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Influence of Plant Density, Fertilizer Levels and Foliar Nutrition on Growth and Yield of Irrigated Blackgram

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A field experiment was conducted to study the influence of plant density, fertilizer levels and foliar nutrition on growth and yield of blackgram during *Rabi* season at Tamil Nadu Agricultural University Wetlands farm, Coimbatore. The experiment was laid out in a split plot design with sixteen treatment combinations encompasing plant density, fertilizer levels and foliar nutrition (2% DAP and TNAU Pulse wonder) replicated thrice. The results revealed that plant density of 3.33 lakhs ha^{-1} combined with basal application of 125% RDF + foliar applications of 2% DAP twice at flowering stages of crop growth and 15 days thereafter recorded better growth and yield parameters, yield and economics in irrigated blackgram. However, all the growth and yield attributing parameters recorded under plant density of 3.33 lakhs ha^{-1} combined with basal application of 125% RDF + foliar applications of TNAU Pulse wonder at flowering stages of crop growth were on par with 125% RDF + foliar spraying of 2% DAP twice coupled with the plant density of 3.33 lakhs ha^{-1}.

Key words: Blackgram, Plant density, DAP, Pulse wonder, Fertilizer nutrients.

Blackgram (*Vigna mungo* L.) is one of the most important pulse crops of irrigated areas grown throughout the India. Black gram supplies a major share of protein requirement of vegetarian population of the country. Very low production potential of blackgram is due to the fact that the crop is mainly grown in rain-fed condition with poor management practices and also due to various physiological, biochemical as well as inherent factors associated with this crop. The productivity of blackgram in India is very low. Thus enhancement of the productivity of blackgram by proper agronomic practices is the need of the hour. There are so many agronomic practices *viz.,* maintaining optimum plant density, fertilizer levels combined with foliar nutrition etc. are available. Foliar application of major nutrients like NPK was found to be more advantageous than soil application and also avoiding the depletion in leaves, thereby resulting in an increased photosynthetic rate, better nutrient translocation of these nutrients from the leaves to the developing grains (Manonmani and Srimathi, 2009). Foliar application of nutrient and growth regulator at pre-flowering and flowering stages resulted in the reduction of flower drop percentage in blackgram (Ganapathy *et al.,* 2008). Lacks of suitable agronomic practices is the major challenges in blackgram cultivation. Therefore, keeping above points in consideration an experiment was planned with the objectives, to find out the influence of plant density and foliar nutrition on growth and on soil fertility status and economics of black gram

Material and Methods

A field experiment was conducted during *rabi* season 2017-18 at Tamil Nadu Agricultural University Farm Coimbatore to study influence of plant density, fertilizer level and foliar nutrition on growth and yield of blackgram. The experimental site is geographically located at the Western Agro climatic zone of Tamil Nadu situated at 11^{o} N latitude, 77^{o} E longitude and at an altitude of 426.7 m above mean sea level. The soil of experimental field was clay loam in texture with a pH of 7.2 and EC of 0.5 dSm^{-1} with moderate drainage. The experiment was conducted in a split plot design with two factors and four each main and sub plot treatments with three replications. The treatments tried were, in main plot M_1 - 3,33 lakhs ha^{-1} (30 × 10 cm), M_2 -2,22 lakhs ha^{-1} (45 × 10 cm), M_3 - 2,22 lakhs ha^{-1} (30 × 15 cm), M_4 -1,48 lakhs ha^{-1} (45 × 15 cm) and sub plot, S_1 - 100% RDF + foliar spray of 2% DAP twice at flowering and 15 days thereafter, S_2 - 100% RDF + foliar spray of TNAU Pulse wonder once at peak flowering stage, S_3 - 125% RDF + foliar spray of 2% DAP twice at flowering and 15 days thereafter, S_4 - 125% RDF + foliar spray of TNAU Pulse wonder once at peak flowering stage. Seeds were sown as per treatment spacing levels and plant population was also maintained. Revised recommended dose of fertilizer (25:20:25 kg NPK ha^{-1}) was calculated and balanced for 100% and 125% and applied as per treatment schedule. The spray solution of DAP were prepared by dissolving 20 g of DAP in 1 litre of water to get 2% concentration. DAP granules were dissolved in little quantity of water and allowed to settle overnight and the supernatant solution was taken for spraying after dilution with remaining quantity of water. Spray solution of TNAU Pulse wonder was prepared by dissolving 8.3 g of TNAU Pulse wonder in one litre of water and sprayed directly to plots.

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Results and Discussion

Drymatter production

Data on mean drymatter production (kg ha^{-1}) at 20, 40 and 60 DAS were given in Table 1. Higher drymatter production of blackgram was recorded when blackgram was raised at a spacing of 30 × 10 cm (3.33 lakhs plants/ha) (M_1), which was superior than other levels at 20, 40 and 60 DAS. However, the drymatter production at a spacing of 30 cm × 15 cm (2.22 lakhs ha^{-1}) (M_3) is comparable with the blackgram sown at 45 cm × 10 cm spacing (M_2) with the same level of population (2.22 lakhs ha^{-1}). Lesser drymatter production was recorded at a spacing level of 45 × 15 cm accommodating plant density of 1.48 lakhs ha^{-1} (M_4). This might because of absorption of effective radiation during photosynthesis and also due to the differences in the efficiency of the plants in using the light absorbed at various plant densities besides variation in plant height, more number of leaves and more plant population. Similar finding was observed by Sathyamoorthi *et al.* (2008) and Rajeshkumar *et al*. (2017), who have reported that higher plant density favoured the total drymatter production than lower plant densities.

Higher drymatter production at 20, 40 and 60 DAS was noted in plots applied with 125% RDF + 2% DAP spraying twice at flowering stage and 15 days thereafter (S_3), which is comparable to 125% RDF + foliar spraying of TNAU Pulse wonder once at peak flowering stage (S_4) and it was comparable to the application of 100% RDF + 2% DAP spray twice at flowering stage and 15 days thereafter (S_1). The increased application of NPK might have facilitated more availability and the absorption of nutrients and K plays a major role in improving the water status of plant and that's why increase the drymatter production. This might attributed to the formation of higher quantity of leaf chlorophyll in the leaf tissues which increased the drymatter production. Similar finding was reported by Saxena *et al.* (1996) and Nagaraju and Mohankumar (2010).

The interaction effect between the plant density (M) and fertilizer levels and foliar nutrition (S) significantly influenced the drymatter production at 20 DAS. Plant density of 3.33 lakhs ha^{-1} (30 × 10cm) in combination with basal application of 125% RDF + foliar spraying of TNAU Pulse wonder once at peak flowering stage (M_1S_4) registered significantly higher drymatter production. The interaction also had significant influence on the drymatter production at 40 DAS. Plant density of 3.33 lakhs ha^{-1} in combination with basal application of 125% RDF + 2% DAP twice at flowering stage and 15 days thereafter (M_1S_3) recorded significantly higher drymatter production. The interaction between plant density (M) and fertilizer level and foliar nutrition (S) had significantly influence on drymatter production of blackgram at 60 DAS. Blackgram grown at a plant density of 3.33 lakhs ha^{-1} (30 × 10 cm) in combination with 100% RDF + 2% DAP twice at flowering stage and 15 days thereafter (M_1S_1) recorded significantly higher DMP.

Number of pods/plant

Plant density and fertilizer levels combined with foliar nutrition had perceptible influence on number of pods $plant^{-1}$. Observations on number of pods $plant^{-1}$ are presented in Table 2. Plant density of 3.33 lakhs ha^{-1} (30 × 10 cm) produced significantly higher number of pods $plant^{-1}$ and this was followed by plant density of 2.22 lakhs ha^{-1} with a spacing level of 30 × 15 cm and spacing of 45 × 10 cm (2.22 lakh plants ha^{-1}) and both were on par with each other. The increase in yield attributes at closer planting geometry might be due to higher number of yield attributing characters with more number of plant populations, optimum spacing available for plants, lesser competition for moisture and nutrients between plants. This is in corroboration with the findings of Subramani *et al.* (2002) in blackgram under irrigated condition.

Significant influence by fertilizer levels combined with foliar spray of nutrient on number of pods $plant^{-1}$ of blackgram was also observed. More numbers of pods $plant^{-1}$ were registered by application of 125% RDF + foliar spray of DAP 2% twice at flowering and 15 days thereafter (S_3) compared to others. This might be due to prevention of flower drop by spraying of nutrients and plant growth regulator and more number of branches per plant. Such results were also earlier reported by Subramaini *et al.* (2002) and Ganapathy *et al.* (2008).Interaction between plant density and fertilizer level combined with foliar nutrition showed significant difference among treatments. Plant density of 3.33 lakhs plant/ha with a spacing level of 30 cm × 10 cm along with application of 125% RDF foliar sprayed of 2% DAP twice at flowering and 15 days thereafter produced higher number of pods $plant^{-1}$.

Number of grains per pod

The results on number of grains per pod are presented in Table 2. Plant density or fertilizer level combined with foliar nutrition did not significantly influence the number of grains per pod of blackgram MDU1 and similarly there is no interaction effect between them. Plant density of 3.33 lakhs ha^{-1} recorded higher (7.2) number of grains per pod. which might be due to sufficient availability of nutrients (nitrogen, phosphorus, potassium and with optimum spacing) and their absorption by the plants, together with better photosynthetic activity due to proper light interception and spacing between the plants increased the vigour and plant growth thereby resulting in higher number of grains per plant. These findings are similar to the results reported by Swapna *et al.* (2012).

Test weight

The result on hundred grain weight is presented in Table 2. Hundred grain weight of blackgram MDU1 was not significantly influenced by any of plant density or fertilizer level combined with foliar nutrition and interaction between plant density and fertilizer level

combined with foliar nutrition. According to the data presented hundred grain weight of blackgram MDU 1 was not statistically influenced by any of plant density or fertilizer level combined with foliar nutrition and their interaction.

Grain yield

The data on grain yield influenced by the different plant density and fertilizer level combined with foliar nutrition are presented in Table 3. The grain yield of blackgram was significantly influenced by different plant density and fertilizer level combined with foliar nutrition. Among the different plant densities, plant density of 3.33 lakh plant ha^{-1} with a spacing level of 30 × 10 cm produced significantly higher grain yield which was significantly superior than other spacings. However plant density of 2.22 lakhs ha^{-1} with a spacing level of 30 × 15 cm was comparable with plant density of 2.22 lakh plants ha^{-1} (45 × 10 cm). Lesser grain yield was recorded when blackgram sown at a spacing of (45 × 15 cm) accommodating plant density of 1.48 lakh plants ha^{-1}. Accommodating the optimum plant density of 3.33 lakhs ha^{-1} might have enjoyed favorable growing environment, which was reflected through higher yield attributes coupled with better physiological and growth parameters as earlier observed by Biswas *et al.* (2002) in blackgram.

Among fertilizer level combined with foliar nutrition higher grain yield was observed in plots applied with 125% RDF + 2% DAP spray twice at flowering stage and 15 days thereafter which was superior to other treatments.

Table 1. Effect of plant density, fertilizer level and foliar nutrition on drymatter production (kg/ha) of blackgram

Treatments	20 DAS					40 DAS					60 DAS				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
M_1	100	98	109	111	104	1133	1178	1400	1133	1211	3711	3355	3477	3221	3441
M_2	65	59	65	71	65	622	607	756	756	685	2829	2518	3185	3422	2989
M_3	64	65	79	59	67	667	637	1022	800	781	3066	3274	3162	2996	3125
M_4	43	43	36	37	40	514	454	435	523	481	2316	2182	2420	2549	2367
Mean	68	66	72	70		734	719	903	803		2981	2832	3061	3047	
	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	1.4	1.8	3.5	3.6		22	27	51	53		81	92	179	184	
CD (P=0.05)	3.5	3.8	7.4	7.5		55	55	110	110		200	NS	385	381	

The next best treatment was basal application of 125% RDF along with foliar spraying of TNAU Pulse wonder once at peak flowering stage. Lesser grain yield was observed with application of 100% RDF + foliar spraying of TNAU Pulse wonder once at peak flowering stage and it was comparable with basal application of 100% RDF + 2% DAP spraying twice at flowering stage and 15 days thereafter. Increased dose of RDF increased the grain yield which might be due to adequate supply of nutrients which helped in better absorption and translocation inside the plant system efficiently for developing pods which help in higher grainy yield of blackgram. Similar finding were also reported Subba *et al.* (2011), and Babu (2017) in blackgram. The interaction effect between the plant density and fertilizer levels and foliar nutrition is significantly influenced grain yield. Plant density of 3.33 lakh plants ha^{-1} (30 **× 10 cm)** in combination with basal application of 125% RDF+ foliar spray of DAP 2% twice at flowering and 15 days thereafter (M_1S_3) registered significantly superior grain yield However, lesser grain yield was observed with blackgram raised at a spacing of 45 × 15 cm (1.48 lakhs ha^{-1}) combined with 100% RDF + foliar spraying of TNAU Pulse wonder once at peak flowering stage.

Table 2. Effect of plant density, fertilizer level and foliar nutrition on yield attributes of blackgram

Treatments	No. of pods/plant					No. of grains/pod					Hundred grain weight				
	S_1	S_2	S_3	S_4	**Mean**	S_1	S_2	S_3	S_4	**Mean**	S_1	S_2	S_3	S_4	**Mean**
M_1	29.93	24.87	32.87	28.27	28.98	7.1	6.9	7.3	7.4	7.2	5.27	5.27	5.20	5.13	5.22
M_2	27.67	27.80	29.47	29.80	28.68	6.8	6.9	7.4	6.9	7.0	5.13	5.07	5.23	5.10	5.13
M_3	27.27	29.00	27.93	31.60	28.95	7.1	7.0	6.9	7.2	7.0	5.13	5.13	5.20	5.30	5.19
M_4	28.20	26.13	31.40	24.40	27.53	7.1	6.8	6.9	6.9	6.9	5.03	4.97	5.17	5.23	5.10
Mean	28.27	26.95	30.42	28.52		7.0	6.9	7.1	7.1		5.14	5.11	5.20	5.19	
	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	0.23	0.33	0.62	0.66		0.11	0.13	0.25	0.26		0.16	0.13	0.28	0.26	
CD (P=0.05)	0.58	0.68	1.30	1.60		NS	NS	NS	NS		NS	NS	NS	NS	

M_1: 3.33 lakhs ha^{-1} (30 cm x 10 cm) S_1: 100% RDF + foliar spray DAP 2% at Flowering and 15 days thereafter

M_2: 2.22 lakhs ha^{-1} (45 cm x 10 cm) S_2: 100% RDF + foliar spray Pulse wonder at peak flowering

M_3: 2.22 lakhs ha^{-1} (30 cm x 15 cm) S_3: 125% RDF + foliar spray DAP 2% at Flowering and days thereafter

M_4: 1.48 lakhs ha^{-1} (45 cm x 15 cm) S_4: 125% RDF + foliar spray Pulse wonder at peak flowering

Haulm yield

The haulm yield of blackgram was appreciably influenced by plant density and fertilizers level combined with foliar spray of nutrients and the data are presented in Table 3. Among the different plant densities, significantly higher haulm yield was recorded at plant density of 3.33 lakhs ha^{-1} with a spacing level of 30 × 10 cm produced significantly higher haulm yield compared to others. The next best treatment was plant density of 2.22 lakhs ha^{-1} with a spacing level of 30 × 15 cm, which was comparable with plant density of 2.22 lakhs ha^{-1} (45 × 10 cm). Spacing of 45 × 15 cm (1.48 lakhs ha^{-1}) recorded significantly lower haulm yield over others. The increase in haulm yield under closer planting spacing might be due to the increased in vegetative growth and higher plant population at reproductive stage. Kumar *et al*. (2013) also reported similar findings in mungbean. who have reported that might be due to better expression of growth characters and yield attributes may also be the possible reasons for the production of higher haulm yields.

Table 3. Effect of plant density, fertilizer level and foliar nutrition on yield of irrigated blackgram

Treatments	Grain yield (kg ha^{-1})					Haulm yield (kg ha^{-1})				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
M_1	1030	1019	1179	1079	1077	2325	2202	2532	2398	2364
M_2	905	842	1006	1028	945	1924	1676	2179	2394	2043
M_3	951	968	1003	959	970	2115	2306	2159	2037	2154
M_4	807	769	877	847	825	1509	1413	1672	1573	1542
Mean	923	900	1016	978		1968	1899	2135	2101	

	Grain yield (kg ha^{-1})				Haulm yield (kg ha^{-1})			
	M	S	M at S	S at M	M	S	M at S	S at M
SEd	16	14	30	29	71	75	148	150
CD (P=0.05)	41	30	66	61	173	155	319	310

M_1: 3.33 lakhs ha^{-1} (30 cm x 10 cm) S_1: 100% RDF + foliar spray DAP 2% at Flowering and 15 days thereafter

M_2: 2.22 lakhs ha^{-1} (45 cm x 10 cm) S_2: 100% RDF + foliar spray Pulse wonder at peak flowering

M_3: 2.22 lakhs ha^{-1} (30 cm x 15 cm) S_3: 125% RDF + foliar spray DAP 2% at Flowering and days thereafter

M_4: 1.48 lakhs ha^{-1} (45 cm x 15 cm) S_4: 125% RDF + foliar spray Pulse wonder at peak flowering

Among fertilizer level combined with foliar nutrition, higher haulm yield was observed in plots applied with 125% RDF + 2% DAP spray twice at flowering stage and 15 days thereafter (S3) which was superior than other treatments. The next best treatment was application of 125% RDF + foliar spraying of TNAU Pulse wonder once at peak flowering stage (S4), which was comparable with application of 100% RDF + 2% DAP spraying twice at flowering stage and 15 days thereafter (S1). Increased dose of RDF and foliar spray of nutrient increased haulm yield this might be due to adequate supply of NPK, which helped in better vegetative growth and save plant sticky and reduce flower drop which my increase pods biomass it might help in higher haulm yield of blackgram. Similar finding were also reported Murade et al. (2014). The interaction effect between the plant density (M) and fertilizer levels and foliar nutrition (S) is significantly influenced by haulm yield. Plant density @ 3.33 lakh plants ha-1 (30 × 10 cm) in combination with basal application of 125% RDF+ foliar spraying of DAP 2% twice at flowering and 15 days thereafter registered significantly higher haulm yield.

Economics

Gross return (Rs. 75,804) and net return (Rs. 46,229) were higher with the treatmental combination of plant density of 3.33 lakhs ha^{-1} with spacing level of 30 × 10 cm along with basal application of 125% RDF combined with foliar spraying of 2% DAP twice at flowering and 15 days thereafter(M_1S_3). The next best combination was plant density of 3.33 lakhs ha^{-1} along with basal application of 125% RDF combined with foliar spraying of TNAU Pulse wonder once at peak flowering stage (M_1S_4) of crop growth, with a gross return of Rs.66, 964 and net return of Rs. 35,489.

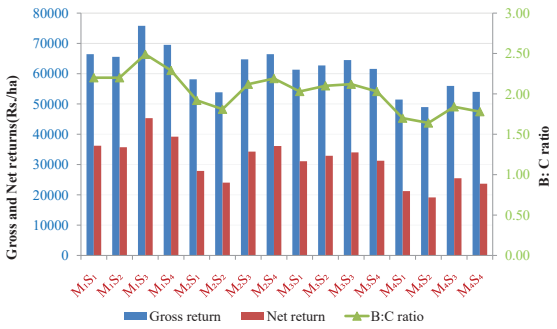

Fig 1. Effect of plant density, fertilizer level and foliar nutrition on economics of irrigated blackgram

Among different treatment combinations tried, plant density of 3.33 lakhs ha-1 with spacing level of 30 × 10cm along with basal application of 125% RDF combined with foliar spraying of 2% DAP twice at flowering and 15 days thereafter recorded higher benefit cost ratio of 2.49. This was followed by plant

density of 3.33 lakhs ha^{-1} with spacing level of 30 × 10cm along with basal application of 125% RDF combined with foliar spraying of TNAU Pulse wonder once at peak flowering stage of crop growth recorded the benefit cost ratio of 2.29. In all the combinations, the plant density of 1.48 lakhs ha^{-1} with spacing level of 45 × 15cm along with 100% RDF combined with foliar spray TNAU pulse wonder once at peak flowering stage of crop growth, (M4S2) recorded lower benefit cost ratio of 1.64. It was due to higher plant population which ultimately gave higher yield and thus recorded higher net realization and B:C ratio. The superiority of this treatment combination was might be due to better performance of individual treatments with respect to grain and haulm yield production. Similar finding was reported by Khan and Prakash (2014).

From the field experiment it could be concluded that plant density of 3.33 lakhs ha^{-1} combined with basal application of 125% RDF + foliar applications of 2% DAP twice at flowering stages of crop growth and 15 days thereafter recorded better growth and yield parameters, yield and economics in irrigated blackgram.

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