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Influence of different irrigation methods on growth and yield of summer greengram (*Vigna radiata* L.)

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Abstract
A field experiment was conducted at Wetland farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during summer 2022 to study the effect of growth and yield parameters of greengram under different irrigation methods. The field experiment was laid out in randomized complete block design having seven treatments and replicated thrice. The treatment are T_1: Check basin method (Line sowing), T_2: Check basin method (Broadcasting), T_3: Raised bed method (Line sowing), T_4: Ridges and furrow method (Line sowing), T_5: Drip irrigation system (Line sowing), T_6: Drip irrigation system (Broadcasting) and T_7: Sprinkler irrigation system (Line sowing). Experimental results showed that significantly higher plant height, number of branches plant^{-1}, number of pods plant^{-1}, pod weight plant^{-1}, number of seeds plant^{-1}, seed yield and haulm yield were recorded in drip irrigation system (Line sowing) in greengram which was on par with sprinkler irrigation system (Line sowing). Drip and sprinkler irrigation systems recorded the higher seed yield (42.1% and 36.1%, respectively) over check basin method (Broadcasting). This study revealed that the drip and sprinkler irrigation methods along with line sowing resulted better growth and yield parameters of summer greengram and enhanced its production.

Keywords: Greengram, irrigation methods, drip irrigation, sprinkler irrigation, growth and yield parameters

Introduction
Greengram (*Vigna radiata* L.) is an important short duration leguminous crop. It contains 25% of dietary protein, 1.3% of fat, 4.1% of fibres, 3.5% of minerals and 56.7% of carbohydrate (Kumar *et al*., 2021a) [5]. It is a drought-resistant crop and cannot withstand waterlogging conditions. It fixes atmospheric nitrogen with the help of *Rhizobium* in root nodules through the symbiotic nitrogen fixation process and also used as a manure crop that adds 35 kg of nitrogen ha^{-1} to soil and makes it available to the next season crop. In India, greengram shares an area of 5.13 m ha with the production of 3.09 m t and 601 kg ha^{-1} of productivity (Indiastat, 2021) [2]. Generally, greengram cultivation is possible during all the seasons (*Kharif*, *Rabi* and summer). However, it is mainly grown during the *Kharif* season because of more availability of rainwater and minimum groundwater usage. But during summer and *Rabi* season, there is a limitation for rainfall and less groundwater availability. So, the greengram cultivated an area and production (1.3 m ha and 1.1 m t, respectively) is quite lesser compared to the *Kharif* season (3.8 m ha and 2.0 m t, respectively). Therefore, increase in area and production during summer season through the effective use of irrigation water is the only solution to overcome this scenario. This can be achieved by using various irrigation methods such as surface, drip and sprinkler irrigation methods. In the traditional surface irrigation methods, check basin, raised bed and ridges and furrow method are normally followed by farmers. Among these, raised bed and ridges and furrow methods saves water as well as increases grain yield of greengram compared to the check basin method (Yadav and Singh, 2014). However, the surface irrigation method also causes more losses of water through seepage, deep percolation, evaporation loss and improper management of irrigation water (Dixit and Dwivedi, 1994) [1]. Therefore, modern micro irrigation such as drip and sprinkler irrigation methods were used for the effective utilization of irrigation water in a field. Researchers estimated that maximum application efficiency of irrigation water through drip and micro-sprinkler methods was 90% and 75% over flood irrigation method (40%) (Rao *et al*., 2016) [8]. Keeping the above point in view, a study was carried out by combining different irrigation practices from traditional surface irrigation methods to modern micro irrigation methods with an objective of identifying the effect of various irrigation methods on growth and yield parameters on greengram.

2. Materials and Methods

A field experiment was carried out during summer season of 2022 at Wetland farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore which is located at the latitude of $11^{0}2'$ N with longitude of $77^{0}6'$ E and an altitude of 426.6 m above mean sea level. Amount of rainfall received during the experimental period was 57.9 mm with 6.3 mm of mean evaporation and average relative humidity of morning and afternoon was 82.7% and 44.7%, respectively. The soil of the experimental field is clay loam in texture and alkaline in pH (8.75) and EC value of 0.37 dSm^{-1}. Bulk density and particle density of the soil was 1.33 and 2.22 g cm^{-3}, respectively. Soil was low in available nitrogen (269.0 kg ha^{-1}) and medium in available phosphorus (16.9 kg ha^{-1}) and high in available potassium (524.9 kg ha^{-1}) content along with 0.75% of organic carbon content.

The field experiment was laid out in randomized complete block design having seven treatments with three replications. The treatment details *viz*., T_1: Check basin method (Line sowing), T_2: Check basin method (Broadcasting), T_3: Raised bed method (Line sowing), T_4: Ridges and furrow method (Line sowing), T_5: Drip irrigation system (Line sowing), T_6: Drip irrigation system (Broadcasting) and T_7: Sprinkler irrigation system (Line sowing). Check basin, raised bed and ridges and furrow methods were irrigated through surface irrigation which was scheduled based on 0.5 IW/CPE ratio. In the raised bed method, bed width and height of 90 cm and 15 cm, respectively along with a 30 cm furrow width was made. Four rows of plants per bed were sown. In ridges and furrow method, 30 cm ridge width and height of 15 cm along with furrow width of 30 cm and a ridge was made and two rows of plants were maintained. Irrigation was given once in three days interval for drip irrigation method and five days interval for sprinkler irrigation method based on daily pan evaporation value using USWB Class A open pan evaporimeter. In drip irrigation method, emitter to emitter spacing was 40 cm and spacing between lateral to lateral was 60 cm with a discharge capacity of 4 lph. Micro-sprinklers were used for sprinkler irrigation with radius coverage of 1.5 m and the discharge capacity was 80 lph. Micro-sprinklers were mounted on wooden stakes for support at a height of 60 cm.

Greengram variety 'CO 8' was chosen for the experiment. Sowing was done in both line sowing at 30 cm and sown at a distance of 10 cm and broadcasting. The recommended dose of fertilizer (25 kg N ha^{-1}, 50 kg P_2O_5 $ha^{-1}$and 25 kg K_2O ha^{-1}) was applied before sowing as basal. Optimum plant population was maintained by thinning. Observations were taken from five plants randomly selected from each plot at different growth stages like 15, 30, 45 DAS and harvest stage. Harvesting was done at the maturity stage and yield parameters were calculated.

Biometrics observations like plant height (cm), number of branches $plant^{-1}$, root length (cm) and drymatter production (kg ha^{-1}) were taken at different growth stages. The yield and yield parameters such as number of pods $plant^{-1}$, pod weight (g $plant^{-1}$), number of seeds $plant^{-1}$, 100 seed weight (g), grain yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and harvest index were calculated at the time of harvest stage of greengram. The experimental data was statistically analysed through the AGRESS software with the critical difference of 5% probability level of significance.

3. Result and Discussion

3.1. Growth parameters

The experiment results on growth parameters such as plant height (cm), number of branches $plant^{-1}$, root length (cm) were mentioned in Table 1. In case of plant height, there is no significant difference was observed on 15 DAS. However, treatment T_5 (Drip irrigation system with line sowing) had recorded higher plant height (27.8 cm) on 30 DAS when compared to other treatments. Similar trend was observed in 45 DAS and harvest stage of greengram, which was on par with treatment T_7. Treatment T_2 recorded the lowest plant height in all the stages of observation. This might be due to the reason that frequent irrigation interval maintains the soil moisture leads to nutrient availability and enhanced microbial action in the soil, influences the rapid growth of nodes and internodes. These results were similar to the findings of Vaghasia *et al*. (2017) [13].

The number of branches $plant^{-1}$ was significantly higher in treatment T_5 (1.47) and it was on par with treatment T_7 (1.33) and the lowest value was noted in treatment T_2 at 30 DAS. A similar trend was noticed in 45 DAS and harvest stages and the lowest number of branches in both of broadcasting treatments T_6 and T_2. This might be due to the reason that higher plant population under broadcasting creates the competition for space, nutrients, light and water between plants which results in less photosynthesis from source to sink, minimum soil moisture causes reducing plant nutrient uptake as well as the number of branches $plant^{-1}$. Such results were similar to the findings of Khan *et al.* (2017) [3].

Meanwhile, the maximum root length was observed in treatment T_3 (4.19 cm) which was on par with treatment T_4 (3.68 cm) and lower root length in treatment T_6 at 15 DAS of greengram. On 30 DAS, there is no significant difference occurred between treatments. At 45 DAS and harvest stages, the treatment T_3 was recorded more root length (19.87 and 23.51 cm, respectively) and it was on par with treatment T_4 (19.54 and 22.89 cm, respectively) and the least was in T_6 treatment. This might be due to the reason that raised bed and ridges and furrow methods helps in loosening of soil, better aeration and it provided enough depth for root development which aids in the uptake of more nutrients from the soil when compared to the check basin method. Tomar *et al.* (2016) [12] also opinioned the similar results. While T_6 recorded lower root length might be due to proper soil moisture maintained because of frequent irrigation intervals in the drip irrigation method. This is similar to the findings of Palriya (2012) [7].

The drymatter production of greengram was illustrated in Fig 1. It was higher in treatment T_6 (170 kg ha^{-1}) and lower in treatment T_1 (132 kg ha^{-1}) and there is no significant difference between treatments at 15 DAS. Similarly, at 30 DAS, more drymatter production was noted in treatment T_6 (785 kg ha^{-1}) and lower in treatment T_1. As treatment T_6 had more plant population which resulted in more drymatter production at 15 DAS and 30 DAS. Also on 45 DAS, the drymatter production was significantly higher in treatment T_6 (3076 kg ha^{-1}). At the final stage (harvest), treatment T_5 (5101 kg ha^{-1}) had produced significantly higher drymatter production and it was on par with treatment T_7 (4723 kg ha^{-1}) followed by treatment T_6 and the lowest drymatter production in treatment T_1. The lowest drymatter production of greengram in treatment T_6 might be due to decrease in the number of branches $plant^{-1}$, leaf area plant and also decreasing of yield parameters such as number of pods $plant^{-1}$, weight of

pods plant^{-1} and number of seeds plant^{-1} which leads to decreases the drymatter production. This result confirmed the findings of Khan *et al.* (2017) [3] that insufficient light availability, lower photosynthetic activity, plant spacing and minimum nutrient supply at harvesting stages might be the reason for less vigour and strength of the plants which reduces the dry weight plant^{-1}.

3.2. Yield parameters

The yield parameters such as the number of pods plant^{-1} @ 45 DAS and harvest stage, pod weight plant^{-1}, number of seeds plant^{-1} and test weight of greengram were presented in Table 2. The number of pods plant^{-1} @ 45 DAS and harvest stage was significantly higher in treatment T_5 (17.87 and 35.33, respectively) and it was on par with treatment T_7 followed by treatment T_3 and the lowest in treatment T_2. These findings were confirmed by Shree *et al.* (2021) [9] and stated that drip irrigation with five days interval shown the highest number of pods plant^{-1} due to maintaining the optimum soil moisture during the entire growth period as it enhanced the root growth, nodule formation and might have stimulated the maximum nutrient uptake by plant resulting the higher yield parameters when compared to the surface irrigation methods.

The pod weight plant^{-1} was significantly higher in treatment T_5 (16.92 g) which was on par with treatment T_7 (15.07 g) followed by treatment T_3 and the lowest pod weight plant^{-1} was noted in treatment T_2. The number of seeds plant^{-1} was increased in treatment T_5 which increased the weight of pods plant^{-1}. These results are in conformity with Soni and Raja (2017) [10] and concluded that the highest pod weight was recorded in drip irrigation with 100% Pan Evaporation (PE) followed by drip irrigation with 75% PE and micro-sprinkler irrigation at 100% PE and lower pod weight in surface irrigation at 0.8 IW/CPE ratio.

Similar trend was followed in the total number of seed plant^{-1} of greengram. Treatment T_5 recorded significantly higher number of seeds plant^{-1} (329.7) and it was on par with treatment T_7 (292.5) and the lowest number of seed plant^{-1} in treatment T_2. Similar findings were reported by Shree *et al.* (2021) [9]. Test weight was found to be non-significant since it was governed by genetic makeup of plant. This result was in line with the findings of Kumar *et al.* (2021b) [6].

3.3. Yield of greengram

The result of the experiment on yield parameters such as seed yield, haulm yield and harvest index were illustrated in Fig 2. The seed yield depends on the yield parameters of the plants. The increasing number of pods plant^{-1}, pod weight plant^{-1} and number of seeds plant^{-1} significantly increased the seed yield in treatment T_5 (1335 kg ha^{-1}) and it was on par with treatment T_7 (1209 kg ha^{-1}) and lower seed yield in treatment T_2 (773 kg ha^{-1}) in greengram. The result was similar to the drip irrigation system having higher grain yield followed by the sprinkler irrigation system, furrow irrigation and the lowest in flood irrigation method (Kumar *et al.*, 2017) [4]. This might be due to improved water and nutrient availability through drip irrigation system from the limited wetted area at frequent intervals. Higher nutrient availability resulted in increased nutrient uptake, which ultimately had an impact on the yield.

The haulm yield was significantly higher in treatment T_5 (2753 kg ha^{-1}) which was on par with treatment T_7 (2576 kg ha^{-1}) and a lower haulm yield was noted in treatment T_1 (1995 kg ha^{-1}) in greengram. As the plant population was higher in treatment T_2, it produced more drymatter production when compared to others. These results were similar to the findings of Soni *et al.* (2019) [11] and found that drip irrigation at 100% PE recorded higher haulm yield (6452 kg ha^{-1}) followed by drip irrigation at 75% PE and micro-sprinkler irrigation at 100% PE and the lowest in surface irrigation method. The harvest index was significantly higher in treatment T_3 (0.335) and it was on par with treatment T_5 (0.326) and lower in treatment T_6 (0.280) and T_2 (0.249) which might be due to the production of more haulm yield but less in seed yield.

Table 1: Effect of irrigation methods on growth parameters of greengram

Treatment	Plant height (cm)				No. of branches plant^{-1}			Root length (cm)			
	15 DAS	30 DAS	45 DAS	Harvest stage	30 DAS	45 DAS	Harvest stage	15 DAS	30 DAS	45 DAS	Harvest stage
T_1	8.3	23.0	40.7	49.4	1.20	2.40	3.73	3.5	10.1	17.3	21.4
T_2	8.3	21.4	37.1	47.4	0.93	1.73	2.80	3.3	10.0	16.3	20.4
T_3	8.5	24.9	43.3	51.3	1.40	2.53	4.00	4.2	10.9	19.9	23.5
T_4	8.6	24.0	42.5	50.5	1.27	2.47	3.80	3.7	10.8	19.5	22.9
T_5	9.2	27.8	48.6	57.5	1.47	2.73	4.20	3.2	9.5	16.0	19.2
T_6	8.6	23.4	42.1	49.7	1.07	1.93	3.07	3.1	9.4	15.7	18.1
T_7	9.0	26.5	46.0	54.0	1.33	2.67	4.13	3.3	10.0	16.9	19.8
SEd	0.7	1.7	3.0	2.7	0.09	0.15	0.27	0.3	0.8	1.4	1.6
CD(P=0.05)	NS	3.8	6.5	5.9	0.19	0.33	0.60	0.6	NS	3.0	3.4

Table 2: Effect of irrigation methods on yield parameters of greengram

Treatment	Number of pods plant^{-1}		Pod weight (g plant^{-1})	Number of seeds plant^{-1}	100 seed weight (g)
	45 DAS	Harvest			
T_1	14.1	25.7	10.6	215.1	3.250
T_2	10.3	17.7	7.2	144.9	3.161
T_3	15.3	28.6	12.9	255.7	3.347
T_4	14.5	27.2	12.1	242.6	3.273
T_5	17.9	35.3	16.9	329.7	3.460
T_6	11.7	20.7	8.9	184.4	3.267
T_7	17.3	32.7	15.1	292.5	3.413
SEd	1.1	2.2	0.9	18.7	0.258
CD(P=0.05)	2.4	4.7	1.9	40.8	NS

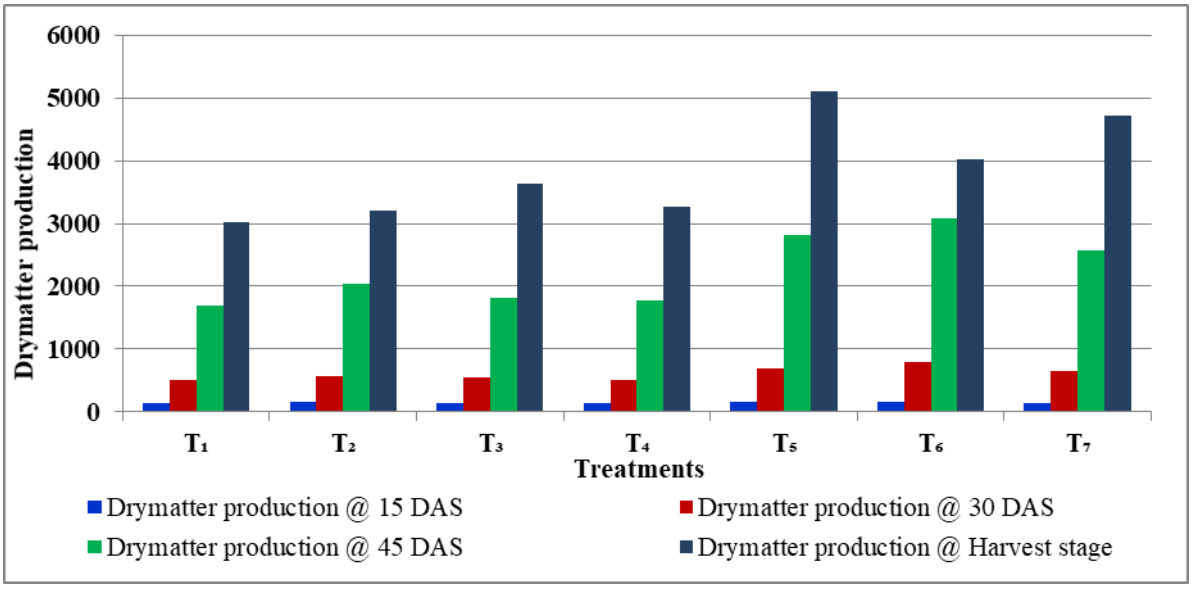

Fig 1: Effect of irrigation methods on drymatter production (kg ha^{-1}) of greengram

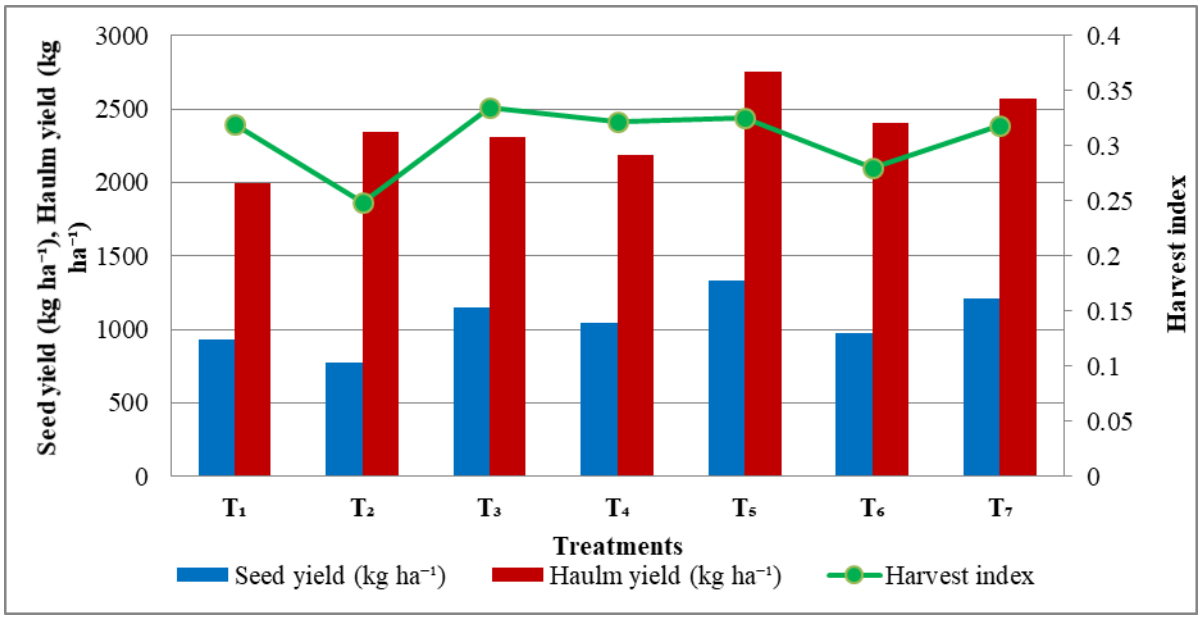

Fig 2: Effect of irrigation methods on yield of greengram

4. Conclusion

From the above results, it can be concluded that the drip irrigation and sprinkler irrigation methods with line sowing recorded better growth and yield parameters than all other methods of irrigation. When compared to conventional broadcasting with check basin irrigation, drip and sprinkler methods of irrigation recorded 42.1 and 36.1%, respectively increased yield. Overall, it is concluded that drip and sprinkler irrigation methods along with line sowing would be a promising irrigation methods over surface irrigation methods and broadcasting for obtaining higher production in greengram.

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