The Pharma Innovation Journal 2021; 10(10): 2557-2561

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(10): 2557-2561

www.thepharmajournal.com
Received: 12-08-2021
Accepted: 21-09-2021

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Effect of foliar nutrition on growth and yield of irrigated black gram under unprecedented soil saturation

K Kiruthika, M Hemalatha, E Somasundaram and S Jothimani

Abstract
A field experiment was conducted at Agricultural College and Research Institute, Killikulam in Tuticorin district during *summer* season (March 2020- May 2021) to assess the effect of foliar nutrition on growth and yield of blackgram under unprecedented soil saturation. The experiment was laid out in split plot design and replicated thrice. The treatments comprised of three levels of soil moisture condition *viz.*, conventional method with normal irrigation frequency (M_1), maintenance of soil moisture at saturation from 20-30 DAS (M_2), maintenance of soil moisture at saturation from 30-40 DAS (M_3) as main plot and four levels of foliar spray of nutrients *viz*., foliar spray of 2% DAP at 30 and 45 DAS (S_1), 1% pulse wonder at 30 DAS(S_2), 1% MAP + Micro Nutrient mixture at 20 and 35 DAS (S_3), and 1% polyfeed + Micro Nutrient mixture at 30 and 45 DAS (S_4) as subplots. The results of the study revealed that excess moisture exceeding field capacity is more detrimental to crop growth and establishment at the early stages than at later stages. With regard to foliar nutrition, application of 1% pulse wonder once at 30 DAS significantly recorded higher growth components (plant height, number of branches plant^{-1}, leaf area index, dry matter production), yield attributes (pod length, no of pods plant^{-1}, no of seeds pod^{-1}) and yield (seed and haulm) under saturation which was on par with application of 1% poly feed + micronutrient mixture twice at 30 and 45 DAS.

Keywords: Soil saturation, foliar nutrition, growth, yield attributes, yield, black gram

1. Introduction
Black gram (*Vigna mungo* L.) is an extensively grown legume with substantial food and nutritional importance. In India, it is grown as a sole crop, intercrop or fallow crop under rainfed and irrigated conditions. Globally, India is the largest producer as well as consumer of blackgram and it accounts for 70% of total production. It occupies nearly 19 per cent of the total pulse acreage and 23% of total pulse production in India (MoA, 2021).
Owing to climate change, there is an abrupt change in the rainfall patterns. Generally, pulses seems to be more vulnerable to extreme weather events followed by oilseeds and cereals and its production is affected by various biotic and abiotic stresses. Intense rainfall during the crop growing season may often lead to transient waterlogging or saturation of the soil thereby limiting the availability of nutrients. Water may remain in the field for a few days or immediately recede, but the soil may still retain water over the field capacity. The impact of soil saturation on crop yield depends on the frequency and duration as well as the timing in relation to the different growth stages of the crop (Biswas and Kalra 2018) [4].
Hence, there is a need to increase the productivity of black gram by adapting suitable management practices. Foliar application of nutrients is one of the suitable and feasible options to overcome excess water stress. Basant *et al.* (2020) [3] reported that foliar spraying can supply the nutrients necessary for the growth and development when the plant is unavailable to obtain the nutrients from the soil. The foliar fertilization hastens the uptake of nutrients than through the roots. The research findings regarding the response of black gram to the foliar application under excess moisture conditions are scarce. Hence, the present study was carried out to assess appropriate nutrient management techniques through foliar application of nitrogen, phosphorus, potassium and micronutrients to enhance the production of black gram under unprecedented saturation.

2. Materials and Methods
A field experiment was conducted at Agricultural College and Research Institute, Killikulam in Tuticorin district during *summer* season of 2020-2021.

The experimental soil was sandy clay loam in texture having a pH of 7.14 and Electrical Conductivity of 0.07 dS/m. The availability of N, P and K was low, medium and high respectively. The trial was laid out in Split plot design with three replications. The treatments comprised of three levels of soil moisture conditions *viz*., conventional method with normal irrigation frequency (M_1), maintenance of soil moisture at saturation from 20-30 DAS (M_2), maintenance of soil moisture at saturation from 30-40 DAS (M_3) as main plot and four levels of foliar spray of nutrients *viz.*, foliar spray of 2% DAP at 30 and 45 DAS (S_1), 1% pulse wonder at 30 DAS (S_2), 1% MAP + Micro Nutrient mixture at 20 and 35 DAS (S_3), and 1% polyfeed + Micro Nutrient mixture at 30 and 45 DAS (S_4) as subplot treatments. Blackgram variety VBN 8 was chosen for this study. The recommended dose of 25:50:25 kg ha^{-1} of N:P:K was applied as basal to all the plots before sowing. Saturation was maintained artificially as per the treatment schedule from 20-30 DAS and 30-40 DAS. Foliar application of nutrients *viz.*, DAP, pulse wonder, polyfeed, MAP along with micronutrients (Mo, Cu and Bo) were sprayed on 20, 30, 35 and 45 DAS. The plant protection measures were taken up as per the recommendations of Tamil Nadu Agricultural University. Data regarding the growth and yield attributes viz., plant height (cm), number of branches per plant, leaf area index (LAI), dry matter production, pod length (cm), number of pods per plant, no of seeds per pod were taken at 40 DAS and at harvest. The seed and haulm yield were also recorded.

3. Result and Discussion

3.1. Growth attributes

Growth characters such as plant height (60.2 cm), number of branches plant^{-1}(7.1), leaf area index (4.2), and dry matter production (3999 kg ha^{-1}) at harvest were significantly recorded higher under conventional method (M_1) followed by soil saturation at 30-40 DAS (M_3) (Table 1 and 2). Lower plant height (47.6 cm), number of branches plant^{-1}(6.5), leaf area index (2.8) and dry matter production (2863 kg ha^{-1}) were observed under soil saturation at vegetative stage 20-30 DAS (M_2). Maintenance of optimum soil moisture in the conventional method (M_1) might favourably influenced the crop growth and establishment resulting in higher growth attributes. The significant decrease in the growth parameters under saturation stress (M_2) could be due to the reduced oxygen concentration in soil which in turn affected the transpiration and respiration as well as nutrient uptake by plants thus ultimately affecting plants physiological functions despite excess water. These results are in conformity with the findings of Amri *et al.* (2014) [1] and Singh and Jain (2020) [9]. Among various foliar treatments, application of 1% pulse wonder at 30 DAS (S_2) significantly increased the plant height (55.9 cm), number of branches plant^{-1}(7.6), Leaf area index(4.0) and dry matter production (3881 kg ha^{-1}) at harvest. This was statistically on par with the application of 1% poly feed + micronutrient mixture (S_4) twice at 30 and 45 DAS (Table1 and 2). The adequate supply of nutrients and growth regulators through foliar spray of pulse wonder (S_2) helped to sustain a higher auxin level, resulting in enhanced plant height, leaf area and chlorophyll content. Similar findings were reported by Chinnusamy (2017) [5] and Balaji *et al.* (2019) [2].

The interaction effect between different soil moisture regimes and foliar nutrition was found to be significant. Among the various treatments imposed, maintenance of optimum soil moisture in conventional method coupled with foliar application of 1% pulse wonder at 30 DAS (M_1S_2) recorded greater values of growth parameters *viz*., plant height (64.4 cm), number of branches plant^{-1}(7.6), leaf area index(4.9) and dry matter production (4504 kg ha^{-1}) respectively. These findings are in close conformity with Marimuthu and Surendran (2015) [8].

3.2. Yield attributes and yield

Generally, pulses are highly sensitive to excess moisture and hence the yield of blackgram was significantly affected by the excess moisture. Higher yield attributes *viz.*, pod length (5.1 cm), number of pods per plant (21.7) and number of seeds per pod (6.8) (Table 3) was recorded under conventional method (M_1) followed by soil saturation at 30-40 DAS (M_3). Whereas, the lower yield attributes *viz.*, pod length (4.1cm), number of pods per plant (17) and number of seeds per pod (5.8) was recorded under soil saturation at vegetative stage 20-30 DAS (M_2). Excess moisture at vegetative stage (M_2) hampered the root growth and shoot resulting in lesser flower production leading to lower yield attributes as reported by Jung *et al.* (2008). Regarding yield, maximum seed yield (868 kg ha^{-1}) and haulm yield (2461 kg ha^{-1}) was registered under conventional method (M1) followed by soil saturation at 30-40 DAS (M_3). Significantly lower seed yield and haulm yield of 589 kg ha^{-1} 2073 kg ha^{-1} respectively was recorded under saturation at vegetative stage 20-30 DAS (M_2) and it is ascribed to the resultant reduction in yield attributes.

With respect to foliar nutrition, application of 1% pulse wonder at 30 DAS (S_2) recorded higher pod length (5.0 cm), number of pods per plant (23.6) and no of seeds per pod (6.7) which was on par with application of 1% poly feed + micronutrient mixture (S_4) twice at 30 and 45 DAS. Similarly, this treatment recorded higher seed yield (807 kg ha^{-1})and haulm yield (2508 kg ha^{-1}) (Table 3). Regarding the use of pulse wonder, the reason for the resultant increase in yield could be due to the nature of this crop booster, which contains a combination of nutrients and growth regulators that aid in boosting physiological efficiency, including photosynthetic activity, as well as improving the effective partitioning of accumulates from source to sink thus improved pod filling and resulting in more pods. Sreemathi *et al.* (2019) [10] and Karthikeyan *et al.* (2020) [7] also reported the similar findings.

Soil moisture regimes and foliar nutrition had significant interaction with each other on the yield attributes and yield. Foliar application of 1% pulse wonder at 30 DAS under conventional method (M_1S_2) registered a maximum seed yield of 934 kg ha^{-1} and haulm yield of 2719 kg ha^{-1} and it was on par with application of 1% poly feed + micronutrient mixture (M_1S_4) twice at 30 and 45 DAS (Table 3).

Table 1: Effect of different soil moisture level and foliar nutrition on plant height (cm) and number of branches in blackgram

Plant height (cm)											
40 DAS	**S1**	**S2**	**S3**	**S4**	**Mean**	**Harvest**	**S1**	**S2**	**S3**	**S4**	**Mean**
M1	37.4	48.6	39.8	46.9	43.2	M1	55.6	64.4	57.2	63.7	60.2
M2	26.2	32.3	28.3	30.9	28.0	M2	39.7	45.8	41.1	44.3	47.6
M3	31.5	36.5	31.2	35.9	35.8	M3	47.6	57.7	50.2	55.5	52.8

Mean	31.7	39.1	33.1	37.9		Mean	47.6	55.9	49.5	54.5	
	M	S	M at S	S at M			M	S	M at S	S at M	
SEd	1.1	1.08	1.62	1.53		SEd	1.70	1.50	2.06	1.90	
CD (p=0.05)	2.4	2.27	3.5	3.3		CD (p-0.05)	3.80	3.60	4.40	4.11	
Number of branches per plant											
40 DAS	S1	S2	S3	S4	Mean	Harvest	S1	S2	S3	S4	Mean
M1	6	7.1	6.1	6.9	6.5	M1	6.8	7.6	6.9	7.2	7.1
M2	5.4	5.9	5.5	5.8	5.7	M2	6.1	6.7	6.5	6.6	6.5
M3	5.7	6.6	5.9	6.2	6.1	M3	6.8	7	6.6	6.9	6.8
Mean	5.7	6.5	5.8	6.3		Mean	6.6	7.1	6.7	6.9	
	M	S	M at S	S at M			M	S	M at S	S at M	
SEd	0.19	0.19	0.22	0.21		SEd	0.23	0.22	0.26	0.24	
CD (p=0.05)	0.41	0.41	0.5	0.45		CD (p=0.05)	0.48	0.47	0.58	0.54	

M_1- conventional method with normal irrigation frequency, M_2- maintenance of soil moisture at saturation from 20-30 DAS, M_3- maintenance of soil moisture at saturation from 30-40 DAS, S_1 - foliar spray of 2% DAP at 30 and 45 DAS, S_2-1% pulse wonder at 30 DAS, S_3- 1% MAP + Micro Nutrient mixture at 20 and 35 DAS and S_4 -1% polyfeed + Micro Nutrient mixture at 30 and 45 DAS.

Table 2: Effect of different soil moisture level and foliar nutrition on Leaf area index and Drymatter Production (kg ha^{-1}) in blackgram Var. VBN 8

Leaf area index (LAI)											
40 DAS	S1	S2	S3	S4	Mean	Harvest	S1	S2	S3	S4	Mean
M1	2.11	3.34	2.21	3.23	2.7	M1	3.54	4.89	3.71	4.68	4.2
M2	1.24	1.67	1.34	1.53	1.4	M2	2.54	2.98	2.7	2.87	2.8
M3	2.2	3.1	2.3	2.7	2.3	M3	3.24	4.1	3.5	3.7	3.6
Mean	1.9	2.7	2.0	2.5		Mean	3.1	4.0	3.3	3.8	
	M	S	M at S	S at M			M	S	M at S	S at M	
SEd	0.06	0.07	0.08	0.08		SEd	0.11	0.1	0.13	0.12	
CD (p=0.05)	0.15	0.16	0.19	0.18		CD (p=0.05)	0.24	0.23	0.28	0.26	
Dry matter production (kg ha^{-1})											
40 DAS	S1	S2	S3	S4	Mean	Harvest	S1	S2	S3	S4	Mean
M1	1822	2329	1878	2182	2053	M1	3568	4504	3664	4259	3999
M2	1350	1583	1392	1538	1466	M2	2668	3070	2740	2973	2863
M3	1592	2099	1671	1962	1831	M3	3050	4068	3211	3790	3530
Mean	1588	2004	1647	1894		Mean	3095	3881	3205	3674	
	M	S	M at S	S at M			M	S	M at S	S at M	
SEd	64.7	66.2	69.6	67.3		SEd	127.2	128.3	132.08	129.4	
CD (p=0.05)	140.7	143.7	150.8	146.2		CD (p=0.05)	274.2	279.04	286.8	281.06	

Table 3: Effect of soil moisture level and foliar nutrition on yield attributes and yield in blackgram

Pod length (cm)						**No of pods per plant**						**No of seeds per pod**					
Harvest	S1	S2	S3	S4	**Mean**	**Harvest**	S1	S2	S3	S4	**Mean**	**Harvest**	S1	S2	S3	S4	**Mean**
M1	4.6	5.7	4.7	5.5	5.1	M1	15.0	28.5	17.0	26.3	21.7	M1	6.4	7.2	6.6	7.1	6.8
M2	3.9	4.2	4	4.1	4.1	M2	15.1	19.1	15.2	18.6	17.0	M2	5.6	6.1	5.8	6.01	5.8
M3	4.1	5	4.2	4.9	4.6	M3	12.6	23.3	15.7	21.9	18.4	M3	5.9	6.9	6	6.6	6.4
Mean	4.1	5.0	4.3	4.8		Mean	14.2	23.6	16.0	22.3		Mean	5.9	6.7	6.0	6.5	
	M	S	M at S	S at M			M	S	M at S	S at M			M	S	M at S	S at M	
SEd	0.16	0.14	0.19	0.18		SEd	0.59	0.58	0.85	0.79		SEd	0.21	0.19	0.28	0.25	
CD (p=0.05)	0.33	0.31	0.43	0.39		CD (p=0.05)	1.32	1.28	1.86	1.72		CD (p=0.05)	0.45	0.42	0.59	0.55	

Seed yield (kg ha^{-1})						**Haulm yield (kg ha^{-1})**					
Harvest	S1	S2	S3	S4	Mean	Harvest	S1	S2	S3	S4	Mean
M1	809	934	829	899	868	M1	2258	2719	2298	2568	2461
M2	522	657	569	608	589	M2	1861	2254	2039	2139	2073
M3	694	831	709	775	752	M3	2105	2552	2101	2286	2261
Mean	675	807	702	761		Mean	2075	2508	2146	2331	
	M	S	M at S	S at M			M	S	M at S	S at M	
SEd	26.3	27.0	28.4	27.9		SEd	84.3	84.6	88.8	87.5	
CD (p=0.05)	56.5	58.5	61.8	60.6		CD (p=0.05)	183.2	183.6	193	190.07	

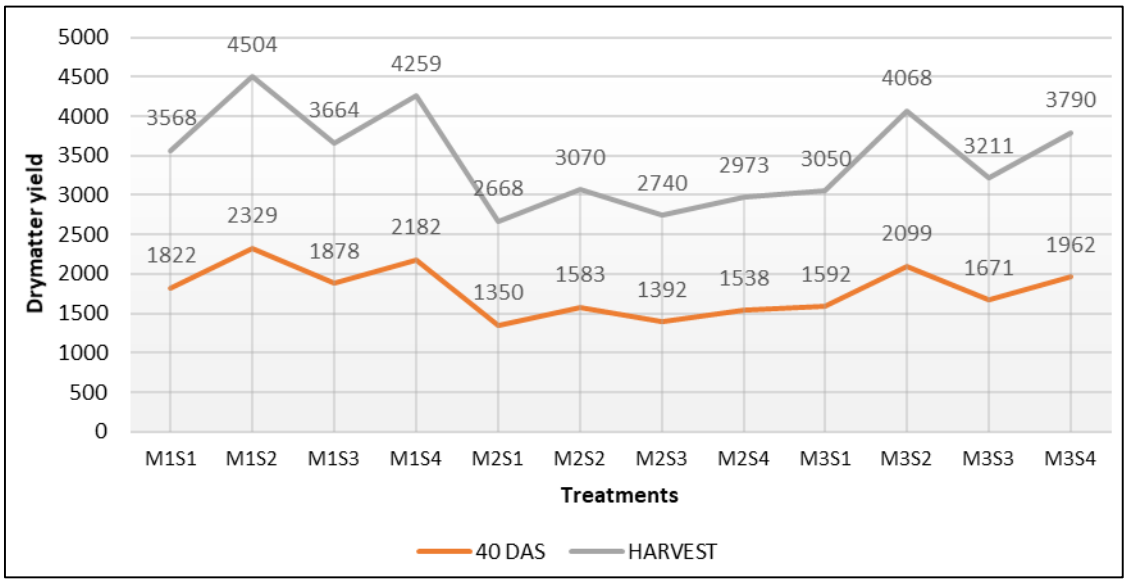

Fig 1: Influence of soil moisture level and foliar nutrition on Drymatter production (kg ha^{-1}) of blackgram

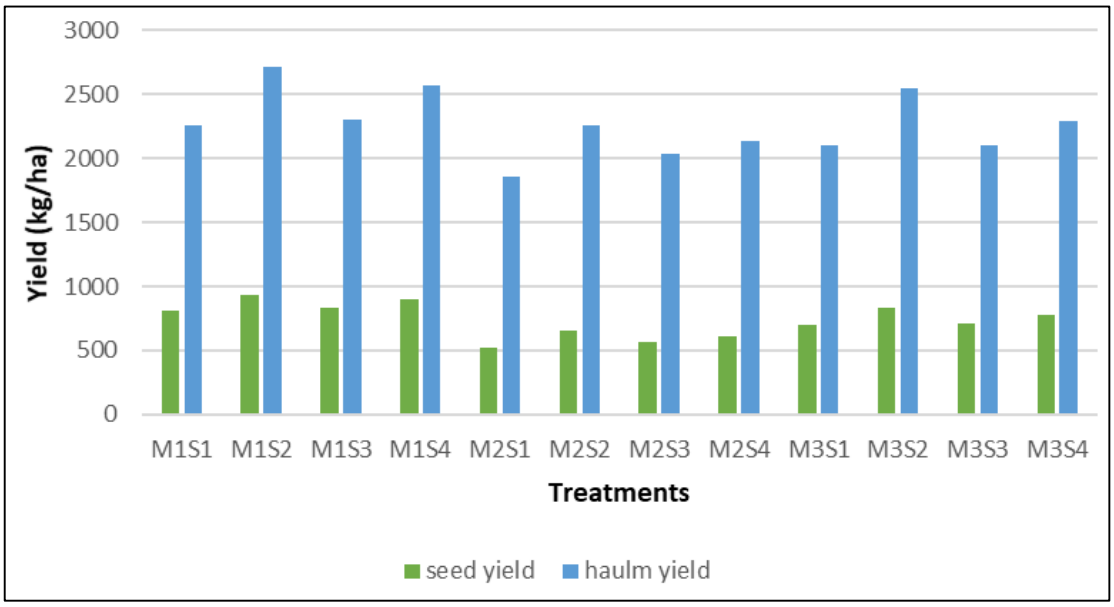

Fig 2: Seed and Haulm yield of black gram as influenced by the effect of soil moisture levels and foliar nutrition.

4. Conclusion

Foliar application of nutrients under different moisture levels positively influenced the growth and yield of blackgram VBN 8. Based on the findings, it is observed that soil saturation at vegetative Stage (20-30 DAS) and reproductive stage (30-40 DAS) caused yield reduction of 32 per cent and 13 per cent respectively, compared to conventional method. However, the yield has been substantially increased to that of convention through foliar application. Hence, it is concluded that foliar application of pulse wonder and polyfeed along with micronutrients could be a suitable nutrient management technique to mitigate excess moisture.

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