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Effect of drip fertigation on the productivity of green gram under sodic soil

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Abstract
A field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirapalli during *summer* 2021 to study the effect of drip fertigation with different irrigation intervals and phosphorus sources on the productivity of green gram under sodic soil condition. Treatments consisted of four main plots with different irrigation intervals such as drip irrigation in three days interval (M_1), five days interval (M_2), seven days interval (M_3) compared with surface irrigation (M_4). Subplot treatments consisted of different phosphorus sources *viz.*, SSP (S_1), DAP (S_2) as soil application, MAP (S_3) and Phosphoric acid (S_4) as a fertigation and control plot without phosphorus application (S_5). The experiment was laid out in split plot design with three replications. Drip irrigation was given at 80% pan evaporation (PE). Drip fertigation was given once in five days interval. Results revealed that among the irrigation intervals, drip irrigation with five days intervals recorded significantly higher growth characters such as plant height (40.0 cm), number of branches plant^{-1}(5.1), root length (16.1cm), root nodules (12.4), dry matter production (2822 kg ha^{-1}), LAI (5.2), yield attributes *viz.*, number of pods plant^{-1} (40.8), number of seeds pod^{-1}(12.4), pod length (8.0 cm), test weight (3.46 g), grain yield (841kg ha^{-1}) and haulm yield (1821 kg ha^{-1}) than the other irrigation intervals and surface irrigation. Drip irrigation with seven days three days interval recorded significantly higher growth and yield than surface irrigation. Among the phosphorus sources, fertigation of phosphoric acid recorded significantly taller plants (42.8 cm), more number of branches plant-^{1} (5.8), root length (14.5 cm), root nodules (13.0), dry matter production (2713 kg ha^{-1}), LAI (5.5) and yield attributes *viz.*, number of pods plant^{-1} (41.5), seeds pods^{-1} (12.2), pod length (8.2 cm), test weight (3.72 g), seed yield (814 kg ha^{-1}) and haulm yield (1745 kg ha^{-1}) than soil application of SSP and DAP. However, it was comparable with fertigation of MAP. Thus, drip irrigation with 80% pan evaporation at five days interval and fertigation with either MAP or phosphoric acid as a source of phosphorus could be recommended for improving the productivity of green gram under sodic soil condition.

Keywords: Drip irrigation, fertigation, green gram, MAP, phosphoric acid, irrigation intervals

1. Introduction
Green gram [*Vigna radiata* (L.)] locally called as moong or mung bean. It is a major kharif pulse crop that can also be produced as a catch crop between the rabi and kharif seasons in India. India produces 65 percent of the world's average production in green gram. It is mostly grown in Rajasthan, Maharashtra, Andhra Pradesh, Karnataka, Orissa, and Bihar on around 4.5 million hectares (Anonymous 2020) [1]. Its seed has 24.7% protein, 0.6% fat, 0.9% fibre, and 3.7% ash (Potter and Hotchkiss, 1997) [11]. The productivity of green gram in India is low (548 kg ha^{-1}). Currently per capita pulse availability in India was 48 g person $^{-1}$ as against the ICMR recommendation of 80 g person^{-1}. It is imperative to increase the productivity of green gram to meet out the pulse requirement of growing population. The yield level of green gram under sodic soil is very low mainly due to poor soil water status and nutrient availability. Hence, suitable agro technologies have to be developed to improve the productivity of green gram in sodic soil. Generally, green gram requires 5-6 irrigations during summer season where, farmers depends on ground water for irrigation. Surface irrigation causes poor establishment, growth and yield of green gram under sodic soil mainly due to poor soil physical properties. Drip irrigation is hi-tech method receiving better acceptance and adoption, particularly in areas of water scarcity (Solaimalai *et al*. 2005) [15]. Drip irrigation is one of the best methods to reduce salt accumulation in the root zone and salt injury to the crops. Hence, it is necessary to optimize irrigation interval under drip irrigation for green gram cultivation.

Phosphorus is an important nutrient next to nitrogen. Phosphorus application has beneficial impacts on nodule stimulation, root formation, and growth as well as hastening maturity and improving crop quality of green gram. Application of phosphorus to legumes increased the grain

yield (Ryan, 2002). When phosphorus is supplied in a higher dose, it increased nitrogen fixation and consequently improves green gram productivity. Availability of phosphorus is low under sodic soil because of higher P^H. Its nutrient availability can be improved by identifying suitable phosphorus source under drip fertigation for sodic soil under drip irrigation system.

Fertigation is the process of applying fertilizers to crops using irrigation water. When essential nutrients and water were applied by a drip irrigation system, there was a significant reduction in fertilizer use, as well as higher production and water savings, when compared to the surface irrigation. The fertigation system maximises crop water and nutrient uptake while minimising nutrient leaching. (Gardenas *et al.* 2005) [3]. Research on drip fertigation in green gram is very meagre particularly under problem soil condition. Hence, an experiment has been conducted to optimize the irrigation interval and phosphorus sources in drip fertigation for higher productivity of green gram under sodic soil.

2. Materials and Methods

2.1 Experimental site

A field experiment was carried out at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli. The experimental site is located at 10 º 45'N latitude, 78 º 36'E longitude and at an altitude of 85 m above MSL. The soil has pH of 8.6 and EC (0.34) which is sodic in nature and has organic carbon of 0.45 with low nitrogen, medium phosphorus and potassium content.

2.2 Experimental design and treatment details

The experiment was laid out in split plot design replicated thrice. The main plot treatments consisted of drip irrigation with three days interval (M_1), drip irrigation with five days interval (M_2), drip irrigation with seven days interval (M_3) and surface irrigation (M_4). Sub plot treatments consisted of different phosphorus sources *viz*., Single super phosphate (SSP) as soil application (S_1), Diammonium phosphate (DAP) as soil application (S_2), Mono ammonium phosphate as Fertigation (MAP) as fertigation (S_3) Phosphoric acid as Fertigation (S_4) and Control (S_5). Drip irrigation was given at 80% pan evaporation level according to the treatment intervals. Surface irrigation was given once in seven days. The recommended dose of fertilizer at 25:50:25 kg NPK ha^{-1} was applied. Fertigation was given at 60:60:20 % NPK at 0-20 days, 40:20:40 % NPK at 21 – 40 days and 20:40 % P and K at 41 – 55 days once in five days interval. Green gram variety VBN Gg (2) was used.

2.3 Observations

Five plants were tagged randomly from each plot and used to record growth and yield parameters. Plant height was recorded by measuring from base of the plant to its growing tip and it was expressed in cm. Number of branches $plant^{-1}$ was recorded and expressed in numbers. Root length was recorded by measuring bottom of the root tip up to the shoot portion and expressed in cm. Root nodules was recorded by counting the nodules in the root portion. Leaf area index was recorded at 45 days after planting and calculated using the formula given by Palanisamy and Gomez (1974) [9]. The yield parameters such as number of pods $plants^{-1}$, number of seeds pod^{-1}, test weight and expressed in g, grain yield and haulm yield were recorded at harvest stage and it was expressed in kg ha^{-1}

2.4 Statistical analysis

Experimental data was statistically analysed which outlined by Panse and Sukhatame (1967) [10]. Critical difference at 5 per cent probability level was calculated for the treatment with significant difference.

3. Results and Discussion

3.1 Growth parameters

Growth parameters of green gram significantly influenced by irrigation intervals and phosphorus sources. Among the irrigation intervals, drip irrigation at five days interval recorded significantly higher plant height (40.0 cm) and more number of branches $plant^{-1}$ (5.1), root length (16.1 cm), root nodules (12.4), dry matter production (2822 kg ha^{-1}) and leaf area index (5.2) over other irrigation intervals and surface irrigation (Table 1). However, this was comparable with seven days interval in plant height and root nodules. Drip irrigation at five days interval supplied optimum soil moisture to the plants that transported water efficiently through xylem vessels and boosted crop growth which in turn produced higher plant height, more number of branches, plant dry matter production and leaf area index. These findings were in accordance with Selva Rani (2009). Drip irrigation at three days interval registered lesser growth attributes than other irrigation intervals. Lower growth attributes were recorded under surface irrigation. Being green gram is an water sensitive crop, frequent irrigation at three days interval reduced the plant height, yellowing of leaves and affected the plant dry matter production.

Among the phosphorus sources, fertigation with phosphoric acid produced significantly higher plant height (42.8 cm), number of branches $plant^{-1}$ (5.8), root length (14.5 cm), root nodules (13.0), dry matter production (2713 kg ha^{-1}) and leaf area index (5.5) than the soil applied phosphorus and control. However, this was on par with MAP fertigation. The lowest growth parameters were recorded under control plot. Fertigation of phosphoric acid or MAP at regular intervals increased the phosphorus absorption in root and enhanced the growth parameters. The solution form of phosphorus from phosphoric acid and MAP improved the phosphorus uptake in plants, which actively participated in cell division and elongation activities which reflected on increased plant growth, dry matter production, leaf area index, root development and nodulation. These results are similar with findings of Papadopoulos *et al*. (2010), Singh *et al*. (2014) [14]. Application of readily available form of fertilizers with adequate irrigation intervals (once in five days) reduced the nutrient loss and increased nutrient use efficiency which might have resulted in higher growth attributes.

Table 1: Effect of drip fertigation on growth parameter of green gram under sodic soil

Treatments	Plant height(cm)	Number of branches	Root length(cm)	Root nodules	DMP (kg ha^{-1})	LAI
Main plots – Irrigation intervals						
M_1- Drip irrigation with three days interval	38.0	4.7	12.5	09.0	2656	4.6
M_2 – Drip irrigation with five days interval	40.0	5.1	16.1	12.4	2822	5.2
M_3 – Drip irrigation with seven days interval	39.2	4.7	15.2	11.8	2726	4.9
M_4 – Surface irrigation	35.5	4.6	12.2	08.6	2407	4.1
SEd	1.1	0.1	0.28	0.3	102	0.2
CD (P =0.05)	2.7	0.3	0.70	0.8	228	0.4
Sub plots – Phosphorus sources						
S_1- SSP (soil application)	35.7	4.9	13.9	07.7	2519	4.8
S_2- DAP (soil application)	39.7	5.0	14.0	10.0	2546	5.0
S_3- MAP (fertigation)	39.1	5.1	14.3	11.4	2630	5.2
S_4- Phosphoric acid (fertigation)	42.8	5.8	14.5	13.0	2713	5.5
S_5- Control	35.5	3.1	13.3	06.0	2400	3.0
SEd	1.1	0.1	0.5	0.4	94	0.1
CD (P= 0.05)	1.3	0.3	1.1	0.9	196	0.3

3.2 Yield parameters

Significantly higher yield parameters *viz.*, number of pods plant^{-1} (40.8), seeds pod^{-1} (12.4), pod length (8.0 cm) were registered under drip irrigation at five days interval than three days interval and surface irrigation (Table 2). However, it was on par with drip irrigation at seven days interval. Surface irrigation recorded lesser yield attributes than drip irrigation. There was no significant difference in test weight. Increased yield attributes under drip irrigation at five days interval might be due to optimum soil moisture condition maintained throughout the crop period had stimulated the root growth and enhanced physiological process which increased the nutrient uptake and led to increased number of pods plant $^{-1}$, seeds pod^{-1} and length of the pod. These results are in accordance with the findings of Yazar *et al.* (2002).

Fertigation with phosphoric acid registered significantly higher number of pods plant^{-1} (41.5), number of seeds pod^{-1} (12.2) pod length (8.2 cm) over other soil applied phosphorus sources and control (Table 2). However, this was comparable with MAP fertigation which produced more number of pods plant $^{-1}$(38.9), number of seeds pod^{-1}(12.0), pod length (8.0 cm). Various phosphorus sources did not influence the test weight of green gram. Lower yield attributes were recorded under control plot. Higher yield attributes under phosphoric acid as well as MAP might be due to higher nutrient availability and subsequent crop absorption under optimal moisture conditions, along with frequent nutrient delivery by fertigation resulted in translocation of assimilates from source to sink. Similar outcomes were found by Shah *et al.* (2001) and Geetha (2003) [4].

3.3 Yield

The higher grain yield (841 kg ha^{-1}) and haulm yield (1821 kg ha^{-1}) were obtained in drip irrigation with five days interval than the three days interval and surface irrigation (Table 2). These was on par with drip irrigation at seven days interval. Lower grain yield was registered under surface irrigation. Adequate moisture under five days interval created a healthy root system and enough water requirement for plants, resulted in increased nutrients availability that improved the photosynthetic capacity which in turn increased the grain yield. These results are in accordance with Ibrahim (2010) [7].

Phosphorus fertigation with phosphoric acid recorded significantly higher grain yield (814 kg ha^{-1}) and haulm yield (1745 kg ha $^{-1}$) than soil applied phosphorus and control (Table 2). This was comparable with MAP fertigation which produced grain yield of 795 kg ha^{-1} and haulm yield of 1686 kg ha^{-1}. While phosphorus is a yield limiting factor, frequent phosphorus fertigation by either phosphoric acid or MAP increased the phosphorus uptake by the roots. Phosphoric acid fertigation reduced soil rhizosphere pH, resulted in enhanced availability of micronutrients such as Zn and Fe, which improved the phosphorus uptake and increased yield components and yield. Appropriate irrigation coupled with frequent fertigation increased the phosphorus uptake and greater mobility in plants and it maintains three-dimensional water and nutrients distribution patterns, resulted in higher mobility of nutrients throughout the crop period, which potentially increased the yield. Similar findings were reported by Khetre Mayur Lahurao (2010) [6]

Table 2: Effect of drip fertigation on yield attributes and yield of green gram under sodic soil

Treatments	Number of pods plant $^{-1}$	Number of seed pod $^{-1}$	Pod length(cm)	Test weight (g)	Seed yield (Kg ha^{-1})	Haulm yield (kg ha^{-1})
Main plots – Irrigation intervals						
M_1 -Drip irrigation with three days interval	35.8	11.3	7.0	3.38	761	1745
M_2 - Drip irrigation with five days interval	40.8	12.4	8.0	3.46	841	1821
M_3 - Drip irrigation with seven days interval	37.2	11.9	7.9	3.38	783	1789
M_4 - Surface irrigation	29.9	10.9	7.6	3.34	645	1626
SED	0.8	0.33	0.11	0.05	22	47
CD (0.05)	2.1	0.83	0.29	NS	54	104
Sub plots – Phosphorus sources						
S_1- SSP (soil application)	35.9	11.5	7.9	3.30	741	1635
S_2- DAP (soil application)	36.0	11.8	8.0	3.37	752	1650
S_3- MAP (fertigation)	38.9	12.0	8.0	3.55	795	1686
S_4- Phosphoric acid (fertigation)	41.5	12.2	8.2	3.72	814	1745
S_5- Control	30.8	10.5	7.1	3.00	680	1584
SEd	1.4	0.5	0.1	0.08	28	45
CD (p = 0.05)	2.9	1.0	0.3	NS	58	103

4. Conclusion

From this study, it is concluded that drip irrigation at 80 % pan evaporation with five days interval in combination with 50 kg ha^{-1} phosphorus as phosphoric acid or MAP fertigation at five days interval could be considered as suitable management practice for obtaining higher growth and yield of green gram under sodic soil.

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