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M Arutkumaran
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

K Suseendran
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

C Kalaiyarasan
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

MV Sriramachandrasekharan
Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

S Jawahar
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

M Thiruppathi
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

Corresponding Author:
K Suseendran
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

Effect of foliar nutrition on growth and yield of irrigated greengram (*Vigna radiata*) *cv.* Vamban 4

M Arutkumaran, K Suseendran, C Kalaiyarasan, MV Sriramachandrasekharan, S Jawahar and M Thiruppathi

Abstract
A field experiment was conducted in farmer's field during the *kharif* season (June-September- 2021) in Ambagarathur village, Thirunallar Taluk, Karaikal District of Puducherry to study the effect of foliar nutrition on growth and yield of irrigated greengram. The experimental field soil was sandy clay loam. The treatments consists of T_1- RDF + water spray (control), T_2- RDF + foliar application of 2% DAP and NAA 40ppm on 30 and 45 DAS, T_3- RDF + foliar application of 1% potassium sulphate on 30 and 45 DAS, T_4- RDF + foliar application of 1% TNAU Pulse wonder on 30 and 45 DAS, T_5- RDF + foliar application of 2% poly feed on 30 and 45 DAS, T_6 - RDF + foliar application of 2% DAP and NAA 40ppm + 3% seaweed extract on 30 and 45 DAS, T_7- RDF + foliar application of 1% potassium sulphate + 3% seaweed extract on 30 and 45 DAS, T_8 - RDF + foliar application of 1% TNAU Pulse wonder + 3% seaweed extract on 30 and 45 DAS, T_9 - RDF + foliar application of 2% poly feed + 3% seaweed extract on 30 and 45 DAS, T_{10} - RDF + foliar application of 2% DAP and NAA 40ppm + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS,T_{11} - RDF + foliar application of 1% potassium sulphate + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS, T_{12} - RDF + foliar application of 1% TNAU Pulse wonder + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS, T_{13} - RDF + foliar application of 2% poly feed + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS. The experiment was laid out in an randomized block design, with replicated thrice with thirteen treatments. Among the different treatments tried, application of RDF + foliar application of 1% TNAU Pulse wonder, 3% seaweed extract, 2% humic acid, and fulvic acid on 30 and 45 DAS (T_{12}) recorded the higher growth attributes such as plant height, leaf area index, dry matter production, number of effective root nodules plant^{-1}, number of branches plant^{-1}, andseed yield (1583 kg ha^{-1}) and haulm yield (3561 kg ha^{-1}). This was followed by application of RDF + foliar application of 2% poly feed + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS (T_{13}). The lower values of growth, yield attributes and yield of greengram were recorded in the treatment with the application of RDF + water spray (T_1). Therefore it can be concluded that application of RDF + foliar application of 1% TNAU Pulse wonder, 3% seaweed extract, 2% humic acid, and fulvic acid on 30 and 45 DAS along with RDF is viable practice to enhance the growth and yield of irrigated greengram.

Keywords: Greengram, growth, yield, foliar nutrition

Introduction
Pulses are edible dry seeds of plants in the leguminous family that are consumed in the form of whole seeds, split grains and flour in India. Pulses contain protein, dietary fibre, numerous vitamins and minerals and aid in the management of malnutrition. India is the world's largest producer and consumer of pulses, which are an essential part of the Indian diet. The yearly pulse consumption in India is estimated at around 28 million tonnes. Over the last five years, our domestic production has expanded, resulting in a major decrease in imports. India is on its way to becoming self-sufficient in pulses (Kamaleshwaran and Karthiga, 2021) [10]. Pulses cover approximately 85.40 million hectares worldwide, yielding 87.40 million tonnes and a productivity of 1023 kg ha^{-1}. Pulses are grown on 29.03 million hectares in India, with a total yield of 23.40 million tonnes and a productivity of 806 kg ha^{-1}. In Tamil Nadu, the total area under pulses is 0.83 million hectares, with a yield of 0.57 million tonnes and a productivity of 687 kg ha^{-1} (Ministry of Agriculture, Government of India, 2019). Greengram (*Vigna radiata* L.) is a high-protein staple. It contains approximately 25% protein, which is nearly three times that of grains. It is consumed as split pulses as well as whole pulses and is an important addition to a cereal-based diet. Greengram increases soil physical qualities and fixes nitrogen from the atmosphere. Greengram covers 4.5 million hectares in India, producing 2.5 million tonnes with a productivity of 548 kg ha^{-1}.

In Tamil Nadu, the total area under greengram is 1.95 lakh hectares with a production of 0.89 lakh tonnes and a productivity of 444 kg ha^{-1} (India Stat, 2019) [7].

A greengram crop normally produces a large number of flowers, but only a few remain and develop into pods. The crop suffers from excessive vegetative growth, poor harvest index and low yield, mainly due to poor pod setting in spite of the fact that the flowering is profuse if these potential yield barriers could be alleviated by any means, yield enhancement and an improvement in the quality of greengram could be achieved (Kunjammal and Sukumar, 2019) [16]. Though greengram is an important pulse crop in India, its average yield is low, far from its satisfactory or potential level. It is advisable to grow the crop during spring or summer in medium or upland situations, which are mostly kept fallow during this period. Therefore, there is a scope for augmentation of its yield through agronomic manipulation. Hence, there is a need for the enhancement of the productivity of greengram by correct scientific discipline practices. Several ways are being initiated to boost the productivity of greengram. One among them is foliar application of organic and inorganic sources of nutrients for exploiting the genetic potential of the crop. The soil applied nutrients bear many changes and losses that occur through leaching and volatilization. Therefore, foliar application of nutrients is imperative in order to avoid or minimise the severity of such conditions and found to be inexpensive way to meet nutrient needs of greengram especially at critical stages. The extent of flower drop determines the yield attributing characteristics and yield of greengram. Retention of flowers by the plant gives a higher yield than expected. Several studies on different crops conducted by different scientists around the world and India revealed that flower retention is possible through foliar application of growth regulators as well as macro nutrients during flower initiation and pod development stages, in addition to soil application of nutrients. Foliar application is said to help plants use nutrients quickly and effectively, stop losses from leaching and fixation (Manonmani and Srimathi, 2009 and Sharma Sardana and Sukhvinder Singh, 2013) [18, 26]. Therefore, we tried different foliar applications such as DAP, potassium sulphate, TNAU Pulse wonder, polyfeed, naphthalene acetic acid, humic acid, fulvic acid and seaweed extract in this present study to boost the growth and yield components of irrigated greengram.

Materials and Methods

A field experiment was conducted in the farmers' field in Ambagarathur Village, Thirunallar Taluk, Karaikal District of Puducherry during June – September, 2021 to study the effect of foliar nutrition on growth and yield of irrigated greengram. The experimental field was located at 11º8′ North Latitude and 79º50′ East Longitude with an elevation of +4m above mean sea level. The texture of the experimental field soil was sandy clay loam with a neutral pH and levels of accessible nitrogen, phosphorus, and potassium that were low, high, and high, respectively. The treatment details are T_1- RDF + water spray (control), T_2- RDF + foliar application of 2% DAP and NAA 40ppm on 30 and 45 DAS, T_3- RDF + foliar application of 1% potassium sulphate on 30 and 45 DAS, T_4- RDF + foliar application of 1% TNAU Pulse wonder on 30 and 45 DAS, T_5- RDF + foliar application of 2% poly feed on 30 and 45 DAS, T_6 - RDF + foliar application of 2% DAP and NAA 40ppm + 3% seaweed extract on 30 and 45 DAS, T_7- RDF + foliar application of 1% potassium sulphate + 3% seaweed extract on 30 and 45 DAS, T_8 - RDF + foliar application of 1% TNAU Pulse wonder + 3% seaweed extract on 30 and 45 DAS, T_9 - RDF + foliar application of 2% poly feed + 3% seaweed extract on 30 and 45 DAS, T_{10} - RDF + foliar application of 2% DAP and NAA 40ppm + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS,T_{11} - RDF + foliar application of 1% potassium sulphate + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS, T_{12} - RDF + foliar application of 1% TNAU Pulse wonder + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS, T_{13} - RDF + foliar application of 2% poly feed + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS. The experiment was laid out in randomised block design with three replications. The popular greengram variety VBN 4 was used in this study. The seeds were dibbled at the rate of 20 kg $ha^{-1}$with a spacing of 30 × 10 cm. The foliar nutritions were applied on 30 and 45 DAS as per the treatment schedule. Observations on growth attributes were recorded on 45 and 60 DAS and yield attributes and yield were recorded at harvesting stage of irrigated greengram.

Results and Discussion

Growth attributes

The foliar application of micronutrients, growth regulators, seaweed extract, humic, and fulvic acid to greengram strongly influenced on the growth parameters of irrigated greengram. A thorough inspection of the data in Table1 revealed that RDF + foliar application of 1% TNAU Pulse Wonder + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS (T_{12}) recorded significantly higher plant height (54.60 and 65.29 cm at 45 and 60 DAS, respectively), leaf area index (3.48), dry matter production (2830 and 4887 kg ha^{-1} at 45 and 60 DAS, respectively), number of effective root nodules $plant^{-1}$ (34.47) and number of branches $plant^{-1}$ (7.43) of irrigated greengram. The cumulative and conjunctive application of balanced nutrients to the crop might have provided sufficient nutrient condition for a longer period of time and the nutrients might have been uptake there by allowing the plant to perpetuate with all the growth attributes in the treatment. These results are in accordance with the findings of Bhoopathi (2012) [2] and Babu (2017) [1]. This is also due to the positive influence of foliar spray of nutrients on cell division and cell elongation, which facilitates better crop growth and development. Similar findings were reported by Cheghakhor *et al.* (2009) [3] and Karthikeyan *et al.* (2020) [11]. Conjoint foliar application of TNAU Pulse wonder, seaweed extract, humic and fulvic acid along with the recommended dose of fertilizer served as an excellent source of supplying micro and macro nutrients, trace elements, amino acids, plant growth promoting hormones, vitamins, antibiotics, carbohydrates, proteins and other organic matters exhibits plant growth stimulating properties(Moshe *et al.*, 2015) [23], which increased the various growth traits in greengram(John and Mahadevi, 2014) [9] and nutrient uptake by plants (Dwivedi *et al.*, 2015) [4] and led to higher dry matter accumulation (Pramnick *et al.*, 2017) [25] and Iswarya *et al.* (2019) [8]. The application of RDF + foliar spray of micronutrients resulted in the highest number of nodules, which was significantly greater than the other treatments. Increased nodule count and rhizobial colonisation in the rhizosphere as a result of foliar application of TNAU Pulse Wonder, seaweed extract, humic and fulvic acid. These findings are supported by Meena *et al.* (2012) [19] and Kavya *et al.* (2021) [12].

Table 1: Effect of foliar nutrition on growth attributes of irrigated greengram

Treatments		Plant height (cm)		Leaf area index	Dry matter production (kg ha^{-1})		Number of effective root nodules plant^{-1}	Number of branches plant^{-1}
		45 DAS	60 DAS	At flowering stage	45 DAS	60 DAS		
T_1	RDF + Water spray	33.17	40.48	2.03	1771	2219	21.01	3.44
T_2	RDF + DAP 2% + NAA 40ppm spray on 30 and 45 DAS	37.75	46.92	2.45	2046	2995	25.61	4.81
T_3	RDF + potassium sulphate 1% spray on 30 and 45 DAS	35.26	43.46	2.21	1908	2541	23.31	4.11
T_4	RDF + TNAU pulse wonder 1% spray on 30 and 45 DAS	37.99	48.16	2.49	2089	3158	26.50	4.98
T_5	RDF + poly feed 2% spray on 30 and 45 DAS	42.0	52.20	2.74	2260	3620	28.35	5.65
T_6	RDF + DAP 2% + NAA 40ppm + sea weed extract 3% spray on 30 and 45 DAS	42.87	53.28	2.76	2294	3694	29.20	5.78
T_7	RDF + potassium sulphate 1% +sea weed extract 3% spray on 30 and 45 DAS	35.61	44.44	2.25	1925	2679	24.27	4.30
T_8	RDF + TNAU pulse wonder 1% + sea weed extract 3% spray on 30 and 45 DAS	45.24	56.24	2.92	2442	3984	30.40	6.17
T_9	RDF + poly feed 2% + sea weed extract 3% spray on 30 and 45 DAS	41.25	50.90	2.67	2219	3461	27.58	5.44
T_{10}	RDF + DAP 2% + NAA 40ppm + sea weed extract 3%+ Humic acid and fulvic acid 2% spray on 30 and 45 DAS	49.46	60.00	3.12	2590	4365	32.42	6.75
T_{11}	RDF +potassium sulphate 1% +sea weed extract 3%+ Humic acid and fulvic acid 2% spray on 30 and 45 DAS	46.22	57.50	2.95	2469	4125	31.35	6.35
T_{12}	RDF + TNAU pulse wonder 1% + sea weed extract 3% + Humic acid and fulvic acid 2% spray on 30 and 45 DAS	54.60	65.29	3.48	2830	4887	34.47	7.53
T_{13}	RDF +poly feed 2% + sea weed extract 3%+ Humic acid and fulvic acid 2% spray on 30 and 45 DAS	52.30	62.16	3.29	2710	4639	33.49	7.14
S.Em±		0.75	1.05	0.07	33.28	58.51	0.27	0.12
CD (p=0.05)		1.87	2.10	0.15	98	171	0.97	0.37

Yield attributes

The highest values of yield attributes such as number of pods plant^{-1} (32.43) and number of seeds pod^{-1}(9.00) were recorded under RDF + foliar application of 1% TNAU Pulse wonder + 3% seaweed extract + 2% humic acid and fulvic acid on 30 and 45 DAS (Table 2). This could be because the inclusion of major and minor nutrients in TNAU Pulse wonder and seaweed extract, along with growth regulators, encouraged a better rate of nutrient absorption for stronger crop growth and establishment. Furthermore, humic and fulvic acid provide nutrients, growth hormones, and enzymes that aid in the efficient partitioning and translocation of photosynthetic assimilates to sink. Also, foliar nutrients increased the number of flower buds and stopped flowers from falling at of plants by keeping bio-physiological conditions at their best. This would have caused greengram to have higher yield-attributing characters. The current study's findings are consistent with those of Muhammad Hamayun *et al.* (2011) [24], (Hamayun and Chaudhary, 2014) [6], Mohammad Aslam *et al.* (2019) [21], and Krishnaveni *et al.* (2021) [15]. The greengram test weight had no significant impact.

Yield

The application of RDF in conjunction with foliar sprays of TNAU Pulse wonder at 1%, seaweed extract at 3%, humic acid and fulvic acid at 2% on 30 and 45 DAS recorded the highest seed yield (1583 kg ha^{-1}) and haulm yield (3561 kg ha^{-1}) over the rest of the treatments(Table 2). The consistent improvement in yield attributes with the prescription of a recommended dose of NPK in conjunction with foliar application of beneficial inputs such as TNAU Pulse wonder, seaweed extract, humic and fulvic acid may have resulted in higher post-flowering photosynthesis and assimilate apoplast and symplast movement, ultimately contributing to the production of a higher seed yield. Similar findings were reported by Kaya *et al.* (2005) [14], Babu (2017) [1], and Krishnaveni *et al.* (2021) [15]. The higher haulm yield could be attributed to the beneficial effect of nutrients combined with growth regulators applied at the appropriate time and stage, which resulted in a continuous supply of nutrients and plant growth promoting substances, particularly cytokinin, which could have increased morpho-physiological parameters such as plant height, number of branches, leaf area and dry matter production resulting in a higher haulm yield in treatment T_{12}. The lowest seed and haulm yields were observed under control. These findings are consistent with those of Kuttimani and Velayutham (2011) [17], Minakshi *et al.* (2018) [20], Mohammad Aslam *et al.* (2019) [22] and Kamaleshwaran and Karthiga (2021) [10].

Table 2: Effect of foliar nutrition on yield attributes and yields of irrigated greengram

Treatments		Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	RDF + Water spray	14.91	3.46	3.59	683	1652
T_2	RDF + DAP 2% + NAA 40ppm spray on 30 and 45 DAS	19.08	5.08	3.65	915	2231
T_3	RDF + potassium sulphate 1% spray on 30 and 45 DAS	16.82	4.04	3.67	765	1909
T_4	RDF + TNAU pulse wonder 1% spray on 30 and 45 DAS	20.15	5.35	3.64	975	2349
T_5	RDF + poly feed 2% spray on 30 and 45 DAS	22.46	6.00	3.62	1106	2645
T_6	RDF + DAP 2% + NAA 40ppm + sea weed extract 3% spray on 30 and 45 DAS	23.41	6.36	3.68	1161	2723
T_7	RDF + potassium sulphate 1% +sea weed extract 3% spray on 30 and 45 DAS	17.18	4.19	3.69	836	1984
T_8	RDF + TNAU pulse wonder 1% + sea weed extract 3% spray on 30 and 45 DAS	25.40	7.10	3.62	1278	2916
T_9	RDF + poly feed 2% + sea weed extract 3% spray on 30 and 45 DAS	22.22	5.97	3.63	1096	2547
T_{10}	RDF + DAP 2% + NAA 40ppm + sea weed extract 3%+ Humic acid and fulvic acid 2% spray on 30 and 45 DAS	28.56	7.80	3.64	1421	3173
T_{11}	RDF +potassium sulphate 1% +sea weed extract 3%+ Humic acid and fulvic acid 2% spray on 30 and 45 DAS	26.52	7.24	3.70	1347	2995
T_{12}	RDF + TNAU pulse wonder 1% + sea weed extract 3% + Humic acid and fulvic acid 2% spray on 30 and 45 DAS	32.43	9.00	3.69	1583	3561
T_{13}	RDF +poly feed 2% + sea weed extract 3%+ Humic acid and fulvic acid 2% spray on 30 and 45 DAS	30.47	8.38	3.65	1503	3381
S.Em±		0.52	0.15	0.15	20.30	20.30
CD (*p*=0.05)		1.88	0.55	NS	72.57	72.57

Conclusion

In the light of the above experimental results, it can be concluded that foliar application of 1% TNAU Pulse wonder, 3% seaweed extract and 2% humic and fulvic acid on 30 and 45 DAS along with 100% recommended dose of fertilizer (25:50:25 kg N, P_2O_5 and K_2O ha^{-1}) is an effective practice for enhancing the growth and yield of irrigated greengram. Furthermore, this practise holds promises for greengram farmers as an agronomically sound, environmentally safe and cost effective approach.

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