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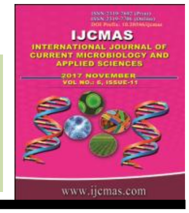

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Effect of Crop Geometry and Foliar Nutrition on Growth and Yield of Irrigated Blackgram (*Vigna mungo* L.)

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ABSTRACT

A field experiment was carried out during *Rabi* season of 2012– 13, at Agricultural College and Research Institute, Killikulam, to evaluate the suitability and economic viability of crop geometry and foliar nutrition on growth and yield of irrigated blackgram. The experiment was laid out in Randomized block design with three replications, comprising fifteen treatments. The variety used was VBN (Bg) 5. Results revealed that Crop geometry at 40 × 30 cm with foliar spray of TNAU Pulse Wonder at 1.125% recorded for better growth characters of individual plant *viz.,* plant height, number of branches plant^{-1}, number of root nodules plant^{-1}, Light interception and Yield attributes of individual plant like number of pod clusters plant^{-1}, number of pods cluster^{-1}, pod length and number of seeds pod^{-1}. In the case of dry matter production kg ha^{-1} and leaf area index of growth attributing characters, grain, bhusa and haulm yield kg ha^{-1} were recorded higher with crop geometry of 30 × 10 cm with foliar spray of TNAU Pulse Wonder at 1.125%. The yield levels were on par with crop geometry of 30 × 20 cm with same application. The uptake of nutrients was also higher under crop geometry of 30 × 10 cm as well as 30 × 20 cm with foliar spray of TNAU Pulse Wonder at 1.125%. The highest net return and B: C ratio were obtained when the crop geometry at 30 × 20 cm with foliar spray of TNAU Pulse Wonder at 1.125%.

Introduction

Pulses are the major source of dietary protein in the vegetarian diet of our country. They occupy a unique position in Indian agriculture by virtue of the fact that they constitute a major and the only high protein component to the average Indian diet. They also supply nutritive fodder and maintain soil fertility through biological nitrogen fixation and thus, play a vital role in furthering sustainable agriculture. Popularity of Blackgram (*Vigna mungo* L.) is mainly because of its superior nutritional quality and can very well fit into multiple cropping systems, because of short duration. It can be grown as intercrop with pigeonpea, maize, sorghum, cotton and sugarcane. It can also be grown as a green manure and fodder crop.

In India, the total area under black gram is 3.06 M. ha with a production of 1.70 Mt and a productivity 555 kg ha^{-1} during 2014 (Anon, 2014). In Tamil Nadu, the total area under black gram is 94.8 (‘000 ha) with a production 160.4 (‘000 tones) and productivity 406 kg ha^{-1} during 2015 (Anon, 2015).

The System of Rice Intensification (SRI) is a novel method originated in Madagascar during 1983 and spread all over the world. The SRI has set of principles that was used in rice and many success stories beyond the technologies. In the recent past, the success of SRI principles are being extrapolated to other crops such as wheat, maize, sorghum, finger millet, soybean, greengram, blackgram, kidney bean, lentil, mustard, sugarcane, tomato, brinjal, chilli, potato, carrot and onion in the name of System of Crop Intensification (SCI) (ISD, 2009). Similar to SRI, the SCI practices also proved to increase the yield level of crops more than two times (Uphoff *et al.*, 2011). In pursuit of extending the beneficial effect of SRI to SCI in blackgram, the present study was programmed with different crop geometry.

And also in agriculture practices, fertilizer is an important source to increase crop yields. Among fertilizer application methods, one of the most important methods of application is foliar nutrition, because foliar nutrients facilitate easy and quick absorption of nutrients by penetrating the stomata or leaf cuticle and enters the cells. Due to several compensations of foliar application methods like quick and proficient response to needs of plants, less needed products and soil conditions independency, the concentration towards foliar fertilizers is arising day by day. It is also determined that during crop growth supplementary foliar fertilization increase plant mineral status and improve crop yields. With this background, an investigation was carried out to test the crop geometry and foliar nutrition in blackgram.

Materials and Methods

The field experiment was carried out during *Rabi* season of November 2012 – January 2013, at Agricultural College and Research Institute, Killikulam. The experimental field is geographically located in the southern part of Tamil Nadu at 8°46' N latitude and 77°42' E longitude at an altitude of 40 meters above mean sea level. The climate of the experimental site is semi-arid tropical type**.** The mean annual rainfall is 786.6 mm in 40 rainy days. The mean maximum and minimum temperature of the location are 33.4˚C and 23.6˚C respectively. The relative humidity ranges from 60 to 80 per cent. The texture of the surface soil (0 – 15 cm) of the experimental field was sandy clay loam. The fertility status was neutral (7.1) in pH (Jackson, 1973), high in organic carbon (0.59 %) (Walkley and Black, 1934) low in available nitrogen (270 kg N ha^{-1}) (Subbiah and Asija, 1956), medium in available phosphorus (13 kg P_2O_5 ha^{-1}) (Olsen *et al.*, 1954) and potassium (233 kg K_2O ha^{-1}) (Stanford and English, 1949). The climate of the experimental site is semi-arid tropical type and annual rainfall is 786.6 mm in 40 rainy days. The experiment was laid out in Randomized block design with three replications, comprising fifteen treatments viz., T_1- 30 × 10 cm, T_2- 30 × 20 cm, T_3- 30 × 30 cm, T_4- 40 × 20 cm, T_5- 40 × 30 cm, T_6- 30 × 10 cm + fs TNAU Pulse Wonder at 1.125%, T_7- 30 × 20 cm + fs TNAU Pulse Wonder at 1.125%, T_8- 30 × 30 cm + fs TNAU Pulse Wonder at 1.125%, T_9- 40 × 20 cm + fs TNAU Pulse Wonder at 1.125%, T_{10}- 40 × 30 cm + fs TNAU Pulse Wonder at 1.125%, T_{11}- 30 × 10 cm + fs DAP at 2%, T_{12}- 30 × 20 cm + fs DAP at 2%, T_{13}- 30 × 30 cm + fs DAP at 2%, T_{14}- 40 × 20 cm + fs DAP at 2%, T_{15}- 40 × 30 cm + fs DAP at 2%. The foliar spray was given twice at flowering stage and 15 days later. VBN (Bg) 5 variety was used as test variety. The recommended dose of 25: 50: 25:25 kg of NPK and $ZnSO_4$ ha^{-1} was applied in the form of urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O). The fertilizers were applied uniformly to all plots at the time of sowing. Foliar spray of DAP or TNAU Pulse Wonder was given on 30 and 45 DAS as per the treatment schedule.

The observations were recorded on growth and growth analysis parameters such as number of branches $plant^{-1}$, number of root nodules $plant^{-1}$, Dry matter production kg $ha^{-1}$and growth analysis parameters LAI, CGR Light interception. The yield parameters of pod clusters $plant^{-1}$, number of pods $cluster^{-1}$, pod length and number of seeds pod^{-}1, grain, bhusa and haulm yield kg ha^{-1}. The observed data on crop were statistically analyzed based on the procedure given by Gomez and Gomez (2010). Critical differences were worked out at five per cent probability level wherever the treatments were significant. The treatment differences that were non-significant were denoted as NS.

Results and Discussion

Influence of crop geometry and foliar nutrition on growth characters

The plant growth is manifested in many ways. Though growth characters viz., plant height, number of branches $plant^{-1}$, root nodules $plant^{-1}$ and dry matter production are largely genetically controlled, can also be altered agronomically by manipulating environment. The plant height is a direct index to measure the growth and vigour of plants. In general, the plant height gradually increased from initial stage to harvest stage. The plant height was not physically affected due to crop geometry and foliar nutrition at 20 DAS. However, an increasing trend with wider crop geometry could be noticed during all growth stages.

The plant height is a direct index to measure the growth and vigour of plants. In general, the plant height gradually increased from initial stage to harvest stage. The plant was not physically affected due to crop geometry. However, an increasing trend with closer geometry level could be noticed during all growth stages (Table. 2). This may be due to the competition between the inter and intra plants for sun light, water, nutrients and space at closer spacing which encouraged self-thinning of branches and enhanced vertical growth rather than horizontal growth in Crop geometry of 40 × 30. Similar findings were also reported by Kumar and Badiyala (2005) in soybean and Siddharaju *et al.,* (2010) in cluster bean. Crop geometry of 40 × 30 cm produced significantly more number of branches $plant^{-1}$ at 50 DAS. This might be due to more space for nutrient absorption in presence of proper soil moisture content during growth period. Similar results have also been reported by Sarkar *et al.,* (2004). Crop geometry of 40 × 30 cm significantly increased the number of root nodules $plant^{-1}$ at 50 DAS. The root nodules increased with decrease in plant densities which might be due to greater root proliferation. Thus increased spacing significantly influenced the growth and root nodulation. These findings are in conformity with Ihsanullah *et al.,* (2002) in mungbean.

The dry matter production of a crop reflects its efficiency in utilizing the available resources. Dry matter production increased steadily with advancing growth stages and reached the maximum at harvest. The DMP (kg ha^{-1}) was found to be more with closer spacing of 30 × 10 cm, which could be attributed to higher population and accumulation of nutrients unit $area^{-1}$ compared to wider spacing. This is in accordance with earlier findings of Vijayakumar *et al.,* (2006) in rice and Sathyamoorthi *et al.,* (2008) in greengram

Influence of crop geometry and foliar nutrition on physiological parameters in blackgram

Agronomic manipulation alters crop physiology to certain extent to derive higher economic product. Physiological attributes like LAI, CGR and LI differed with crop geometry and foliar nutrition in blackgram. Plant stature with broader leaves was observed when blackgram was raised at wider spacings than closer spacings. Though broader leaves and better plant stature have direct relationship with LAI, it could not compensate the cumulative leaf area obtained with more number of plants unit area^{-1} in closer spacing. Crop geometry at 30 × 10 cm produced maximum LAI. This might be attributed to higher number of leaves plant^{-1}, which resulted in more leaves leading to higher LAI. (Table.3.)This is in conformity with the findings of Sathyamoorthi *et al.,* (2008) in greengram and Cheghakhor *et al.,* (2009) in chickpea.

Crop growth rate makes the assessment of crop productivity unit land^{-1}. The CGR was significantly higher with closer crop geometry of 30 × 10 cm all the growth stages, which was mainly due to more population unit area^{-1}. Similar findings were also reported by Kathirvelan and Kalaiselvan (2006) and Sathyamoorthi *et al.,* (2008) in greengram.

Light interception was higher at vegetative and flowering stage crop geometry of 40 × 30 cm. Higher plant density significantly had greatest dry matter productivity and fraction intercepted photosynthetically active radiation and lowest extinction light coefficient in reproductive stage. Similar findings were also reported by Cheghakhor *et al.,* (2009).

Growth analytical characters such as LAI and CGR were higher with foliar spray of 1.125% TNAU Pulse Wonder. The higher leaf area index might be due to positive influence of foliar spray of nutrients on cell division and cell elongation which facilitates better crop growth and development resulting in higher growth characters. These results are in line with Santosh Kumar Meena (2004).

Influence of crop geometry and foliar nutrition on yield attributes in blackgram

Crop geometry at various levels of spacing significantly influenced the yield attributes like number of pod clusters plant^{-1}, number of pods cluster^{-1}, pod length, number of seeds pod^{-1} and test grain weight (Table.4.). Number of pod clusters plant^{-1} was significantly higher with wider crop geometry of 40 × 30 cm when compared to closer crop geometry. Decreased number of pod clusters plant^{-1} under closer spacing was due to mortality caused by mutual shading during pre-flowering stage of the crop. Similar findings were also reported by Siddaraju *et al.,* (2010) in cluster bean.

Crop geometry at 40 × 30 cm recorded the highest number of pods cluster^{-1} and number of seeds pod^{-1} as compared to closer spacing. The increase in number of pods cluster^{-1} and seeds pod^{-1} at wider crop geometry was due to better crop growth, more space available for plants, lesser competition for moisture and nutrients between plants. This is in conformity with the findings of Bhairappanavar *et al.,* (2005) in blackgram, Nadeem *et al.,* (2004) in mungbean, Goyal *et al.,* (2010) and Siddaraju *et al.,* (2010) in cluster bean.

Planting geometry significantly affected the length of green pods. Pod length was also higher at crop geometry of 40 × 30 cm. These results are in accordance with Muhammad Amjad *et al.,* (2001), who reported that the longest pods were recorded with widest spacing.

Table.1 The foliar spray solution details are given below

Name of the chemical	Concentration	Quantity
DAP	2%	20 g / lit.
TNAU Pulse Wonder	1.125%	11.25 g / lit.

Table.2 Influence of crop geometry and foliar nutrition on growth characters in black gram

Treatments	Plant Height				No. of branches $plant^{-1}$	No. of root nodules $plant^{-1}$	DMP ($kg\ ha^{-1}$)			
	20 DAS	35 DAS	50 DAS	Harvest			20 DAS	35 DAS	50 DAS	Harvest
T_1 - 30 x 10 cm	15.5	29.6	38.4	48.6	3.2	20.0	68	854	3778	4299
T_2 - 30 x 20 cm	15.5	30.8	39.8	49.3	3.5	22.7	62	843	3521	4034
T_3 - 30 x 30 cm	15.6	31.9	40.5	49.8	3.5	23.2	40	617	2483	2935
T_4 - 40 x 20 cm	15.7	32.4	40.1	50.9	3.7	24.6	53	732	2912	3377
T_5 - 40 x 30 cm	15.8	33.5	42.8	51.7	3.9	25.4	48	599	2646	3096
T_6 - 30 x 10 cm + 1.125 % Pulse Wonder	15.4	33.5	45.2	57.2	5.1	25.2	88	985	4528	5163
T_7 - 30 x 20 cm + 1.125 % Pulse Wonder	15.5	35.2	45.3	58.5	5.6	26.7	86	965	4361	4978
T_8 - 30 x 30 cm + 1.125 % Pulse Wonder	15.6	36.7	46.3	58.7	5.4	27.0	65	843	3550	4108
T_9 - 40 x 20 cm + 1.125 % Pulse Wonder	15.7	36.8	47.8	59.5	5.6	27.3	79	912	4143	4709
T_{10} - 40 x 30 cm + 1.125 % Pulse Wonder	15.7	37.5	48.3	61.2	5.9	28.0	68	852	3555	4020
T_{11} - 30 x 10 cm + 2 % DAP	15.2	32.3	43.2	54.5	4.4	23.4	70	960	4150	4773
T_{12} - 30 x 20 cm + 2 % DAP	15.4	33.6	43.6	55.2	4.9	24.2	66	940	4089	4712
T_{13} - 30 x 30 cm + 2 % DAP	15.5	34.2	44.7	56.4	4.7	25.8	49	680	3264	3756
T_{14} - 40 x 20 cm + 2 % DAP	15.6	34.8	44.3	55.8	4.9	26.1	65	812	3591	4060
T_{15} - 40 x 30 cm + 2 % DAP	15.8	35.4	45.9	57.3	5.2	26.6	65	799	3339	3790
SEd	0.5	1.0	1.4	1.7	0.14	0.78	2	26	116	133
CD (P=0.05)	NS	2.1	2.8	3.5	0.30	1.62	4	54	238	273

Table.3 Influence of crop geometry and foliar nutrition on Physiological parameters of black gram

Treatments	LAI		Crop growth rate ($kg\ ha^{-1}\ day^{-1}$)			Light Interception		
	35 DAS	50 DAS	20- 35 DAS	35- 50 DAS	50 DAS-Harvest	Vegetative	Flowering	Maturity
T_1 - 30 x 10 cm	4.24	4.97	52.4	194.9	34.7	55	41	21
T_2 - 30 x 20 cm	3.70	4.68	52.1	178.5	34.2	61	47	23
T_3 - 30 x 30 cm	1.87	2.44	38.5	124.4	30.1	65	53	25
T_4 - 40 x 20 cm	2.07	2.05	45.3	145.3	31.0	71	56	29
T_5 - 40 x 30 cm	1.49	1.71	36.7	136.5	30.0	75	60	31
T_6 - 30 x 10 cm + 1.125 % Pulse Wonder	4.64	5.54	59.8	236.2	42.3	63	49	27
T_7 - 30 x 20 cm + 1.125 % Pulse Wonder	3.97	5.39	58.6	226.4	41.1	69	53	29
T_8 - 30 x 30 cm + 1.125 % Pulse Wonder	2.01	3.15	51.9	180.5	37.2	73	61	31
T_9 - 40 x 20 cm + 1.125 % Pulse Wonder	2.16	2.72	55.5	215.4	37.7	79	64	37
T_{10} - 40 x 30 cm + 1.125 % Pulse Wonder	1.65	2.03	52.3	180.2	31.0	83	69	39
T_{11} - 30 x 10 cm + 2 % DAP	4.49	5.24	59.3	212.7	41.5	58	45	24
T_{12} - 30 x 20 cm + 2 % DAP	3.83	5.10	58.3	209.9	40.5	65	49	26
T_{13} - 30 x 30 cm + 2 % DAP	1.95	2.68	42.1	172.3	32.8	68	57	27
T_{14} - 40 x 20 cm + 2 % DAP	2.11	2.52	49.8	185.3	31.3	75	60	33
T_{15} - 40 x 30 cm + 2 % DAP	1.53	1.90	48.9	169.3	30.1	78	65	35
SEd	0.10	0.12	1.6	6.0	1.6	2	2	1
CD (P=0.05)	0.22	0.25	3.41	12.3	2.37	5	4	2

Table.4 Influence of crop geometry and foliar nutrition on yield parameters and yield of black gram

Treatments	No. of pod clusters plant^{-1}	No. of pods cluster^{-1}	Length of pod (cm)	No. of Seeds pod^{-1}	100 seed weight (g)	Grain Yield (kg ha^{-1})	Bhusa Yield (kg ha^{-1})	Haulm Yield (kg ha^{-1})
T_1 - 30 x 10 cm	7.67	3.8	4.7	5.6	4.3	817	759	3438
T_2 - 30 x 20 cm	13.37	4.2	4.8	5.8	4.4	814	726	3166
T_3 - 30 x 30 cm	14.64	4.4	5.0	6.0	4.5	644	555	2452
T_4 - 40 x 20 cm	14.32	4.3	5.5	6.0	4.5	690	626	2727
T_5 - 40 x 30 cm	17.57	4.6	5.8	6.1	4.6	616	542	2444
T_6 - 30 x 10 cm + 1.125 % Pulse Wonder	7.94	4.1	5.1	6.0	4.5	990	859	4048
T_7 - 30 x 20 cm + 1.125 % Pulse Wonder	13.95	4.5	5.3	6.2	4.6	985	850	3975
T_8 - 30 x 30 cm + 1.125 % Pulse Wonder	14.84	5.0	5.4	6.5	4.7	820	751	3169
T_9 - 40 x 20 cm + 1.125 % Pulse Wonder	16.01	4.7	6.0	6.4	4.8	880	818	3703
T_{10} - 40 x 30 cm + 1.125 % Pulse Wonder	18.52	5.2	6.2	6.6	4.8	795	709	3093
T_{11} - 30 x 10 cm + 2 % DAP	7.81	4.0	4.9	6.0	4.4	938	829	3751
T_{12} - 30 x 20 cm + 2 % DAP	13.66	4.4	5.1	6.2	4.4	932	825	3683
T_{13} - 30 x 30 cm + 2 % DAP	14.76	4.7	5.2	6.4	4.6	740	650	2934
T_{14} - 40 x 20 cm + 2 % DAP	15.11	4.5	5.7	6.3	4.6	800	694	3212
T_{15} - 40 x 30 cm + 2 % DAP	18.16	4.9	6.0	6.5	4.7	723	658	2972
SEd	0.007	0.16	0.17	0.06	0.16	27	24	106
CD (P=0.05)	0.016	0.32	0.36	0.11	NS	54	49	218

Table.5 Influence of crop geometry and foliar nutrition on Crop uptak and Post-harvest nutrients of black gram

Treatments	Nutrient uptake (kg ha^{-1})			Available soil nutrients (kg ha^{-1})		
	N	**P**	**K**	**N**	**P_2O_5**	**K_2O**
T_1 - 30 x 10 cm	63.1	10.7	54.0	272.0	13.3	267.3
T_2 - 30 x 20 cm	58.4	10.0	50.1	275.1	13.5	273.2
T_3 - 30 x 30 cm	41.7	7.3	36.2	278.6	13.7	279.7
T_4 - 40 x 20 cm	47.4	8.3	41.3	282.4	14.1	286.1
T_5 - 40 x 30 cm	43.4	7.6	37.7	285.9	14.3	292.1
T_6 - 30 x 10 cm + 1.125 % Pulse Wonder	75.8	12.9	64.8	288.5	14.7	271.4
T_7 - 30 x 20 cm + 1.125 % Pulse Wonder	72.1	12.4	61.8	293.1	15.3	277.1
T_8 - 30 x 30 cm + 1.125 % Pulse Wonder	58.4	10.2	50.7	298.4	15.8	283.3
T_9 - 40 x 20 cm + 1.125 % Pulse Wonder	66.1	11.6	57.6	304.1	16.2	289.3
T_{10} - 40 x 30 cm + 1.125 % Pulse Wonder	56.3	9.9	49.0	309.2	16.8	296.2
T_{11} - 30 x 10 cm + 2 % DAP	70.1	11.9	59.9	279.2	14.1	269.4
T_{12} - 30 x 20 cm + 2 % DAP	68.3	11.7	58.5	283.3	14.5	275.6
T_{13} - 30 x 30 cm + 2 % DAP	53.4	9.3	46.3	288.1	14.8	281.1
T_{14} - 40 x 20 cm + 2 % DAP	57.0	10.0	49.7	292.7	15.1	287.8
T_{15} - 40 x 30 cm + 2 % DAP	53.1	9.3	46.2	297.6	15.4	293.5
SEd	1.81	0.32	1.57	44	0.5	8.7
CD (P=0.05)	3.72	0.67	3.22	NS	1	18

Table.6 Influence of crop geometry and foliar nutrition on Crop uptak and Post-harvest nutrients of black gram

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C Ratio
T_1 - 30 x 10 cm	18216	38808	20592	2.13
T_2 - 30 x 20 cm	17816	38665	20849	2.17
T_3 - 30 x 30 cm	17416	30590	13174	1.76
T_4 - 40 x 20 cm	17496	32775	15279	1.87
T_5 - 40 x 30 cm	17216	29260	12044	1.70
T_6 - 30 x 10 cm + 1.125 % Pulse Wonder	19896	47025	27129	2.36
T_7 - 30 x 20 cm + 1.125 % Pulse Wonder	19496	46788	27292	2.40
T_8 - 30 x 30 cm + 1.125 % Pulse Wonder	19096	38950	19854	2.04
T_9 - 40 x 20 cm + 1.125 % Pulse Wonder	19176	41800	22624	2.18
T_{10} - 40 x 30 cm + 1.125 % Pulse Wonder	18896	37763	18867	2.00
T_{11} - 30 x 10 cm + 2 % DAP	18898	44555	25657	2.36
T_{12} - 30 x 20 cm + 2 % DAP	18498	44270	25772	2.39
T_{13} - 30 x 30 cm + 2 % DAP	18098	35150	17052	1.94
T_{14} - 40 x 20 cm + 2 % DAP	18178	38000	19822	2.09
T_{15} - 40 x 30 cm + 2 % DAP	17898	34343	16445	1.92
SEd	-	-	674	0.07
CD (P=0.05)	-	-	1380	0.14

In the present study, no striking influence of spacing could be noticed on 100 grain weight as documented in early studies by Luikham *et al.*, (2009) in broad bean and Shamsi (2009) in chickpea. Foliar spray of 1.125% TNAU Pulse Wonder recorded the highest yield attributing characters viz., number of pod clusters plant^{-1}, number of pods cluster^{-1}, number of seeds pod^{-1} and pod length than other foliar spray treatments. The increase in yield attributes might be due to supplementation of nutrients at the critical stage without physiological stress. Foliar application of major and minor nutrients coupled with growth regulators enhanced the number of floral buds, by preventing the floral shedding though maintenance of optimum bio-physiological conditions in plants. Kalpana and Krishnarajan (2003) also reported higher number of pods plant^{-1}, number of filled seeds pod^{-1}, seed filling percentage and test weight in soybean as a consequence of foliar application of macro and micronutrients along with growth regulators.

Influence of crop geometry and foliar nutrition on yield of blackgram

Grain yield was significantly higher with closer spacing of 30 × 10 cm and 30 × 20 cm (Table.4.). This could be due to enhanced vegetative growth and lesser yield attributes owing to severe competition between plants. This is in agreement with the findings of Subramani *et al.*, (2002). Plants under optimum spacing would have effectively utilized the growth resources, particularly solar radiation as compared to plants under narrow spacing. This result is corroborating with the findings of Chaniyara *et al.*, (2002) and Singh *et al.*, (2009) in lentil.

Crop geometry at 30 × 20 cm registered higher bhusa and haulm yield as compared to wider spacing, which might be due to more population unit area^{-1}. This would have contributed to more biomass and hence higher haulm yield. Such results were also documented earlier by Sathyamoorthi *et al.*, (2008).

In case of foliar spray, 1.125% TNAU Pulse Wonder recorded significantly higher grain, bhusa and haulm yield of blackgram as compared to other treatments. The impact of foliar nutrients (macro and micro) to meet the nutrient demand of crop at the critical stage on-site, where they are needed without stress, would have resulted in better growth and development of the crop and ultimately yield attributing characters and yield. The balanced growth habit, which induced more flower and fruiting body production with timely supply of nutrients through foliar spray, might have reduced shedding of flowers and fruits, which led to a positive source-sink gradient of photosynthates translocation due to growth regulators. These favourable effects might have attributed for higher yield of blackgram with foliar spray of nutrients. This findings are in line with the results of Manivannan *et al.,* (2003) who had recorded higher grain yield of blackgram by foliar application of microsol (NPK + micronutrients).

Influence of crop geometry and foliar nutrition on nutrient uptake by blackgram

Nutrient uptake is a product of nutrient concentration and dry matter accumulation. Crop geometry of 30 × 10 cm enhanced the uptake of N, P and K compared to other spacings (Table 5). Better nutrient uptake improved the vegetative growth as indicated by higher dry matter accumulation, resulting in greater DMP at the plant spacing of 30 × 10 cm than other spacings. This might due to increase in root length that increases the root activity, under higher populations, which enables the increased absorption of nutrients from soil. Large numbers of plants compete for available nutrients unit area^{-1} resulting in higher uptake as documented by Sathyamoorthi *et al.,* (2007) in greengram.

Foliar spray of TNAU Pulse Wonder at 1.125% concentration enhanced the N, P and K uptake (Fig. 16) which might be attributed to two times of foliar nutritions containing major nutrients providing a balanced nutrient supply. Increased NPK uptake due to foliar application was also observed in greengram by Manu and Wahab (2002).

Influence of crop geometry and foliar nutrition on soil available nutrients after harvest of blackgram

Generally growing of legumes help in nodulation and ultimately enriches soil available N status (Das and Mathur, 1990). Higher post-harvest N status was observed after the harvest of blackgram. This could be primarily due to increased root nodules and microbial activity in blackgram which might have influenced the nutrient content in the soil. This is in accordance with the results of Manivannan *et al.,* (2002) in blackgram.

Soil available N, P and K were markedly influenced by different crop geometry and foliar nutrition in blackgram. Higher available N, P and K were recorded at wider spacing of 40 × 30 cm ((Table.5.). Depletion of available soil nutrients was noticed at crop geometry of 30 × 10 cm spacing. Better growth with higher nutrient availability to crops resulted in increased nutrient uptake of N, P and K, thus depleting the soil available nutrients. Under wider spacing, comparatively lesser competition and loss of nutrients from the soil resulted in increased available nutrients. On contrary, Suganthi (2011) reported higher available nutrients with closer spacing in greengram.

Among the various foliar nutrition applied, 1.125% TNAU Pulse Wonder foliar spray left higher N, P and K in the soil after harvest of the crop. Higher residual nutrient effect may be attributed to the supply of nutrients through foliar sprays, which reduced the NPK uptake from the soil and thus maintaining higher N, P and K status of the soil after the harvest. Further, a vigorous crop growth improves the rooting pattern and higher nodulation and these might have enhanced the atmospheric N fixation supplementing to the higher value of post-harvest available soil nutrient status.

Influence of crop geometry and foliar nutrition on economics of blackgram cultivation

Economic efficiency and viability of crop cultivation are mainly the outcome of crop, yield with lesser management cost. Higher crop productivity with less cost of cultivation resulted in better economic parameters like higher net return and B: C ratio ((Table.6).

The highest cost of cultivation was observed under crop geometry at 30 × 10 cm spacing with foliar nutrition of TNAU Pulse Wonder at 1.125% (₹ 19,896 ha^{-1}). Higher grain productivity with 30 × 10 cm and 30 × 20 cm increased the gross returns (₹ 47,025 and 46,778 ha^{-1} respectively).

The maximum net returns (₹ 27,292 ha^{-1}) and B: C ratio (2.40) were observed under optimum crop geometry of 30 × 20 cm with foliar nutrition of TNAU Pulse Wonder at 1.125%. This might be due to the fact that blackgram utilized the resources available below and above the ground very effectively thereby exhibited better growth and yield parameters. The result is supported by the findings of Singh *et al.,* (2009) in blackgram.

Based on the experimental results, it could be concluded that raising of blackgram variety VBN (Bg) 5 with crop geometry at 30 × 20 cm spacing with foliar spray of TNAU Pulse Wonder at 1.125% (5.625 kg ha^{-1}) twice at flowering and 15 days later proved to be a better option for getting higher productivity and economics under irrigated conditions.

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