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Yield and economics of Black gram (*Vigna mungo* L.) as influenced by foliar spray of nutrients and growth regulators

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Abstract
A field experiment was conducted at Agronomy Section, College of Agriculture, Latur during *kharif* season of 2022 to study the effect of foliar spray of nutrients and growth regulators in black gram (*Vigna mungo* L.). The soil of experimental plot was clayey loam. The experiment was laid out in a Randomized Block Design, with eight treatments and was replicated thrice. The treatments consist of T_1- Control, T_2- Foliar application of 22% seaweed extract at flower initiation, T_3- Foliar application of 0.2% micronutrient grade 2 at flower initiation, T_4- Foliar spray of 30 ppm GA_3 at flower initiation, T_5- Foliar application of 40 ppm NAA at flower initiation, T_6 - Foliar spray of 2% urea at flower initiation, T_7- Foliar application of 1% NPK (19:19:19) at flower initiation, T_8 - Foliar spray of 2% DAP at flower initiation. Among the different treatments, foliar application of 22% seaweed extract at flower initiation (T_2) recorded higher growth and yield attributes such as plant height (cm), number of branches plant^{-1}, total dry matter production (g), seed yield (kg ha^{-1}) and straw yield (kg ha^{-1}). This was followed by foliar application of 1% NPK (19:19:19) at flower initiation (T_7) and foliar application of 30 ppm GA_3 at flower initiation (T_4). The lower values of growth and yield attributes of black gram were recorded in the treatment of Control (T_1). Therefore, it can be concluded that foliar application of 22% seaweed extract at flower initiation (T_2) is viable practice to enhance the growth and yield of irrigated black gram.

Keywords: Black gram, growth, yield, foliar spray, foliar application

Introduction
Pulses are wonderful gift of nature with unique ability of biological nitrogen fixation, deep root system, mobilization of insoluble soil nutrients and bringing qualitative changes in soil properties which restores fertility of soil. Among pulses, black gram [*Vigna mungo* (L.) Hepper] is one of the most chief pulse crop of rainfed areas grown throughout the country. This crop is grown in diverse cropping system as a mixed crop, catch crop and sequential crop in the country. Black gram (*Vigna mungo* L.) belongs to family Leguminoceae. The plant attains a height of 30 to 100 cm. The leaves are large, trifoliate and are also hairy, generally with a purplish tinge. The pods are long and cylindrical and about 4 to 6 cm in length. This crop is itself a mini-fertilizer factory as it has unique characteristics of maintaining and restoring soil fertility through fixing atmospheric nitrogen in symbiotic association with rhizobium bacteria present in the root nodules. Black gram (*Vigna mungo* L.) is also known as black MATPE bean, urid, Urd bean or Urad. It is widely grown in southern Asia as a grain legume and assumes considerable importance with respect to it's nutritional value. It contains 24% protein, 60% carbohydrate, 1.3% fat, 3.2% minerals, 0.9% fiber, 154 mg calcium, 385 mg phosphorus, 9.1 mg iron and small amount of vitamin B-complex. It is popularly grown as short durational (75-80 days) pulse crop as it thrives better in all seasons either as sole, inter, mixed or fallow crop. As India is its primary origin and is mainly cultivated in Asian countries including parts of southern Asia. India is the world's largest producer as well as consumer of black gram. Black gram producing major states in India are Andhra Pradesh, Madhya Pradesh, Rajasthan, Uttar Pradesh, Tamil Nadu and Maharashtra. In *kharif* 2021-22, black gram production in India was 20.5 lakh tonnes (1st advance estimates) in an area of 39.43 lakh hectares (Anonymous, 2021) [3]. In Maharashtra, it is grown on area 5.54 lakh ha with production of 3.72 lakh ha and productivity 672 kg ha^{-1} (Anonymous, 2021) [3]. The major black gram producing districts in Marathwada region are Parbhani, Nanded, Latur, Hingoli, Beed, Chhatrapati Sambhajinagar and Dharashiv. The area under black gram in Latur district is about 1,017.13 hundred ha^{-1} with production of 497.84 hundred tonnes and productivity of 489.46 kg ha^{-1} (Anonymous, 2021) [3]. Foliar nutrition is found to have an important method of

fertilizer application since foliar nutrients easily penetrate the leaf cuticle or stomata and enters the cells facilitating easy and rapid consumption of nutrients. It has an advantage of quick and efficient utilization of nutrients, elimination of losses through leaching, fixation and regulating the uptake of nutrients by plants (Manonmani & Srimathi, 2009) [8]. It increases the photosynthetic rate, better nutrient translocation from leaves to the developing seeds. It is most economical way of fertilization to achieve quality production and yield while nutrient uptake from the soil is restricted (Thakur *et al.* 2017) [12]. Therefore, it is hypothesized that foliar nutrition in addition to soil application in commensuration with prevailing weather particularly rainfall will go a long way in meeting the crop nutrient need and thereby help in enhancing the productivity. Moreover, foliar feeding practice of nutrients and biostimulants would be more useful in early maturing of crops which could be combined with regular plant protection programme (Jadhav & Kulkarni, 2016) [6]. The water soluble fertilizers such as urea, DAP, 19:19:19 (NPK) and micronutrient grade 2 get readily dissolved in water. If scarce situation occurs and deficiency of nutrients observed in the field at that time foliar application through water soluble fertilizers can be used directly in the form of foliar spray for better consumption and easy nutrient uptake by plants. Urea, DAP and 19:19:19 contains macronutrients N, P, K at a fixed ratio out of which nitrogen promotes growth of a plant and facilitates maximum yield. Phosphorous promotes flowering and root development while, potassium controls movement of stomata and maintains electroneutrality of plant cells. Hence, they are found significant to enhance growth and eventually yield of crop. Foliar application is effective for the application of major micronutrients like iron, zinc, boron, copper, manganese and molybdenum. This is considered to be an efficient and economic method of supplementing part of nutrients requirement at critical stages. Naphthalene Acetic Acid (NAA) is a synthetic plant hormone in the auxin. It reduces flower drop and eventually yield increases. Gibberellic acids are diterpene plant growth regulators that are biosynthesized from geranyl diphosphate, a common C_{20} precursor for diterpenoids, which control miscellaneous aspects of growth and development including seed germination, stem elongation, flowering and pod development. Urea is a diamide of carbonic acid [$CO(NH_2)_2$] which contains 46% (N), Foliar spray of urea improves the photosynthetic rate, vegetative growth, leaf area index and yield of crop. Pulse crops particularly black gram gives well response to foliar spray of urea. Diammonium phosphate (DAP) is the world's most widely used phoshphate fertilizer which contains 46% (P) and 18% (N). The foliar spray of 2% DAP twice at flower initiation and pod formation stages of crop growth results in higher number of pods, number of seed, seed index and higher seed yield. Foliar application of water soluble fertilizer 19:19:19 (NPK) may be a good option which enhances yield of pulse crop and reduces the cost of cultivation. In foliar application of nutrients another best option being used by farmers is the use of seaweed extract as plant nutrient bearing fertilizer. Seaweed extracts are rich in major and minor nutrients, amino acid, vitamins, cytokinins, enzymes and auxin like growth promoting substances thus fulfil the basic requirement of crops and have been reported to stimulate the growth and yield of pulses (Pramanick *et al.* 2013) [10]. As the productivity of black gram in our country is very low, there is need for enhancement of its productivity with proper agronomic practices. One among them is foliar application of nutrient source for maximizing yield potential of the crop. Foliar application has been open up to be favourable in short durational crops where the soil moisture is a limiting factor and the soil-applied fertilizer may not fulfil the basic requirement of nutrients before maturity of the crop. Considering the above facts, the experiment was entitled "Effect of foliar spray of nutrients and growth regulators in black gram (*Vigna mungo* L.)" was planned.

Material and methods

A field experiment was carried out during *kharif* season of 2022 Agronomy Section, College of Agriculture, Latur (Maharashtra) to study the effect of foliar spray of nutrients and growth regulators in black gram (*Vigna mungo* L.). The soil of experimental plot was clayey in texture with chemical composition such as low in available nitrogen (125.3 kg ha^{-1}), very low in available phosphorous (18.2 kg ha^{-1}) and very high in available potassium (498.58 kg ha^{-1}). The soil was slightly alkaline in reaction having pH (7.8). A field experiment was laid out in a Randomized Block Design (RBD) with eight treatments and was replicated thrice. The treatments were T_1 - Control, T_2- Foliar application of 22% seaweed extract at flower initiation, T_3- Foliar application of 0.2% micronutrient grade 2 at flower initiation, T_4- Foliar spray of 30 ppm GA_3 at flower initiation, T_5- Foliar application of 40 ppm NAA at flower initiation, T_6 - Foliar spray of 2% urea at flower initiation, T_7- Foliar application of 1% NPK (19:19:19) at flower initiation, T_8 - Foliar spray of 2% DAP at flower initiation. The gross plot size of each experimental unit was 5.4 m x 4.5 m and net plot size was 4.5 m x 3.9 m. The recommended dose of fertilizer (RDF) was 25:50:00 NPK kg ha^{-1}.

Table 1: Effect of different treatments on yield of black gram

Treatments	Seed Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Biological Yield (kg ha^{-1})	Harvest Index (%)
T_1: Control	1117	2020	3137	32.19
T_2: Foliar application of 22% seaweed extract at flower initiation	1435	3023	4458	36.03
T_3: Foliar application of 0.2% micronutrient grade 2 at flower initiation	1133	2059	3192	33.09
T_4: Foliar spray of 30 ppm GA_3 at flower initiation	1321	2643	3964	35.63
T_5: Foliar application of 40 ppm NAA at flower initiation	1270	2360	3630	35.14
T_6: Foliar spray of 2% urea at flower initiation	1169	2112	3281	33.33
T_7: Foliar application of 1% NPK (19:19:19) at flower initiation	1392	2816	4208	35.65
T_8: Foliar spray of 2% DAP at flower initiation	1174	2167	3341	34.99
SE (m) ±	52.91	157.21	206.47	-
CD @ 5%	154.80	459.92	604.02	-
General mean	1251	2400	3651	34.51

Table 2: Effect of different treatments on economics of black gram

Treatments	Yield (kg ha^{-1})		Economics (Rs. ha^{-1})			B:C ratio
	Seed Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	GMR (Rs.ha^{-1})	CC (Rs.ha^{-1})	NMR (Rs.ha^{-1})	
T_1: Control	1117	2020	77632	36103	41529	2.15
T_2: Foliar application of 22% seaweed extract at flower initiation	1435	3023	99709	36963	62746	2.70
T_3: Foliar application of 0.2% micronutrient grade 2 at flower initiation	1133	2059	78744	36563	42181	2.15
T_4: Foliar spray of 30 ppm GA_3 at flower initiation	1321	2643	91833	36913	54920	2.49
T_5: Foliar application of 40 ppm NAA at flower initiation	1270	2360	88265	37503	50762	2.35
T_6: Foliar spray of 2% urea at flower initiation	1169	2112	81246	36162	45084	2.25
T_7: Foliar application of 1% NPK (19:19:19) at flower initiation	1392	2816	96767	36703	60064	2.64
T_8: Foliar spray of 2% DAP at flower initiation	1174	2167	81593	36373	45220	2.24
SE (m) ±	52.91	157.21	3677	-	3677	-
CD @ 5%	154.80	459.92	10758	-	10758	-
General mean	1251	2400	86973	36660	50313	2.37

Results and Discussions

Yield

Due to different treatments seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) was influenced significantly (Table 1). The higher seed yield (1435 kg ha^{-1}), straw yield (3023 kg ha^{-1}) and biological yield (4458 kg ha^{-1}) was recorded with foliar application of 22% seaweed extract at flower initiation (T_2) which was at par with foliar application of 1% NPK (19:19:19) at flower initiation (T_7) and foliar spray of 30 ppm GA_3 at flower initiation (T_4) and also found significantly superior over rest of the treatments. The control treatment (T_1) observed with lowest seed yield (1117 kg ha^{-1}), straw yield (2020 kg ha^{-1}) and biological yield (3137 kg ha^{-1}). The consistent improvement in seed yield, straw yield and biological yield might be due the prescription of a recommended dose of NPK in conjunction with foliar application of seaweed extract which might have resulted in higher post-flowering photosynthesis, ultimately contributing to the production of higher seed yield. These results are in accordance with the findings of Raja & Geetha (2010) [11], Pramanick *et al.* (2013) [10], Yaseen *et al.* (2017) [13], Ghosh *et al.* (2020) [4], Merhej *et al.* (2021) [9], Huda *et al.* (2023) [5].

Economics

The gross monetary returns (GMR), cost of cultivation (CC), net monetary returns (NMR) and benefit cost ratio were influenced significantly due to different treatments (Table 2). The highest gross monetary returns (Rs. 99709) and net monetary returns (Rs. 62746) were recorded with foliar application of 22% seaweed extract at flower initiation (T_2) which was at par with foliar application of 1% NPK (19:19:19) at flower initiation (T_7) and foliar spray of 30 ppm GA_3 at flower initiation (T_4) and also found significantly superior over rest of the treatments. The control treatment (T_1) observed lowest gross monetary returns (Rs. 77632) and net monetary returns (Rs. 41529). The results are in close conformity with the findings of Akhila *et al*. (2017) [1], Kumar *et al.* (2022) [7]. The highest B: C ratio (2.70) was observed with foliar application of 22% seaweed extract at flower initiation (T_2) followed by treatment with foliar application of 1% NPK (19:19:19) at flower initiation (T_7) and foliar spray of 30 ppm GA_3 at flower initiation (T_4), whereas Control (T_1) treatment gave minimum benefit cost ratio i.e. 2.15.

Conclusion

Foliar application of 22% seaweed extract at flower initiation (T_2) recorded higher seed yield (1435 kg ha^{-1}), straw yield (3023 kg ha^{-1}), biological yield (4458 kg ha^{-1}) and also gross monetary returns (Rs. 99709) and net monetary returns (Rs. 62746) of black gram. It was followed by foliar application of 1% NPK (19:19:19) at flower initiation (T_7) and foliar spray of 30 ppm GA_3 at flower initiation (T_4).

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