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Recent advances in the application of seaweed extract and Nano-DAP for sustainable green gram production: A review

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Abstract

Green gram (*Vigna radiata* L.) is one of the important pulse crops which is rich in protein and biological nitrogen fixers useful to soil fertility. It suffers from low yields due to low nutrient availability and low nutrient-use efficiency. The present review is intended to assess the growth, yield, quality and nutrient uptake of green gram under the influence of seaweed extract and Nano-DAP. Seaweed extracts contain a high concentration of plant growth regulators, amino acids, vitamins and micronutrients which stimulate physiological and biochemical processes leading to better plant growth, chlorophyll synthesis and nutrient uptake. Nano-DAP is a nano-fertilizer with nitrogen and phosphorus which has a positive effect on nutrient use efficiency as it helps in quick absorption and transportation of nutrients within the plant. Application of seaweed extract and Nano-DAP has shown to be effective in enhancing growth parameters like plant height, leaf area, dry matter accumulation and nodulation. The inputs also improve yield parameters such as pods/plant, seeds/pod, test weight and yield/seed. In addition, enhanced protein content in seeds, nutrient uptake and crop quality have been reported. Seaweed extract and Nano-DAP are a promising option to achieve sustainable nutrient management as they improve the productivity of the crops and decrease reliance on conventional nutrient sources. Hence, utilization of these new nutrient sources can help to achieve better growth, yield, quality, and nutrient use efficiency in green gram production.

Keywords: Crop, greengram, growth, nano-fertilizer, nutrient uptake, sea-weed extract, yield

1. Introduction

Green gram (*Vigna radiata* L.) is also known as mung bean, is a warm season legume crop that is widely cultivated in tropical and subtropical regions of India. It serves as a good source of proteins, vitamins and minerals and is an important crop in nitrogen fixation, thus enhancing the fertility of the soil. Green gram growth and development is sensitive to various environmental factors like temperature, light, availability of water and nutrients. Nutritive value of mung bean is very high as it contains 24.3% protein, 124 mg/100 g calcium, 1.3% fat, 326 mg/100 g phosphorus, 3.5% minerals, 7.3 mg/100 gm iron, 4.1% fiber, 56% carbohydrate, 10% moisture with calorific value of 334 kcal/100 g (Choudhary *et al.*, 2025) [2]. Pulses offer several health benefits: They are a good source of vitamin C and contain enough vitamin K, which is great for weight loss and weight management; They are also rich in fibre which is helpful for diabetes control; They are helpful in reproductive health, fight against heart disease, strengthen immune system and have anti-cancer properties. Green gram or mungbean is a protein rich and is rich in thiamine and riboflavin, phosphorus and iron. Lysine (4600 mg/g) and Tryptophan (60 mg/g) are the components of Green gram. Phosphorus has to be involved in a chain of critical plant structures and act as a catalysis in the main biochemical reaction in plants (Chundawat *et al.*, 2025) [3]. In India, green gram is the most important pulse crop which can be sown in summer (March-June), *Kharif* (July-October) and *Rabi* (October-December) season. It can be sown in southern States of India during *Kharif* and *Rabi* seasons. But in northern States it can be raised both in Spring season as well as *Kharif* season. It can be affected by excess rainfall during *Kharif* season while during summer season, it will yield good crop because of lesser rain and attack of insect pests and diseases on it. Irrigation requirement of green gram, which is cultivated in the rainy season is more than the demand of *kharif* season crop (Bharath *et al.*,

2025) ^[1]. The seed germination and development of the plant (N-fixation during early vegetative stage) is adversely affected by continuous stagnation of water in the field, which requires high temperature and low humidity, with moderate rainfall of 60-80 cm. Spring green gram is generally grown under assured irrigation areas in Indo Gangetic plains of Northern India. The mung bean requires well drained sandy to loamy soil and requires optimum growth and development at pH 6-7 soil conditions. Green gram is among the pulses and is the primary pulse crop grown mostly during the rainy season (*kharif* season) in India with 69% of the area under green gram (Magar *et al.*, 2025) ^[8].

Although Green gram is a crop of great usefulness, the crop yield is often restricted by several biotic and abiotic stresses such as low soil fertility, water stress, pests, and diseases. To maximise the production of Green gram is thus important for improving food security in countries where there is high population and high dependency on agriculture such as India. New farming technologies and inputs are viewed as a means to overcome these constraints. Bio-enhancers like Nano-DAP (Nano Diammonium Phosphate) and seaweed extract have emerged as interesting potential bio-enhancers for crop growth and productivity in this context. Nano fertilizers are smaller sized which provide superior solubility, availability of nutrients and plant uptake resulting in improved plant growth and yield (Sartaj *et al.*, 2025) ^[12]. Seaweed extracts, however, have been used for their natural growth promoting properties and include hormones such as auxins, cytokinins, and gibberellins that can stimulate plant growth, increase plant resistance to environmental stress, and improve the uptake of nutrients. This is an emerging research field on integration of bio-stimulants (Nano-DAP and Seaweed Extract) in the cultivation of Green gram that has the potential to revolutionize yield maximization strategies (Varghese *et al.*, 2025) ^[14]. The nutrient uptake efficiency is improved by providing Nano-DAP in slow-release form which is a limiting nutrient in leguminous crops such as Green gram. These products together with Seaweed Extract, which has been proven to increase plant resistance to drought, salinity and disease can synergistically enhance plant growth and yield potential under variable environmental conditions (Peshin *et al.*, 2022) ^[10]. The objective of this study is to investigate the effect of Nano-DAP and Seaweed Extract on growth, development and yield of summer Green gram. The study aims to provide practical implications for improving yield, sustainability, and profitability for Green gram farmers in areas where yield improvement is critical to ensure food security while grasping the factors that influence the plant's physiological processes, nutrient utilization, and stress response. It may provide a viable route to enhance agricultural performance in the context of climate change, resource constraints and increased productivity and sustainability of farming.

2. Effect of sea weed extract and nano-DAP on crop growth of green gram

Sea weed extract and Nano-DAP are crucial for growth of green gram crop. Green gram (*Vigna radiata* L.) is one of the significant pulse crops, which is severely affected by nutrient deficiency and abiotic stress. In recent years, the application of seaweed extracts as biostimulants and Nano-DAP as an advanced nutrient source have become a subject of interest to promote crop growth, nutrient use efficiency, and productivity. The positive effect of their application on growth parameters like plant height, leaf area, dry matter accumulation, nodulation, chlorophyll content and biomass production has been

demonstrated in several studies. The extracts of seaweed have plant growth regulators such as auxins, cytokinins, gibberellins, amino acids, vitamins, micronutrients and polysaccharides, which stimulate physiological and biochemical processes in plants. They help seeds to germinate, get roots growing and developing, enhance photosynthetic activity and uptake of nutrients. Iswarya *et al.* (2019) ^[6] reported that, the seed soaking with 0.1% seaweed extract and foliar application of 0.25% seaweed extract at 25 & 35 DAS significantly improved the growth parameters of greengram. The treatment significantly produced the tallest plant (56.06 cm), most root nodules (10.06 plant⁻¹), root volume (3.41 g cc⁻¹), most branches per plant (3.13) and the dry matter production (3795 kg ha⁻¹) over the untreated control. Better vegetative growth was also seen in the form of an enhanced chlorophyll content (52.63 SPAD value) and improved nutrient uptake. Gowrisanker *et al.* (2024) ^[5] has assessed various extracts of seaweed on green gram cv. VBN-2 discovered that *Kappaphycus alvarezii* extract when used as seed treatment with 12 hours significantly improved the growth traits, Physiological parameters and yield attributes. The treatment helped to produce earlier flowering and better vegetative growth than the untreated seeds.

Thangaraj *et al.* (2023) ^[13] studied the effect of seaweed fertilizer prepared from marine algae on the growth and productivity of mung bean and concluded that seaweed fertilizer significantly enhanced growth and productivity of mung bean. The biostimulant effect of seaweed-based fertilizers on crop growth was observed as *Padina hornemannii* at 30% concentration showed the highest seed production of 15.57 g plant⁻¹. The findings of the recent study by Dhar *et al.* (2025) ^[4] also showed that growth performance and vigor of summer mung bean were enhanced due to physiological efficiency and nutrient utilization processes using seaweed as a seed priming material and foliar treatment. Nano-DAP is a nanotechnology P-fertiliser providing P & N in nano sized particles, leading to better NUE (nutrient use efficiency) and less nutrient losses. The overall crop growth is improved due to Nano-DAP's ability to increase root growth, photosynthesis, cell division, energy transfer and nodulation. Magar *et al.*, (2025) ^[8] studied Nano-DAP and Nano Urea applied on the leaf surface of Green Gram. The study showed that treated with 75% RDF + foliar spray of Nano-DAP (0.4%) at 45 DAS, the growth parameters were found to be better and the growth of plants is turned out to be similar with 100% RDF. An increase in plant height, dry matter and vigour were related to increased nutrient availability and uptake. Paymal *et al.* (2025) ^[9] reported that Nano DAP at 4 ml L⁻¹ twice (at 30 and 40 DAS) and 75% RDF significantly improved plant growth, yield attributes and economic return in green gram. Improved availability of phosphorus during critical growth stages was correlated with increased growth. Similarly, Kumar *et al.* (2025) ^[7] noted that application of RDF @ 4 ml L⁻¹ at 30 DAS recorded the highest plant height, dry matter accumulation, seed yield (1214 kg ha⁻¹) and biological yield (3972 kg ha⁻¹) in comparison with the Nano-DAP application. The study showed that vegetative growth and biomass production of green gram could be effectively enhanced by using Nano DAP in the fields.

3. Effect of sea weed extract and nano-DAP on yield of green gram

Sea weed extract and nano-DAP had shown positive effect on yield attributes of green gram. Improvement in green gram yield is highly dependent upon the efficient utilization of nutrients and better physiological activity during flowering and pod

development stage. Among the inputs, extracts of seaweeds and Nano-DAP are promising which enhances the yield attributes like pods plant⁻¹, seeds pod⁻¹, test weight, seed yield and biological yield. Seaweed extracts are rich in endogenous growth promoters such as auxins (indole acetic acid), cytokinins, gibberellins, amino acids, vitamins and micronutrients which stimulate flower initiation, fruit setting and seed filling leading to higher yields. Grain yield of green gram was 1248 kg ha⁻¹ with 0.1% seaweed extract soaked seeds and 0.25% seaweed extract foliar spray at 25 and 35 DAS respectively, which is significantly higher compared to untreated control with 1076 kg ha⁻¹ and dry matter production was 3795 kg ha⁻¹ compared to 1076 kg ha⁻¹ in untreated control (Iswarya *et al.*, 2019) [6]. This yield increase was attributed to the increased chlorophyll content, nutrient uptake and photosynthetic efficiency. Pramanick *et al.* (2013) [11] tested foliage application of *Kappaphycus* and *Gracilaria* seaweed sap at different concentrations and observed that application of 15% *Kappaphycus* sap with RDF result in 38.97% higher grain yield while 15% *Gracilaria* sap with RDF produce 33.58% higher grain yield than control. The same, Zodape *et al.* (2010) [15] concluded that application of 10% extract of *Kappaphycus alvarezii* at flowering time significantly increased the seed yield by 30.11% compared to the control. The increment was correlated with higher pod number, pod weight, seed yield per plant and 100 seed weight.

According to Gowrisanker *et al.* (2024) [5], the seed yield and seed yield attributes of green gram cv. showed significant improvement over the control (water treatment) when treated with 2.5% extract of *Kappaphycus alvarezii* for 12 hours, which indicates that it had excellent pod characters. VBN-2 vs. untreated seeds. The application of Nano-DAP offers the advantage of supplying phosphorus and nitrogen in a nano-sized particle which results in higher nutrient-use efficiency, lower nutrient losses and increased nutrient availability during the reproductive stage. Better phosphorus nutrition results in flowering, pod formation, seed development and final yield. In the field experiment Kumar *et al.* (2025) [7] performed in Rajasthan, the highest seed yield (1214 kg ha⁻¹), haulm yield (2758 kg ha⁻¹), and biological yield (3972 kg ha⁻¹) were recorded with 100% RDF + Nano-DAP @ 30 DAS in green gram. Magar *et al.* (2025) [8] revealed that 75% RDF + 0.4% Nano-DAP spray at 45 DAS did not differ significantly from recommended fertilizer application rate (100% RDF) regarding yield attributes and seed yield. The study showed that Nano-DAP can replace in part the use of conventional fertilizers without affecting productivity. In another study, Magar *et al.* (2025) [8] found that the seed yield of 75% RDF + 0.4% Nano Urea at 25 DAS and 0.4% Nano-DAP at 45 DAS was similar to 100% RDF suggesting the role of Nano-DAP in maintaining yield with lower fertilizer input.

4. Effect sea weed extract and nano-DAP on quality and nutrient uptake

In Green Gram, important grower's quality parameters and nutrient uptake are important indicators of crop performance. Better nutrient availability leads to better protein synthesis, seed quality and nutrient accumulation in plant tissues. Use of seaweed extract and Nano-DAP has been reported to increase nutrient absorption, translocation and utilization leading to better seed quality and nutrient uptake. The extracts from seaweeds contain a lot of macro- and micronutrients, amino acids, vitamins, polysaccharides and plant growth regulators. These compounds activate growth of the roots, increase absorption and

metabolism of nutrients, and increase metabolism related to protein synthesis and seed development. Iswarya *et al.*, 2019 [6], reported that 0.1% seaweed extract treated seeds and 0.25% seaweed extract foliar spray at 25 and 35 DAS enhanced the chlorophyll content (52.63 SPAD value), protein content and nutrient uptake in green gram. The treatment with the highest uptake of nitrogen, phosphorus and potassium was because of the better root activity and photosynthetic efficiency. Pramanick *et al.* (2013) [11] found that foliar application of 15% *Kappaphycus* sap in combination with recommended fertilizer dose significantly increased the uptake of nutrients by green gram. The uptake of Nitrogen was 81.23 kg/ha, Phosphorous was 8.84 kg/ha and Potassium was 41.84 kg/ha in the treated plants whereas it was considerably less in the control plants. This improvement was explained as due to the improved absorption and translocation of nutrients as a result of the bioactive compounds produced by the seaweeds. Zodape *et al.* (2010) [15] reported that foliar spray with extract of *Kappaphycus alvarezii* significantly enhanced the quality of the seeds with protein content increased from 21.71% in control to 23.94% in treated plants. Better acquisition of some critical minerals like iron, zinc, copper and manganese in the seeds was also observed, which highlights better nutrient acquisition and assimilation. Thangaraj and Jayasri (2023) [13] found that marine algae-based seaweed fertilizer enhanced nutrient uptake and protein accumulation in mung bean seeds. The maximum amount of seaweed extract gave significantly higher uptake of N, P and K resulting in better seed quality and productivity. Nano-DAP is a special formulation that provides phosphorus and nitrogen in an easily absorbed form by the leaves and roots, resulting in a higher efficiency of nutrient use. Better phosphorus nutrition enhances energy transfer, biological nitrogen fixation, protein synthesis and accumulation of nutrients in seeds. In the case of green gram, foliar application of 0.4% Nano-DAP at 45 DAS with 75% RDF was found to be effective to enhance nutrient uptake and nutrient-use efficiency (NUE) (Magar *et al.* 2025) [8]. The treatment resulted in higher N and P availability in the reproductive growth phase, resulting in improved seed development and quality. It was observed that nutrient uptake, protein synthesis and seed quality parameters were significantly improved under application of Nano-DAP with 30 and 40 DAS along with 75% RDF than conventional fertilization alone (Paymal *et al.*, 2025) [9]. Phosphorus uptake increased root activity and biological nitrogen fixation enhancing nitrogen accumulation in the seeds. The highest nutrient uptake and seed quality were achieved by 100% RDF + Nano-DAP @ 4 ml L⁻¹, reported by Kumar *et al.* (2025) [7]. The better quality of the produce and increased biomass production were due to enhanced phosphorus availability that led to better nodulation, nitrogen fixation and protein formation.

5. Conclusion

Growth, yield, quality and nutrient uptake of green gram are greatly influenced by the application of seaweed extract and Nano-DAP. The seaweed extract is a natural biostimulant that provides plant growth regulators, amino acids and micronutrients and Nano-DAP increases the efficiency of nutrient use by delivering Nitrogen and Phosphorous efficiently. The use of these inputs improves plant growth, chlorophyll content, nodulation, dry matter accumulation, yield attributes and seed yield. They also improve the protein content, nutrient assimilation and crop quality. Research has proven that seaweed extract in combination with judicious use of Nano-DAP can enhance crop performance and lower the usage of conventional

fertilizers. So the use of seaweed extract and Nano-DAP in the integrated nutrient management system is a must for the higher production, quality and sustainable cultivation of green gram.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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