientific name *"Arachis hypogaea"* is derived from two Greek words *"Arachis"* meaning to legume and *"hypogaea"* meaning below ground, referring to the formation of pods in the soil. Groundnut is the fourth most important source of edible oil (51 per cent) and third most important source of high quality vegetable protein (28 per cent) and is also rich source of riboflavin, thiamine, nicotinic acid and vitamin E.Globally, India ranks first in acreage with annual all season coverage of about 61.00 lakh hectare, and with an output of about 99.52 lakh tonnes of shell groundnuts, second in production after China. Average productivity of groundnut in the country is 1,631 kg per hectare in (Anon, 2020). The water requirement of groundnut varies from 500 to 700 mm depending upon the climate as related to the development stages, the Kc value for the initial stage is 0.45-0.5 (15 to 35 days), the development stage 0.7-0.8 (30-45 days), the mid season-stage 0.95-1.1 (30 to 50 days), the late-season stage 0.7-0,8 (20-30 days) and at harvest 0.55-0.6 (Anon., 2015). Micro-irrigation has been widely investigated as a valuable and sustainable production strategy in dry regions. Drip or trickle irrigation is a type of micro irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plant.Even though groundnut is a fairly-drought tolerant crop, its production fluctuates considerably as a result of rainfall variability. This is because farmers are afraid of low yield due to scarcity of water during the lean season. The reason behind that the most of the area under groundnut is under rainfed and remain as an "unpredictable legume", showing inconsistency in pod and oil yield. Drip irrigation, however, promises to minimize the problem of water stress for crops under situation of severe water scarcity. In addition, a drip irrigation system is easy to use for fertigation,every crop nutrient requirement can be met with precision. Dueto surface irrigation there will be more vegetative growth, but in micro irrigation vegetative growth can be managed. To economize the use of water and to bring more area under irrigation, advanced method of irrigation like drip to groundnut crop is essential. Hence, the present investigation was planned with the objectives to study the effect of different levels of irrigation on yield of groundnut, to work out the optimum water requirement for groundnut under different levels of irrigation and finally to work out the economics.

Material and methods

A field experiment was conducted during *summer* -2021 at AICRP on Groundnut, Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad. The experiment was laid out in randomized block design with eight micro-sprinkler irrigation treatments *viz.* T_1- Sprinkler method (50 mm depth of irrigation at all stages except 60 mm depth at 50 and 60 DAS), T_2- 80% of T_1 Treatment, T_3- 70% of T_1 Treatment, T_4- 60% of T_1 Treatment, T_5- 50% of T_1 Treatment, T_6- 70% of T_1 Treatment + Foliar application of 0.5% KNO_3 at 50 DAS, T_7- 60% of T_1 Treatment + Foliar application of 0.5% KNO_3 at 40 and 60 DAS, T_8- 50% of T_1 Treatment + Foliar application of 0.5% KNO_3 at 30, 50 and 70 DAS, one drip irrigation treatment *viz.* Drip method of irrigation at 0.6 ET_0 (S), 1.0 ET_0 (F), 1.25 ET_0

(P) and 0.8 ET_0(PF) + fertigation of N and P [3 splits at NF on 3rd, 4th and 5th week] + $CaNO_3$ and S nutrients [3 splits at PGF on 7th, 8th and 9th week] and two flood irrigation treatments *viz*. Flood irrigation at 0.45 ET_0 (Seedling), 0.75 ET_0 (Flowering), 1.05 ET_0 (Pegging), 0.70 ET_0 (Pod Formation) (FAO) and irrigation as per UAS recommendation (Irrigating at 25, 40, 55, 70 and 85 DAS at 60 mm depth) replicated thrice as controls.

The groundnut seeds were hand dibbled and covered with soil in the experimental plot on 28th January, 2021 using Kadiri Lepakshi (K-1812). Irrigation was provided as per treatments based on deficit water supply at 15, 30, 40, 50, 60, 70, 80 and 90 days after emergence (DAE) in micro-sprinkler irrigated plots. Irrigation in drip plots was done based on actual evapotranspiration at 4 days interval. In flood irrigation as per FAO recommendation, irrigation was provided based on actual evapotranspiration depending on growth stage and in flood irrigation as per UAS package of practice, irrigation was provided at 25, 40, 55, 70 and 85 DAS with 60 mm depth at each irrigation. The irrigation provided uniformly to all treatments up to establishment. There was continuous rainfall from 10th April till harvest, so, irrigation was either skipped or adjusted as per treatment requirement.

The actual evapotranspiration was calculated by using the following formula given by Choudhary and Kadam (2006) as follows,

$ETo = Kp \times Ep$

Where,

ET_o= Actual evapotranspiration

Kp= Pan coefficient (0.70)

Ep= Daily pan evaporation (mm)

Hand weeding was done two times during the cropping period to keep weed free condition and fertilizer was applied to the groundnut as per recommended package of practices. Moisture percentage was recorded by gravimetric method before irrigation and used to calculate the quantity of water to be given.

Groundnut yield parameters like number of pods per plant and pod weight per plant was recorded at harvest. The shelling percentage was calculated by dividing the weight of kernels to weight of pods and expressed in percentage. Pod yield per plant was calculated from randomly selected five plants in each treatment and pod yield per hectare is worked out from the net plot yield.

The growth and yield parameters of groundnut recorded were analyzed with randomized block design. Growth and yield parameters of the experimental data obtained was compiled and subjected to statistical analysis by adopting Fischer's method of analysis of variance and the mean values of treatments were then subjected to Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984). The critical difference values at 5 per cent level of significance were used.

Results and discussion

Effect of irrigation levels and methods on pod yield and yield parameters

The groundnut yield was significantly higher in irrigation through drip at 0.6 ET_0(S), 1.0 ET_0(F), 1.25 ET_0 (P) and 0.8 ET_0 (PF) along with fertigation of N and P [3 splits at nodule formation on 3rd, 4th and 5th week] and $CaNO_3$ and S nutrients [3 splits at peg formation on 7th, 8th and 9th week] (4103 kg ha^{-1}) and showed 19.03 and 17.33 per cent higher yield as compared to control (Flood irrigation as per FAO and UAS POP, respectively) (Table 2). However, it was on par with treatment with sprinkler irrigation receiving 50 mm, 40 mm and 35 mm water in each irrigation and sprinkler irrigation with 35 mm in each irrigation along with spray of 0.5% KNO_3 at 50 DAS. Soni *et al.* (2017) also reported 45.6 % higher yield in drip irrigation at 100 % PE with fertigation at 100% RDF as WSF compared to control and Ranjitha *et al.* (2018) also reported 39.17 % higher yield in drip irrigation at 1.0 E pan compared to control (surface irrigation at 1.0 E pan). Similarly, Kumar *et al.* (2021) reported that application of KNO_3 @ 1 % spray at 45 DAS recorded significantly higher seed yield and stalk yield followed by KNO_3 @ 0.5 % spray at 45 DAS. Higher pod yield in these treatments was mainly due to higher availability of water near the root zone which helped in higher water and nutrient uptake and efficient translocation of photosynthates from source to sink which might have increased the growth and yield parameters ultimately resulting in higher pod yield. The response yield was of on par with 40 and 35 mm mainly due to good amount was rainfall received during later stages of crop growth i.e., pegging and pod formation stage might helped crop to perform better as that of drip method even though, growth parameters was significantly lower in early stages of crop growth. Among the sprinkler irrigation treatments, pod yield reduced subsequently with decrease in irrigation level and lower yield was recorded with sprinkler irrigation receiving 25 mm water in each irrigation (except 30 mm depth at 50 and 60 DAS) and showed 16.14 per cent yield reduction compared to sprinkler irrigation with 50 mm depth (Table 2). However, this reduction would be more magnitude if the rains were not received in later stages of crop growth. yield reduction by inducing stress in groundnut was also reported by Kumara (2017) and El-Metwally *et al.* (2020).

The key components contributing to yield of groundnut are number of pods per plant, pod weight per plant, 100 kernel weight and shelling percentage. All yield parameters *viz*. number of pods per plant (29.85) and pod weight per plant (26.70 g) were significantly higher in treatment receiving fertigation through drip (Table 2) and the per cent increase in yield parameters were 14.34 and 12.02 per cent for pod weight per plant and 19.76 and 19.26 per cent for number of pods per plant over control flood (FAO and UAS POP, respectively). However, results were on par with treatment with sprinkler irrigation treatments receiving 50 mm and 40 mm water in each irrigation and sprinkler irrigation receiving 35 mm water in each irrigation along with foliar application of 0.5% KNO_3 at 50 DAS in case of

Table 1. Effect of different levels and methods of irrigation on total water applied, number of irrigations and water saving in groundnut

Particulars	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}
Total rainfall received (mm)	245.60	245.60	245.60	245.60	245.60	245.60	245.60	245.60	245.60	245.60	245.60
Effective Rainfall *(mm)	115.20	115.20	115.20	115.20	115.20	115.20	115.20	115.20	115.20	115.20	115.20
Total number of irrigations	7	6	6	6	6	6	6	6	12	11	5
Water through drip (mm)	-	-	-	-	-	-	-	-	300.75	-	-
Sprinkler (mm)	344.81	269.96	237.96	205.96	173.96	237.96	205.96	173.96	-	-	-
Flood irrigation (mm)	-	-	-	-	-	-	-	-	-	244.00	350
Total water applied (mm) (Rainfall + Amount of water applied)	590.41	542.56	483.56	451.56	419.56	483.56	451.56	419.56	546.35	489.60	595.60
Total water applied (mm) (Effective rainfall + Amount of water applied)	459.99	385.14	353.14	321.14	289.14	353.14	321.14	289.14	415.93	359.18	465.18
Percentage water saving	1.12	17.19	24.08	30.96	37.84	24.08	30.96	37.84	10.59	22.79	-

*Calculation of effective rainfall: $Re= 0.0011 P^2 + 0.4422 P$ Re= Effective rainfall; P= Precipitation

T_1 - Sprinkler irrigation (SI) (50 mm except 60 mm at 50 and 60 DAS)
T_2 - SI (40 mm except 48 mm at 50 and 60 DAS)
T_3 - SI (35 mm except 42 mm at 50 and 60 DAS)
T_4 - SI (30 mm except 35 mm at 50 and 60 DAS)
T_5 - SI (25 mm except 30 mm at 50 and 60 DAS)
T_6 - SI (35 mm except 42 mm at 50 and 60 DAS) + FA of 0.5% KNO_3 at 50 DAS
T_7 –SI (30 mm except 25 mm at 50 and 60 DAS) + FA of 0.5% KNO_3 at 40 and 60 DAS
T_8 - SI (25 mm except 30 mm at 50 and 60 DAS) + FA of 0.5% KNO_3 at 30, 50 and 70 DAS
T_9 - DI at 0.6 ET_0 (S), 1.0 ET_0 (F), 1.25 ET_0 (P) and 0.8 ET_0 (PF) + fertigation of N and P [3 splits at NF on 3rd, 4th and 5th week] + $CaNO_3$ and S nutrients [3 splits at PGF on 7th, 8th and 9th week]
T_{10} -Flood irrigation at 0.45 ET_0 (S), 0.75 ET_0 (F), 1.05 ET_0 (P), 0.70 ET_0 (PF) (FAO recommendation)
T_{11} - Irrigation given as per UAS recommendation (Irrigating at 25, 40, 55, 70 and 85 DAE at 60 mm 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

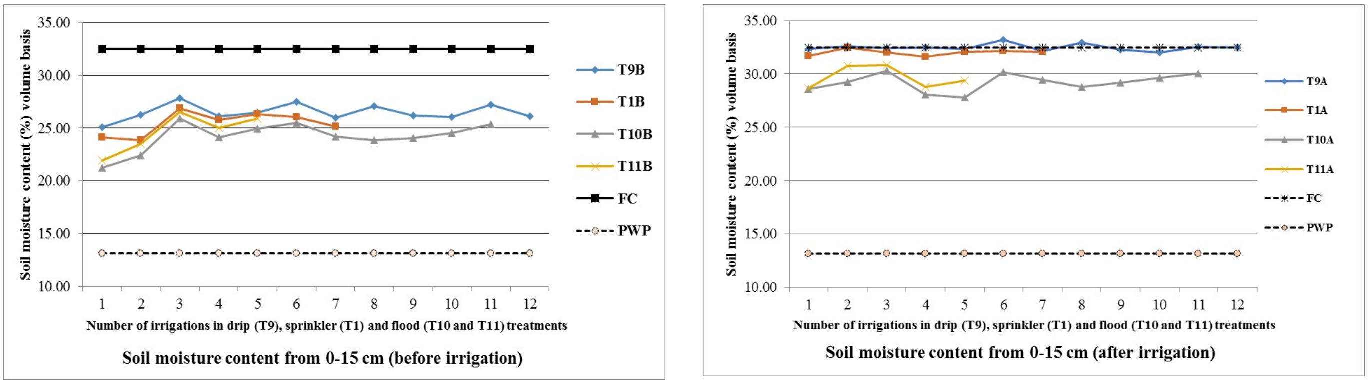

Fig. 1. Soil moisture content from 0-15 cm soil depth for drip, sprinkler and flood irrigation methods before and after irrigation

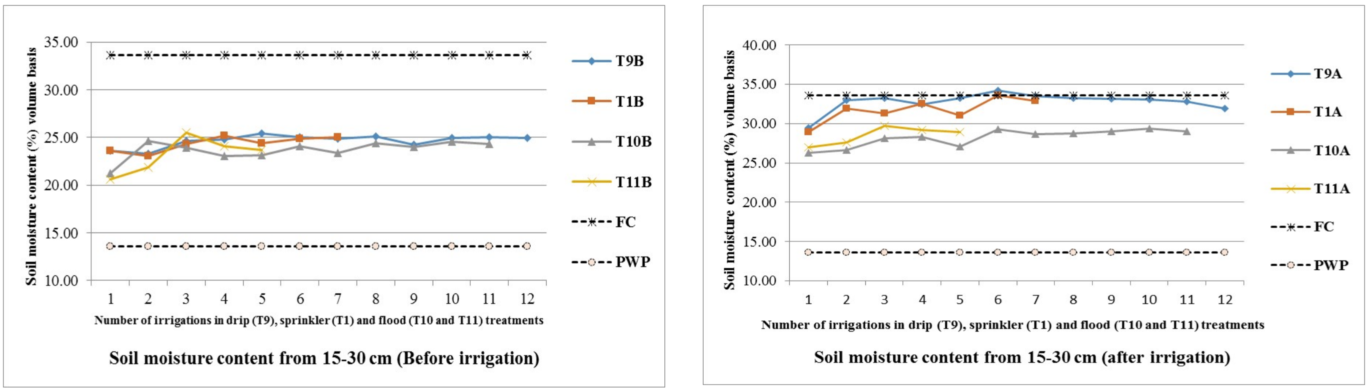

Fig. 2. Soil moisture content from 15-30 cm soil depth for drip, sprinkler and flood irrigation methods before and after irrigation

Table 2. Effect of different irrigation levels and methods on yield, yield parameters and water productivity of groundnut

Treatment	Pod wt. plant^{-1} (g)	No. of pods plant^{-1}	Pod yield (kg ha^{-1})	TWP (kg m^{-3})	IWP (kg m^{-3})
T_1 – SI (50 mm)	25.35^{ab}	27.45^{ab}	3896^{ab}	0.87^{ef}	1.16^{f}
T_2 - 80 % of T_1	25.10^{abc}	26.03^{bc}	3738^{abc}	0.99^{cde}	1.43^{de}
T_3 - 70 % of T_1	24.06^{bcd}	24.85^{bc}	3636^{abc}	1.05^{bcd}	1.57^{d}
T_4 - 60 % of T_1	23.74^{bcd}	24.50^{bc}	3547^{bc}	1.13^{ab}	1.77^{bc}
T_5 - 50 % of T_1	22.64^{d}	23.60^{c}	3267^{c}	1.15^{ab}	1.93^{ab}
T_6 - 70 % of T_1 + FA 0.5% KNO_3 @ 50 DAS	24.80^{abcd}	25.65^{bc}	3700^{abc}	1.07^{bc}	1.60^{cd}
T_7 - 60 % of T_1+ FA 0.5% KNO_3 @ 40 & 60 DAS	24.45^{bcd}	25.20^{bc}	3606^{bc}	1.14^{ab}	1.80^{b}
T_8 - 50 % of T_1+ FA 0.5% KNO_3 @ 30,50 & 70 DAS	23.69^{bcd}	24.55^{bc}	3477^{bc}	1.22^{a}	2.06^{a}
T_9 - Drip irrigation + Fertigation	26.70^{a}	29.85^{a}	4103^{a}	0.99^{cde}	1.36^{e}
T_{10} - Flood (FAO recommendation)	22.87^{cd}	23.95^{bc}	3322^{c}	0.92^{de}	1.36^{e}
T_{11} - Flood (UAS recommendation)	23.49^{bcd}	24.10^{bc}	3392^{c}	0.73^{f}	0.97^{f}
S.Em.±	0.67	1.08	148	0.04	0.06

T_1 - Sprinkler irrigation (SI) (50 mm except 60 mm at 50 and 60 DAS) T_2 -SI (40 mm except 48 mm at 50 and 60 DAS) i.e. 80% of T_1
T_3 - SI (35 mm except 42 mm at 50 and 60 DAS) i.e. 70% of T_1 T_4 -SI (30 mm except 35 mm at 50 and 60 DAS) i.e. 60% of T_1
T_5 - SI (25 mm except 30 mm at 50 and 60 DAS) i.e. 50% of T_1
T_6 - SI (35 mm except 42 mm at 50 and 60 DAS) + FA of 0.5% KNO_3 at 50 DAS
T_7 - SI (30 mm except 25 mm at 50 and 60 DAS) + FA of 0.5% KNO_3 at 40 and 60 DAS
T_8 - SI (25 mm except 30 mm at 50 and 60 DAS) + FA of 0.5% KNO_3 at 30, 50 and 70 DAS
T_9 - DI at 0.6 ET_0 (S), 1.0 ET_0 (F), 1.25 ET_0 (P) and 0.8 ET_0 (PF) + fertigation of N and P [3 splits at NF on 3rd, 4th and 5th week] + $CaNO_3$ and S nutrients [3 splits at PGF on 7th, 8th and 9th week]
T_{10} - Flood irrigation at 0.45 ET_0 (S), 0.75 ET_0 (F), 1.05 ET_0 (P), 0.70 ET_0 (PF) (FAO recommendation)
T_{11} – Irrigation as per UAS recommendation (Irrigating at 25, 40, 55, 70 and 85 DAE at 60 mm depth)
SI= Sprinkler Irrigation; FA= Foliar Application; DI= Drip Irrigation; TWP = Total Water Productivity; IWP = Irrigation Water Productivity;
S = Seedling; F = Flowering; P= Pegging; PF = Pod Formation; NF = Nodule formation; PGF= Peg formation

Table 3. Effect of different irrigation levels and methods on economics of groundnut

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs.ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1– SI (50 mm)	73513	210454^{ab}	136941^{ab}	2.86^{a}
T_2 - 80 % of T_1	73513	202044^{abc}	128531^{abc}	2.75^{ab}
T_3 - 70 % of T_1	73513	196561^{abc}	123048^{abc}	2.67^{ab}
T_4 - 60 % of T_1	73513	191506^{bc}	117993^{abc}	2.61^{ab}
T_5 - 50 % of T_1	73513	176416^{c}	102903^{c}	2.40^{b}
T_6 - 70 % of T_1 + FA 0.5% KNO_3 @ 50 DAS	74663	199983^{abc}	125320^{abc}	2.68^{ab}
T_7- 60 % of T_1+ FA 0.5% KNO_3 @ 40 & 60 DAS	74963	194782^{bc}	119819^{abc}	2.60^{ab}
T_8 - 50 % of T_1+ FA 0.5% KNO_3 @ 30,50 & 70 DAS	76113	187866^{bc}	112036^{bc}	2.48^{b}
T_9 - Drip irrigation + Fertigation	81563	221595^{a}	140032^{a}	2.72^{ab}
T_{10} - Flood (FAO recommendation)	70860	179417^{c}	108557^{c}	2.53^{ab}
T_{11}- Flood (UAS recommendation)	70860	183062^{c}	112202^{bc}	2.58^{ab}
S.Em±		7551	7812	0.11

T_1 - Sprinkler irrigation (SI) (50 mm except 60 mm at 50 and 60 DAS)
T_2 - SI (40 mm except 48 mm at 50 and 60 DAS) i.e. 80% of T_1
T_3 - SI (35 mm except 42 mm at 50 and 60 DAS) i.e. 70% of T_1
T_4 - SI (30 mm except 35 mm at 50 and 60 DAS) i.e. 60% of T_1
T_5 - SI (25 mm except 30 mm at 50 and 60 DAS) i.e. 50% of T_1
T_6 - SI (35 mm except 42 mm at 50 and 60 DAS) + FA of 0.5% KNO_3 at 50 DAS
T_7 – SI (30 mm except 25 mm at 50 and 60 DAS) + FA of 0.5% KNO_3 at 40 and 60 DAS
T_8 - SI (25 mm except 30 mm at 50 and 60 DAS) + FA of 0.5% KNO_3 at 30, 50 and 70 DAS
T_9 - DI at 0.6 ET_0 (S), 1.0 ET_0 (F), 1.25 ET_0 (P) and 0.8 ET_0 (PF) + fertigation of N and P [3 splits at NF on 3rd, 4th and 5th week] + $CaNO_3$ and S nutrients [3 splits at PGF on 7th, 8th and 9th week]
T_{10} - Flood irrigation at 0.45 ET_0 (S), 0.75 ET_0 (F), 1.05 ET_0 (P), 0.70 ET_0 (PF) (FAO recommendation)
T_{11} - Irrigation as per UAS recommendation (Irrigating at 25, 40, 55, 70 and 85 DAE at 60 mm 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

pod weight per plant and with only sprinkler irrigation receiving 50 mm water in each irrigation for number of pods per plant. These results were in conformity with that of Arif *et al.* (2016) who reported higher pods per plant and kernels per pod with irrigation at 1.0 ETc in groundnut during *kharif* season compared to control. Higher yield parameters recorded in drip and sprinkler treatments receiving higher water depth in each irrigation is attributed to the uniform and regular application of water in those treatments and maintenance of water level near the field capacity throughout the entire crop growth period. So, favorable moisture conditions were maintained in plant to produce higher growth in order to increase yield attributes as a result of improved dry matter output and accumulation in various plant sections.

Effect of irrigation levels and methods on soil moisture content before and after irrigation

Drip fertigation recorded higher mean moisture content before irrigation (26.49 %) and after irrigation (32.48 %) compared to controls. which recorded lower moisture content before irrigation (24.19 and 24.58 %, respectively) and after irrigation (29.19 and 29.64 %, respectively) compared to other treatments. However, lower soil moisture content was observed in sprinkler irrigation receiving 25 mm water depth in each irrigation before irrigation (21.36 %) and after irrigation (27.38 %) in 0-15 cm soil depth (Fig. 1 and 3).

Among different irrigation levels, drip fertigationrecorded higher mean moisture content before irrigation (24.67 %) and after irrigation (32.93 %) compared to controls which recorded lower moisture content before irrigation (23.71 and 23.14 %, respectively) and after irrigation (28.22 and 28.50 %, respectively) compared to other treatments. However, lowest soil moisture content was observed in sprinkler irrigation receiving 25 mm water depth in each irrigation before irrigation (21.50 %) and after irrigation (26.68 %) obtained from 15-30 cm soil depth (Fig. 2 and 4).

Effect of irrigation levels and methods on total water use and water productivity

Among the different treatments, higher amount of water was applied in flood irrigation as per UAS, recommendation (465.18 mm) and while the lower water requirement was observed in sprinkler irrigation receiving 25 mm irrigation water depth with and without KNO_3 spray (289.14 mm) and per cent water saving was 37.84 per cent compared to control. Similarly, amount of water used in sprinkler irrigation treatments receiving 50 mm, 40 mm, 35 mm and 30 mm water depth in each irrigation were 459.99, 385.14 and 353.14 and 321.14 mm, respectively and per cent water saved over surface flood irrigation (UAS, recommendation) were 1.12, 17.19, 24.08 and 30.96 per cent, respectively (Table 1).

The treatment receiving sprinkler irrigation with 25 mm water depth along with foliar application of 0.5% KNO_3 at 30, 50 and 70 DAS recorded significantly higher total and irrigation water productivity (1.22 and 2.06 kg m^{-3}, respectively) compared to other treatments. However, it was on par with sprinkler irrigation with 25 mm water depth (1.15 kg m^{-3}), sprinkler irrigation with 30 mm water depth (1.13 kg m^{-3}) and sprinkler irrigation with 30 mm water along with foliar application of 0.5% KNO_3 at 50 DAS

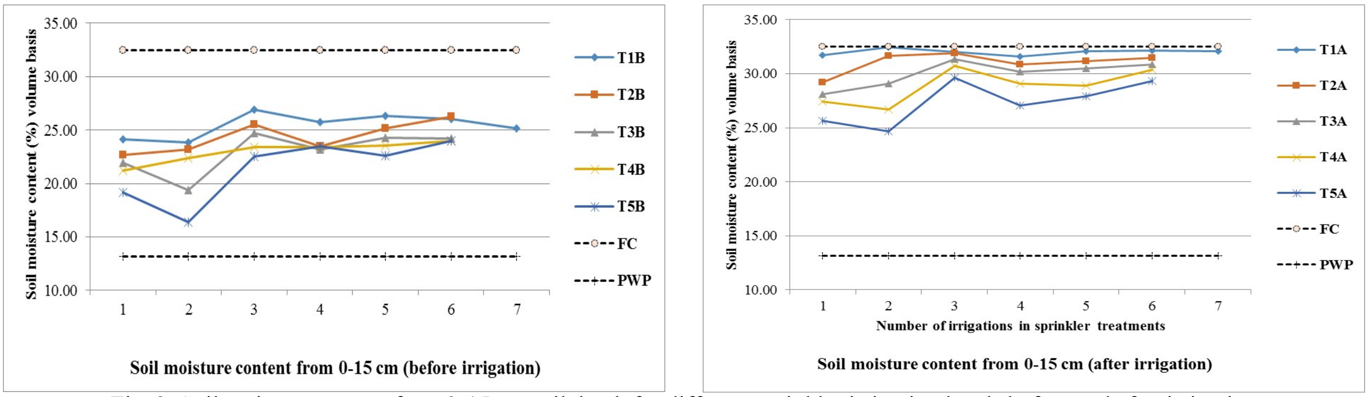

Fig. 3. Soil moisture content from 0-15 cm soil depth for different sprinkler irrigation levels before and after irrigation

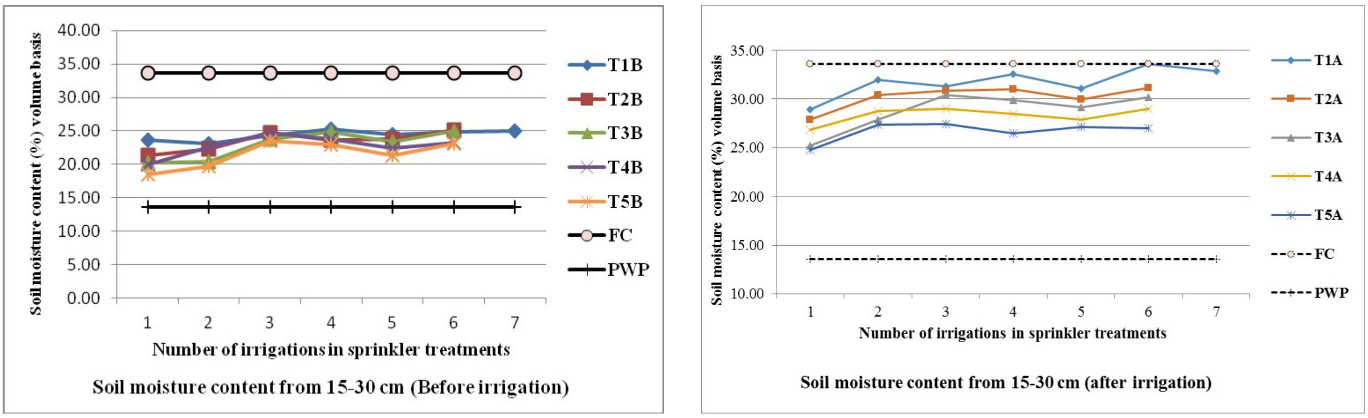

Fig. 4. Soil moisture content from 15-30 cm soil depth for different sprinkler irrigation levels before and after irrigation

(1.14 kg m^{-3}) for total water productivity and with that of sprinkler irrigation with 25 mm water depth (1.93 kg m^{-3}) for irrigation water productivity (Table 2). Higher water productivity in these treatments was mainly because of the fact that lower amount of irrigation was applied in those treatments compared to others. There was incessant rainfall after 90 days of the crop, so, the effect of different treatments on yield and water requirement of the crop were lost and the crop in the different treatments produced comparable yields.Hence, drip could not show higher difference in water productivity as against the general trend.Number of irrigations varied from 6 to 7 in the sprinkler treatments, whereas 12 irrigations were applied in drip method. However, 11 irrigations were applied in flood method as per FAO recommendation, whereas, 5 irrigations were applied in flood method as per UAS, recommendation. On the other hand, amount of water applied through drip was 415.93 mm and it saved 10.59 per cent compared to control (flood method as per UAS recommendation).

Effect of irrigation levels and methods on economics

Application of drip irrigation at 0.6 ET_0 at Seedling, 1.0 ET_0 at Flowering, 1.25 ET_0 at Pegging, 0.8 ET_0 at Pod formation stages along with fertigation of N and P [3 splits at NF on 3rd, 4th and 5th week] and $CaNO_3$ and S nutrients [3 splits at PGF on 7th, 8th and 9th week] recorded significantly higher gross return (₹ 1,99,983 ha^{-1}) and net return (₹ 1,18,095 ha^{-1}) mainly because of higher economic yield obtained in that treatment (Table 3). Similarly, Shinde (2020) found that scheduling irrigation at 100 % ETc recorded significantly higher gross returns, net returns and benefit-cost ratio and the values decreased with subsequent decrease in irrigation level. Rathore *et al.* (2021) reported that full irrigation (100 % ETc), 10 per cent and 20 per cent water deficit (90 % ETC and 80 % ETc, respectively) showed higher net returns as compared to lower irrigation levels and 40 and 50 per cent deficit water application which recorded negative net returns. However, the present results showed on par results with sprinkler irrigation with 50 mm and 40 mm water in each irrigation and sprinkler irrigation receiving 35 mm water in each irrigation along with foliar application of 0.5 per cent KNO_3 at 50 DAS for gross return and with sprinkler irrigation treatment receiving 50 mm, 40 mm, 35 mm and 30 mm water in each irrigation with and without foliar application of 0.5 per cent KNO_3. However, the sprinkler treatments with KNO_3 spray showed higher returns compared to those with same level of water deficit but without the chemical spray. The reason for on par results of drip with most of the sprinkler treatments might be due to equitable yield in those treatments and higher cost of cultivation in drip compared to others. However, there was no significant difference among the treatments for benefit cost ratio with numerically higher B:C ratio being recorded in sprinkler treatment with 50 mm water in each irrigation (2.86).

Conclusion

It was concluded from the results that, drip fertigation to summer groundnut found to be more promising for higher yield and net returns over control. Application of water through micro sprinkler with 50 mm, 40 mm or 35 mm water depth in each irrigation also resulted higher ground nut yields comparable to drip irrigation. In addition, sprinkler irrigation with 25 mm water depth along with foliar application of 0.5% KNO_3 at 30, 50 and 70 DAS found optimum for higher water productivity.

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