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Effect of different levels of irrigation and nutrient on growth and yield of Summer Green gram cv. Bireswar in New Alluvial Zone of West Bengal

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Abstract
A field experiment was conducted to investigate the effect of irrigation and nutrient sources on growth and yield of green gram in split-plot design with three replications at Bidhan Chandra Krishi Viswavidyalaya on the Gangetic alluvial soil of West Bengal during 2015 and 2016. The treatments comprised of two factors i.e. irrigation (I_1 = IW/CPE ratio of 0.4), (I_2 = IW/CPE ratio of 0.6), (I_3 = critical growth stages (Branching, Flowering, Pod development) and nutrient levels (N_1 = 100% Recommended dose of fertilizer, N_2 = 100% Recommended dose of fertilizer + *Rhizobium*, N_3 = 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium*) and N_4 = 50% Recommended dose of fertilizer + 2 t/ha Vermicompost + *Rhizobium*). The result indicated that plots treated with combination of I_3N_3 was positively and significantly influenced the growth parameters and seed yield of green gram and performed better than all other treatments.

Keywords: green gram, growth, irrigation, nutrient, yield

Introduction
Green gram (*Vigna radiata* L. Wilczek) is one of the most ancient and extensively grown leguminous crop of India. It is native of India and Central Asia and commonly known as mung bean. It is the third important pulse crop after chickpea and pigeon pea, cultivated throughout India for its multipurpose uses as vegetable, pulse, fodder and green manure crop. It is a good source of protein (20-24 %), carbohydrates (60-62 %), water (10%), fat (1.0%), fiber (4.0%) and ash (3.0%). Green gram protein is deficient in methionine and cysteine but rich in lysine making it an excellent compliment to rice in terms of balanced human nutrition (Yadav *et al.* 2009) [20]. It is a good source of the mineral, pro-vitamin A, B complex and ascorbic acid. Besides being a rich source of protein, it maintains soil fertility through biological nitrogen fixation in soil and thus plays a vital role in furthering sustainable agriculture (Kannaiyan, 1999) [8]. In India, it is mainly cultivated in Maharashtra, Andhra Pradesh, Rajasthan, Orissa and Karnataka etc. It is grown usually as rainfed crop and can also be grown as pre-monsoon (summer) and late monsoon crop. It is cultivated over an area of 30.41 lakh hectares with a total production of 14.24 lakh tonnes and productivity of 468 kg ha-1 (Anonymous 2016) [1]. West Bengal produces only 1.5% of the total pulse produced in India. The productivity of this crop is very low because of its cultivation on marginal and sub-marginal lands of low soil fertility where little attention is paying to adequate fertilization (Saravanan *et al.* 2013) [16]. However, yield potential of summer green gram is quite high yet at farmers' field, its yield is low. In summer green gram, a high reduction in yield has been reported to occur due to no use of fertilizers (Singh and Sekhon. 2008) [18].

Besides, persistent nutrient depletion is posing a greater threat to the sustainable agriculture. Consumption of chemical fertilizers will also be quite a limiting factor of agricultural production in future. Because of escalating energy cost, chemical fertilizers are not available at affordable price to the farmers. Therefore, there is an urgent need to reduce the usage of chemical fertilizers and intern increase in the usage of organics is needed to check the yield and quality levels. On the other hand, use of organics alone does not result in spectacular increase in crop yields, due to their low nutrient status (Subba Rao and Tilak, 1977) [19]. Therefore, the aforesaid consequences have paved way to grow green gram by integration of organic and inorganic fertilizers along with bio-fertilizers.

Summer green gram cultivation is being pushed to adjust between the time left after the harvesting of Rabi and sowing of Kharif crops, where the incidence of diseases and pests are relatively low and also the vacant land is efficiently utilized without affecting the main crops. Green gram responds well to add nitrogen to overcome its lag phase and it influences nutrient uptake by promoting root growth and nodulation. Nitrogen enhances the uptake of other nutrients and increasing nitrogen content in the crop which increases the protein content of green gram. Research revealed that green gram yield and quality could be improved by the use of balanced fertilizers (Choudhry, 2005; Aslam *et al.* 2010) [5, 2]. Salah Uddin *et al.* (2009) [14] stated that most of the growth components significantly influenced by chemical and biofertilizers. Green gram responses favourably to irrigation especially when irrigation is given at the time of flowering resulting in higher yields (Miah and Carangal, 1981) [12]. In summer season when the temperature is high, relative humidity is low and evapotranspiration is greater and 3 to 4 irrigations may be needed to obtain higher yields of green gram (Lal and Yadav, 1981) [11]. Irrigation during flowering stage helps for retention of flowers and pod development. Therefore, the present investigation was undertaken to determine the nutrient and irrigation application for getting higher seed yield and quality parameters of summer green gram in New Alluvial Zone of West Bengal.

Materials and Methods

The field experiment was carried out during Summer (March-May) season of 2015 and 2016 at the District Seed Farm, AB block, Kalyani, BCKV, ($22^0$58' N latitude, $88^0$32' E longitude and 9.75 m above mean sea level), West Bengal, India. The variety was used in this experiment is Bireswar (WBM 4-34-1-1). The study site was flat, medium high land situated in the south of tropic of cancer with 'Sub-tropical humid' climate. In this region, the temperature begins to rise from March and reaches its peak during May. During the experimental period, the maximum average temperature ranged from 35.50^0C to 37.60^0C and the average minimum temperature ranged from 19.20^0C to 27.20^0C. Only 30.57 mm rainfall was received during the period of experimentation. Physio-chemical properties of soil during both the seasons are given in Table 1.

Table 1: Physio-chemical properties of experimental fields during the two seasons

Physical composition	Season I	Season II
Sand (%)	47.5	47.4
Silt (%)	30.3	30.12
Clay (%)	21.3	21.4
Chemical Composition		
Soil pH	7.1	7.2
Organic carbon (%)	0.48	0.50
Available Nitrogen (kg/ha)	219.5	220.1
Available phosphorus (kg/ ha)	21.63	21.73
Available potassium (kg/ha)	184.4	185.9

The Seedbed was prepared by ploughing the field three times with tractor-mounted cultivator each followed by planking. Fertilizers were incorporated into the soil with last ploughing for each plot as per treatments. The crop was sown manually with single row hand drill in 30 cm apart lines using 25 kg seed ha^{-1} in 2^{nd} week of March, (Season I and Season II). Plant to plant distance of 10 cm was maintained by thinning ten days after emergence. The experiment during both the seasons were laid out in a split-plot design with irrigation treatments (I_1 = Irrigation at IW/CPE ratio of 0.4), (I_2 = Irrigation at IW/CPE ratio of 0.6), (I_3 = Irrigation at critical growth stages (Branching, Flowering, Pod development) in main plots and nutrient treatments (N_1 = 100% Recommended dose of fertilizer, N_2 = 100% Recommended dose of fertilizer + *Rhizobium*, N_3 = 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium* and N_4 = 50% Recommended dose of fertilizer + 2 t/ha Vermicompost + *Rhizobium*) in subplots in net plot size 5 m X 4 m replicated three times. The crop was irrigated as per treatments with canal water measuring approximately 75 mm each number of irrigation. The crop was monitored throughout crop growth period. Weeds were kept under control with hand weeding as and when required. At maturity, central rows leaving two border rows were harvested. The harvested crop was tied in bundles and dried in sun for few days. Yield and yield components of the crop were recorded after sun-drying. Yield components were recorded from ten randomly selected plants while seed yield was recorded from whole plot. The data, thus obtained and computed were analyzed following the standard method of statistical analysis for split-plot design. (Panse and Sukhtame, 1985) [13].

Results and Discussion

Effect on Growth Attributes

Irrespective of different treatments, it was evident from the data (Table 2) that plant height increased with the advancement in the age of the plant and reached the maximum at harvest. Plant height at 30, 60 DAS was significantly affected by different irrigation and nutrient levels. It was observed in Table 1 that there was a significant difference in plant height due to different irrigation level. The lowest and highest plant height was 18.02 cm and 15.35 cm in the plots treated with Irrigation at IW/CPE ratio of 0.4 (I_1) and irrigation at critical stage (I_3) respectively. The same trend was followed on the next date of observation i.e. at 60 DAS. The highest plant height of 17.88 cm and 57.30 cm at 30 and 60 DAS respectively recorded in plot received the recommended dose of 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium* (N_3). The significant interaction effect was found at 30 DAS and 60 DAS (Table 2), and the best treatment combination of I_3N_3 was observed. This was might be due to improvement in available soil moisture in root zone through irrigation enhanced growth of the plant leading to more plant height. The results clearly indicated the need for adding organic manures to soil conjunctive with inorganic fertilizers, which increased the availability of nutrients over a long period, have a positive effect on height of the plant. A similar result was also observed by Afzal and Bano (2008) [3], Hamid *et al*. (1990) [7]. Results obtained for leaf area index and number of primary branches that there was a significant difference between various treatments of applied irrigation and fertilizer (Table 1). The plants grown attained maximum leaf area index (1.02 and 3.26 at 30 and 60 DAS respectively) also number of primary branches/plant (5.25) due to irrigation at critical stages (I_3). Whereas, the minimum leaf area index (0.81 and 2.75 at 30 and 60 DAS respectively) and primary branches/plant (5.06) recorded for the irrigation at IW/CPE ratio of 0.4 (I_1). Among the different fertilizer treatments the highest leaf area index 1.04 and 3.21 at 30 and 60 DAS respectively and number of primary branches/plant of 5.53 was observed (Table1) with the treatment N_3, i.e. application of recommend dose of 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium*). The significant interaction effect of leaf area index was found at 30 DAS and 60 DAS (Table 2), whereas the number of primary branches was observed no significant differences. Allen and Morgan (1972) [4] reported that leaf area index was significantly affected by nitrogen. Nitrogen is one of the most important factors affecting the leaf area index which might have helped in enhancing photosynthesis and productivity of the crop. The positive effect of vermicompost on leaf area index and primary branches might be due to the fact that vermicompost as a source of macro and micronutrients, vitamin, and growth hormones like gibberellins which enhanced leaf area resulting in higher photo assimilates (Vadgave, 2010) [2].

Dry matter accumulations and crop growth rate (CGR) are very important parameters for the growth studies in crops. As a result, the dry matter accumulation was significantly higher (49.64 and 413.31 gm^{-2} at 30 and 60 DAS respectively) and also the CGR (12.26 gm^{-2} $days^{-1}$) due to irrigation at critical stage (Table 1). Among the different fertilizer treatments the highest dry matter accumulation of 46.28 and 416.32 gm^{-2} at 30 and 60 DAS respectively and CGR of 12.33 gm^{-2} day^{-1} was observed (Table 1) with the treatment N_3, i.e. application of 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium*). The interaction effects (Table 2) between two factors were different significantly at all the growth stages. Singh *et al*. (1993) concluded that *Rhizobium* seed inoculation alone or in combination with fertilizers increased dry matter accumulation in green gram or black gram.

Table 2: Effect of irrigation (main plot) and nutrients (sub-plot) on growth parameters of green gram (mean data of two years)

Treatment	Plant Height (cm)		Leaf Area Index (LAI)		No. of primary branches/plant	Dry matter accumulations (gm^2)		CGR (gm^{-2} day^{-1})
	30 DAS	60 DAS	30 DAS	60 DAS		30 DAS	60 DAS	(30- 60 DAS)
I_1	15.35	49.52	0.81	2.75	5.06	41.48	378.79	11.24
I_2	15.69	54.33	0.86	2.51	5.30	44.39	412.14	12.12
I_3	18.02	63.30	1.02	3.26	5.25	49.64	413.31	12.26
CD @ 0.05	1.01	0.86	0.03	0.22	0.18	1.40	11.15	0.42
SEm(±)	0.53	0.29	0.01	0.05	0.04	0.35	2.77	1.10
N_1	16.00	53.79	0.85	2.90	4.97	44.09	388.39	11.49
N_2	16.04	54.80	0.78	2.73	5.14	45.19	396.91	11.72
N_3	17.88	57.30	1.04	3.21	5.53	46.28	416.32	12.33
N_4	16.29	56.98	0.91	2.76	5.16	45.11	403.99	11.96
CD @ 0.05	1.09	0.99	0.05	0.15	0.19	1.33	7.49	0.24
SEm(±)	0.36	0.34	0.01	0.06	0.07	0.44	2.50	0.80

Table 3: Interaction effect of irrigation (main plot) and nutrients (sub-plot) on growth parameters of green gram (mean data of two years)

Treatments	Plant Height (cm)		Leaf Area Index (LAI)		No. of primary branches/plant	Dry matter accumulations (gm^2)		CGR (gm^{-2} day^{-1})
	30 DAS	60 DAS	30 DAS	60 DAS		30 DAS	60 DAS	(30- 60 DAS)
I_1N_1	15.35	47.27	0.75	2.70	4.71	40.30	356.95	10.55
I_1N_2	16.02	49.01	0.70	2.68	5.17	41.96	366.68	10.82
I_1N_3	17.65	51.41	1.02	3.09	5.34	41.02	401.65	12.02
I_1N_4	14.79	50.40	0.77	2.54	5.01	42.63	389.67	11.57
I_2N_1	16.63	51.94	0.79	2.75	5.32	43.06	401.27	11.94
I_2N_2	14.37	53.10	0.68	2.34	5.10	44.35	415.68	12.38
I_2N_3	16.02	54.21	1.04	3.18	5.57	47.46	421.95	12.48
I_2N_4	15.74	58.07	0.93	2.51	5.21	42.69	409.67	12.23
I_3N_1	16.02	62.16	1.00	3.27	4.89	48.20	406.97	11.96
I_3N_2	17.74	62.28	0.97	3.19	5.14	49.27	408.35	11.97
I_3N_3	19.98	66.29	1.07	3.37	5.67	51.08	425.35	12.48
I_3N_4	18.35	62.45	1.04	3.21	5.27	50.01	412.61	12.09
SEm(±) (I x N)	0.76	1.90	0.03	0.31	0.11	0.75	4.66	0.12
CD@ 0.05	2.67	0.58	0.08	0.09	NS	2.41	15.66	0.41
SEm(±) (N x I)	1.07	1.90	0.02	0.29	0.09	0.70	5.53	0.13
CD@ 0.05	2.21	0.59	0.09	0.11	NS	1.40	14.55	0.39

Table 4: Effect of irrigation (main plot) and nutrients (sub-plot) on yield attributes of greengram (mean data of two years)

Treatment	No. of pods/plant	No. of seeds / pod	Test Weight	Seed Yield (kg/ha)	Stover Yield (kg/ha)	Harvest Index (%)
I_1	24.10	9.28	35.77	703.37	2353.68	23.01
I_2	26.02	9.91	35.98	799.48	2458.79	24.41
I_3	29.02	10.12	36.16	842.20	2610.31	24.37
CD @ 0.05	0.64	0.62	NS	17.55	67.97	0.80
SEM (±)	1.6	0.156	0.11	4.35	16.86	0.20
N_1	24.66	9.21	34.83	682.77	2384.53	22.24
N_2	25.99	9.75	35.82	760.52	2407.30	24.00
N_3	28.33	10.43	36.88	873.02	2603.99	25.05
N_4	26.55	9.69	36.30	810.43	2501.26	24.42
CD @ 0.05	1.02	0.42	0.36	17.55	55.66	0.71
SEM (±)	0.34	0.14	0.12	4.35	18.59	0.24

Table 5: Interaction effect of irrigation (main plot) and nutrients (sub-plot) on growth parameters of green gram (mean data of two years)

Treatments	No. of pods/plant	No. of seeds/pod	Test Weight	Seed Yield (kg/ha)	Stover Yield (kg/ha)	Harvesting Index
I_1N_1	21.76	8.74	34.97	661.27	2295.03	22.37
I_1N_2	24.98	9.78	34.80	726.28	2321.61	23.84
I_1N_3	26.65	9.73	36.63	731.58	2432.02	23.13
I_1N_4	23.01	8.86	36.66	694.35	2366.05	22.69
I_2N_1	24.62	9.24	34.61	641.68	2326.60	21.60
I_2N_2	25.02	9.71	36.36	739.00	2458.68	23.11
I_2N_3	27.53	10.49	36.88	936.26	2552.90	26.83
I_2N_4	26.92	10.21	36.04	880.98	2496.99	26.08
I_3N_1	27.59	9.64	34.91	745.35	2531.95	22.75
I_3N_2	27.95	9.75	36.39	816.28	2441.60	25.06
I_3N_3	30.82	11.07	37.13	951.21	2826.95	25.19
I_3N_4	29.75	10.02	36.19	855.97	2640.72	24.48
SEM (±) (I x N)	0.54	0.26	0.21	13.74	32.58	0.41
CD@ 0.05	1.65	0.09	0.69	42.58	106.61	1.32
SEM (±) (N x I)	0.32	0.31	0.23	8.71	33.72	0.40
CD@ 0.05	1.53	0.51	0.68	46.64	105.36	1.33

Yield attributes and yield

Number of pods plant^{-1} and number of seeds pod^{-1} the most important determinant character of seed yield of pulses and were recorded at the time of picking. Significantly the highest number of pods plant^{-1} and seeds pod^{-1} were recorded in I_3 (Irrigation at critical stages) and N_3, i.e. application of 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium*) (Table 3). It produced highest pods plant^{-1} (29.02) and seed pod^{-1} (10.12) with irrigation at critical stages (I_3). Among the different fertilizer treatments significantly the highest (28.33) number of pods plant^{-1} and 10.43 seed pod^{-1} were recorded in the recommended dose of 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium*) (Table 3). Corresponding the lowest number of pods plant^{-1} (24.10 and 24.66) and seed pod^{-1} (9.28 and 9.21) were observed in I_1 (irrigation at IW/CPE ratio of 0.4) and N_1 (100% Recommended dose of fertilizer) respectively. In the present experiment, the interaction effect was found significant due to different treatment combinations (Table 4). The maximum number of pods plant^{-1} (30.82) and seed pod^{-1}(11.07) were recorded in the treatment combination in I_3N_3 (Irrigation at critical stages+ 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium*). Thus irrigation and nutrient increased the pods plant^{-1} seed pod^{-1} in green gram and this treatment combination was superior to all other treatments. Muchow (1985) reported that green gram is very sensitive to water stress during flowering and pod development stage which corroborate with the presented trial.

Thousand grain weight is an important yield contributing component of every crop including green gram. The data presented in the table 3 revealed that there was no significant difference in treatment with irrigation but the application of different nutrient and interaction of irrigation and nutrient has also shown the significant differences. The highest test weight (37.13) in the treatment combination of I_3N_3 (Irrigation at critical stages+ 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium*) followed by I_2N_3 (Irrigation at IW/CPE ratio of 0.6 + 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium*). Sangakara (1994) [15] studied the effect of soil moisture on seed yield and quality on mungbean and he showed that seeds from irrigated plots have greater weight. Khan (2001) [10] also reported significant effect on thousands seed weight.

The seed yield and stover yield are important yield component which are influence by agronomic crop management and environment. The seed yield and stover yield significantly affected by the different irrigation level (table 3). The highest seed yield (842.20 kg/ha) and stover yield (2610 kg/ha) due to irrigation at critical stage (I_3) followed by I_2 (irrigation at IW/CPE ratio of 0.6). Among the different fertilizer treatments the highest seed yield (873.02 kg/ha) and stover yield (2603.99 kg/ha) due to application of 75% recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium* (N_3) and the lowest seed yield (682.77 kg/ha) and stover yield (2384.53 kg/ha) in N_1 (100% recommended dose of NPK). This is in conformity with the findings reported earlier by Yousef *et al*., (1989) [21]. The interaction (Table 4) also shows significant difference in seed yield and stover yield. The best treatment combination was I_3N_3 (Irrigation at critical stages+ 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium*) in both yield characters. The positive impact of availability of individual plant nutrients and humic substances from organic manure and balanced supplement of nitrogen through inorganic fertilizers might have induced cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency and regulation of water intake into the cells, resulting in the enhancement of yield parameters (Sekar, 2003) [17]. Improvement in stover yield due to combined application of inorganic fertilizer and organic manure might be attributed to controlled release of nutrients in the soil through mineralization of organic manure which might have facilitated better crop growth and yield (Afzal and Bano, 2008 and Katkar *et al*. 2011) [3, 9d].

The harvest index varied significantly due to difference in treatments (Table 3). The highest harvest index (24.37%) was observed in I_3 (irrigation at critical stage). The recommended dose of 75% recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium* (N_3) showed the highest harvest index (25.05 %) of green gram. Among all the treatments significantly the highest harvest index (25.19%) was obtained with the treatment combinations of I_3N_3 (Irrigation at critical stages+ 75% Recommended dose of fertilizer + 1 t/ha Vermicompost + *Rhizobium*) (Table 4). These results led to the conclusion that irrigation at all critical stages along with the combined application of organic and inorganic fertilizers in appropriate proportion is important for getting high grain yield of green gram.

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