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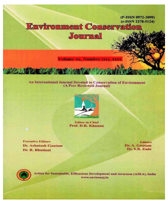

Biomass partitioning, yield and economic performance of green gram (*Vigna radiate* L.) genotypes as influenced by different irrigation levels

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ABSTRACT

A field experiment was conducted during the *Kharif* season of2020 with four main plot treatments consisting of irrigation levels (No post sowing irrigation, one irrigation at the flower initiation stage, one irrigation at the pod filling stage and two irrigations each at flower initiation and pod filling stage) and five subplot treatments as genotypes viz., MH 1142, MH 1468, MH 1703, MH 1762 and MH 1871 following split plot design by replicating thrice. Irrigating green gram, irrespective of the growth stage, increased the seed yield significantly. Two irrigations each at the flower initiation and podding stage bring about greater seed economic yield of green gram than 1 irrigation either at each stage. Among single irrigations, flower initiation stage provided significantly superior (8.6 %) seed yield compared to the pod filling stage. During the flower initiation stage, no rain and irrigation at this stage led to more development of crop plants, as is evident from a higher number of branches per plant and, ultimately, a higher number of pods. Two irrigations, *i.e.,* each at flower initiation and podding phase, lead to considerably greater seed output than single irrigation at either growth stage, which may be attributed to the sufficient supply of water, which indirectly provided a smooth supply of nutrients to crop plants. The increase was 18.4 and 28.6 per cent over-irrigation at flowering and podding stage, respectively. Seed yield varied among green gram genotypes, which might be because of variations in the genetic potential of the genotypes. Genotype MH 1871 produced significantly higher seed yield among different genotypes. The cumulative effect of yield traits *viz.* pods per plant, branches per plant, seed index and seeds per pod attributed to the higher seed yield in MH 1871. This genotype was more efficient in utilizing radiations, as evident from the higher chlorophyll content recorded in this genotype. Genotype MH 1142 was the lowest yielder and MH 1762 although produced. To obtain a higher yield of green gram, genotype MH 1871 be taken with two irrigations each at flower initiation and pod filling stage.

Introduction

Pulses are a significant commodity category of crops that provide the country's primarily extensive vegetarian population with high-quality proteins complementing cereal protein (Satya and Sanjay-Swami, 2021; Kumar *et al.,* 2022, 2022a, 2023a). in India, pulses acreage was 29.9 M ha during 2017-18 with a total production of 25.2 Mt and an average yield of 8.41 q/ha. Green gram [(*Vigna radiata* (L.)] is one of the most crucial indigenous pulse crops of South and Southeast Asia. Green

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gram, which is high in vegetarian protein (24%) and gives much-needed variety to the poor people's cereal-based diets. Per 100 g of dry seed, green gram provides 94 mg of vitamin A, 7.3 mg of iron, 124 mg of calcium, 3 mg of zinc, and 549 mg of folate (Kumar *et al.,* 2023). It is one of the most important conventional pulses in India for edible seed is ground, boiled, fermented, roasted, or sprouted. The rice-wheat system becomes the major production system after green revolution in the Indo-Gangetic Plains and the Peninsular Region. At the national level, the ideal NPK ratio of 4:2:1 was broadened to 8.5:3.1:1. The western Indo-Gangetic Plains exhibit the highest alteration (37.1:8.9:1), with wheat and rice being cultivated in succession on 82% of entire cropped areas. This is causing soil organic matter content to rapidly drop, especially in Punjab and Haryana (0.2% carbon concentration) (Ali and Kumar, 2004). Green gram helps to maintain soil fertility and texture while fixing nitrogen in the soil, yielding a good yield while demanding less irrigation than many field crops (Meena *et al.,* 2021, 2022; Roy *et al.,* 2022). The addition of green gram to the cereal cropping system can boost farm profitability, enhance soil productivity and human health, conserve irrigation water, and advance agriculture's long-term sustainability (Kumar *et al.*, 2017, 2022b; Meena and Kumar, 2022).In a similar manner, irrigation is one of the key elements in agricultural production techniques (Bakhsh *et al.,* 1999). It acts as a vehicle for nutrient absorption, therefore its availability at different phases of crop growth has a significant impact on the yield. For irrigated lands to produce more crops, the right amount of water must be applied. Lack of water in green gram disrupts normal turgor pressure, and a lack of turgidity in the cells may prevent cell elongation, which inhibits plant growth. It thickens and improves the cell walls' root-shoot ratio (Srivalli *et al.,* 2003). Stomatal conductance of leaves, membrane permeability and water deficit saturation are all negatively impacted by hydric deficit (Khadraji and Ghoulam, 2017). Water shortage at vegetative stage limits root growth, leaf area and plant size which lowers seed yield (Nielson and Nelson, 1998). Green gram's flowering, leaf area, and seed germination are all impacted by water stress. Additionally, it increases flowering and fruiting dates and slows photosynthesis, resulting in reduced crop output (Jordan and Ritichie, 2002).

Water stress throughout the green gram plant's blooming and pod-filling growth stages drastically decreased pod growth rates, pod initiation, reduced height, shortened the period of maturity, and decreased yield and yield traits (Masomi *et al.,* 2006). The farmer schedules irrigation by deciding when to irrigate, how much water to provide to the crop, and how to respond to yield. It is important to understand the crop water needs and yield responses to water, as well as the limitations of each irrigation method and equipment, the water supply system, and the financial and economic effects of the irrigation practice. Grain yield may be more pretentious by moisture stress during some growth stages than by equivalent stress during other growth stages. Water stress on these crops reduced the seeds, pods, test weight, and eventually the seed output. In regions of super-optimal temperature during reproductive growth, additional irrigation, especially at the stage of pod filling to advance water status of plant, results in an economically higher increase in yields. The stages of late flowering and pod formation are most vulnerable to the stress of soil moisture. When irrigation treatments were applied during flowering, whether or not pre-flowering irrigation was also used, green gram production was reduced. In irrigated farms, sufficient water must be applied at the proper time to increase crop yield.In order to maximize crop yield in a constrained space, it is crucial to understand how much water plants use and when they are vulnerable to water, in addition to the irrigation intervals. Depending on the plant species and growth stages, different plants require different amounts of water from planting seeds through harvest. Therefore, the present field research experiment was planned and conducted with the title "Biomass partitioning, yield and economic performance of green gram genotypes as influenced by different irrigation levels" during the *Kharif* season of 2020.

Material and Methods

Features of study site: The present field experiment was performed in the drought micro plots (6 x 1 x 2 m) at the Agronomy Farm of CCS HAU, Hisar, Haryana, India ($29^0 10^0$N latitude,

$75^0 46^0$E longitude and elevation of 215.2 m. The experimental is characterized by a sub-tropical and semi-arid climate with very dry and hot summers, cold winters and a humid, warm rainy season.

Details about the experiment: Green gram was used as a test crop. The investigation was conducted by following the principles of split plot design with four main plot treatments consisting of irrigation levels (No irrigation, one irrigation at the flower initiation stage, one irrigation at pod filling stage and two irrigations each at flower initiation and pod filling stage) and five subplot treatments as genotypes *viz*. MH 1142, MH 1468, MH 1703, MH 1762 and MH 1871, replicating thrice (Plate 1). Following the CCS HAU package and practices, uniform nutrient and weed management was done. 20 kg N + 40 kg P_2O_5/ha basis were given as basal dose using D.A.P. Irrigations were given as per treatments.

Plate1: Layout plan of experiment

Sampling and analysis: The crop was sown in drought micro plots (6 x 1 x 2 m), which were filled with dunal sand, which was low in organic carbon (0.08 %), available N (65 kg/ha) and P_2O_5 (19.5 kg/ha) and medium in K_2O (192.0 kg/ha) with slightly alkaline in reaction (pH= 7.9). The climate data were recorded at the meteorological observatory of CCS HAU, Hisar (Table 1). The mean maximum/minimum temperature, morning/ evening relative humidity, wind speed, bright sunshine hours, Pan evaporation, total rainfall and total rainy days during crop duration from sowing up to harvesting during the study year (2020) was 35.7/26.6 °C, 87.2/63.5 %, 6.6 km/hr, 7.1, 5.3 mm, 274.4 mm and 16, respectively. The overall weather during the crop study remained favorable for the green gram crop. Three plants from each treatment (three replicates) were undertaken to determine the dry matter, yield attributes and yield for dry matter accumulation and partitioning at each sampling stage. After separating the shoot and root, the fresh weights (F.W.) of each were calculated. The shoot and roots were dried for 48 hours at 65 °C in a hot air oven before being weighed to determine their dry weight (D.W.). The canopy temperature depression and chlorophyll content were recorded on a third fully expanded leaf from the top between 1000-1200 hours at the 50% flowering stage. Transpiration cooling, *i.e.,* canopy temperature depression (CTD (-°C), was measured using an infra-red thermometer (ModelAG-42 Tele-temp Corp, California, U.S.A.). Chlorophyll content in plant leaves was also determined by using SPAD meter by assessing light absorbance of plant leaves, *viz*., blue (400-500 nm) and red (600-700nm) light. Following the last harvest at physiological maturity, the number of pods, seeds per pod, and test weight were recorded. To determine the total biomass and seed output, the harvested plants were exposed to the sun for five days. The economics (Cost and return) of different treatments was calculated by using economic input and out balance as well as the prevailing market rate of different chemicals used as per treatments in the study. Net profit was attained after subtracting the cost of cultivation from gross returns.

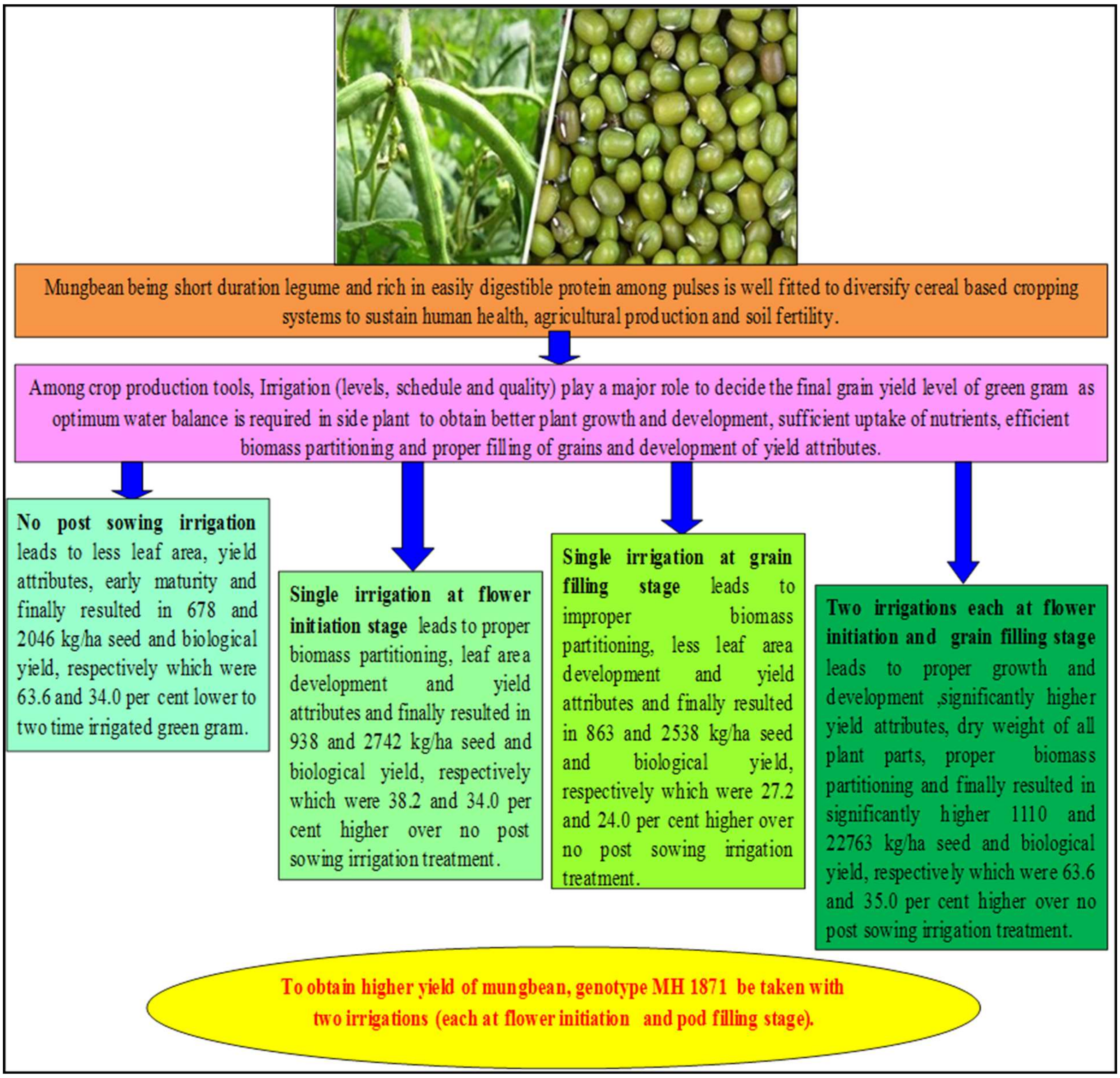
Statistical Analysis: The field experiment was replicated three times, adopting a Split Plot Design (S.P.D.). Data for different parameters under investigation were analyzed using Statistical Analysis Package (OPSTAT, CCS HAU, Hisar, India) and tested for their statistical significance with a critical difference (CD) at a 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Dry weight: A schematic flow chart of effect of different irrigation levels on mung bean crop is given in Figure 1. Irrespective of irrigation levels and genotypes, total dry weight and dry weight accumulated by differenHamidt plant parts, viz. root, shoot, leaf and pod, showed an increasing trend up to the harvest stage.

Table 1: Weekly meteorological data during crop season of study

Year	Period of crop duration	Temperature (°C)		Relative humidity (%)		Average Wind Speed (KM/H)	Bright Sun Shine Hours	P.A.N. Evaporation	Rainfall (mm)	Rainy Days
		Max	Min	Morning	Evening					
***Kharif* 2020**	0-15 DAS	37.6	27.4	83	58	7.9	8.4	7.3	47.1	4
	15-30 DAS	34.6	26.4	89	68	6.9	6.1	5.0	125.8	5
	30-45 DAS	35.9	27.3	87	65	6.3	7.1	4.8	32.8	1
	45 D.A.S.- harvest	34.9	25.4	90	63	5.3	6.8	4.4	68.7	6
	Total (30th June-21st. Sep, 2020	35.7	26.6	87.2	63.5	6.6	7.1	5.3	274.4	16



Mungbean being short duration legume and rich in easily digestible protein among pulses is well fitted to diversify cereal based cropping systems to sustain human health, agricultural production and soil fertility.

Among crop production tools, Irrigation (levels, schedule and quality) play a major role to decide the final grain yield level of green gram as optimum water balance is required in side plant to obtain better plant growth and development, sufficient uptake of nutrients, efficient biomass partitioning and proper filling of grains and development of yield attributes.

No post sowing irrigation leads to less leaf area, yield attributes, early maturity and finally resulted in 678 and 2046 kg/ha seed and biological yield, respectively which were 63.6 and 34.0 per cent lower to two time irrigated green gram.

Single irrigation at flower initiation stage leads to proper biomass partitioning, leaf area development and yield attributes and finally resulted in 938 and 2742 kg/ha seed and biological yield, respectively which were 38.2 and 34.0 per cent higher over no post sowing irrigation treatment.

Single irrigation at grain filling stage leads to improper biomass partitioning, less leaf area development and yield attributes and finally resulted in 863 and 2538 kg/ha seed and biological yield, respectively which were 27.2 and 24.0 per cent higher over no post sowing irrigation treatment.

Two irrigations each at flower initiation and grain filling stage leads to proper growth and development ,significantly higher yield attributes, dry weight of all plant parts, proper biomass partitioning and finally resulted in significantly higher 1110 and 22763 kg/ha seed and biological yield, respectively which were 63.6 and 35.0 per cent higher over no post sowing irrigation treatment.

To obtain higher yield of mungbean, genotype MH 1871 be taken with two irrigations (each at flower initiation and pod filling stage).

Figure 1. Growth and yield dynamics of green gram as influenced by different irrigation levels and their schedules

But the maximum increase in dry weight was recorded between 45 D.A.S. and the harvest stage (Table 2). Due to the non-imposition of irrigation treatments during the initial 30 days of crop growth, non-significant variation among irrigation schedules for dry weight of different plant parts and the total weight was recorded. At 45 D.A.S. and harvest stage, dry weight accumulated by plant parts and total weight were significantly affected by irrigation schedules. At 45 D.A.S. and harvest stage among irrigation schedules, two irrigations (each at flower initiation and pod filling stage) and no post-sowing irrigation recorded significantly higher and lower root, stem, leaf and total dry weight than other irrigation schedules, respectively. Two irrigations (each at flower initiation and pod filling stage) compared to no post-sowing irrigation recorded 62.2 and 82.9, 123.1 and 62.8, 52.5 and 69.1, 21.4 and 90.9 per cent higher root, shoot, leaf and total dry weight at 45 D.A.S. and harvest stage, respectively. Significantly higher and lower pod weight at 45 DAS stage was recorded with no post-sowing irrigation and two irrigations (at grand growth and flowering) treatments, respectively. But a reverse trend was obtained at the harvest stage regarding pod dry weight. Significantly higher dry weight with two irrigations (at grand growth and flowering) compared to no post-sowing irrigation might be attributed to better vegetative growth and proper biomass partitioning due to favorable water balance in these treatments vice-versa (Plate 2). Higher dry weight with crops irrigated during vegetative growth compared to stress was also reported by Summy *et al.* (2015), Ibrahim *et al.* (2017), Sadeghipour (2009), Mondal *et al.* (2018). Hamid *et al.* (2012) observed that water stress reduced the dry matter of plant parts in green gram. The results follow Khan (2001), who noted that irrigation significantly increased dry matter production. Similarly, Sangakara (1994) reported that the presence of adequate soil moisture increased the growth and yields of green gram. The overall dry weight and dry weight of various plant components varied significantly between genotypes at all growth stages till harvest. Among genotypes, MH 1871 and MH 1142 recorded significantly higher and lower dry weights of all plant parts and total dry weight, respectively, at all stages of observation (Plate 3).

Plate 2: Biomass petitioning

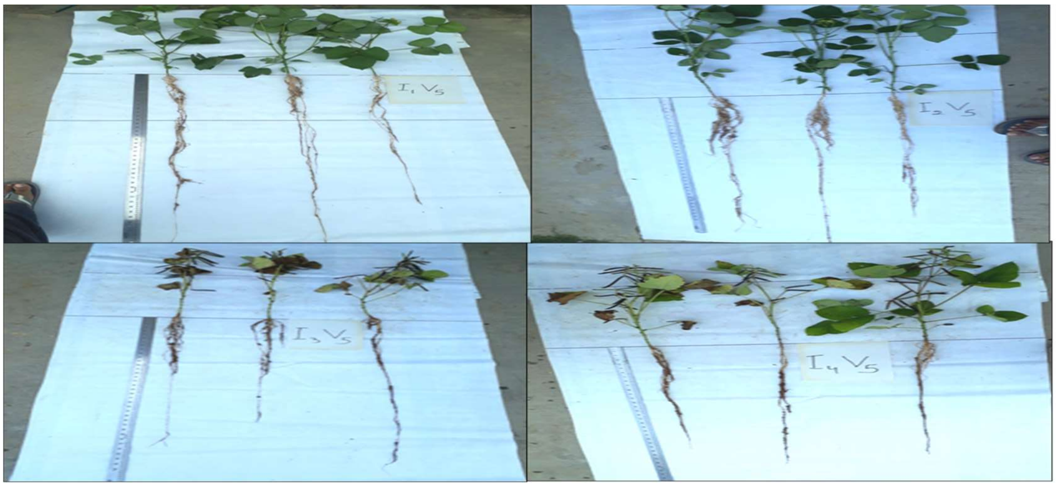


Plate 3: Effect of irrigation levels on green gram genotype MH 1871

Despite the non-imposition of irrigation schedules during the initial 30 days of plant growth, significant variation among genotypes for dry weight might be attributed to their relative ability to utilize resources and differences in biomass partitioning and genetic variability. At the 45 DAS stage, MH 1871, followed by MH 1762 over MH 1142, recorded 106.6, 147.6, 102.5, 161.1 and 110.8 per cent higher dry weight of root, shoot, leaf, pod and total, respectively. While at the harvest stage, MH 1871 recorded a significant increase of 95.0, 127.7, 149.1, 116.9 and 119.8 per cent, respectively, for root, shoot, leaf, pod and total over MH 1142. Significantly higher dry weight with MH 1871 might be a credit to its higher shoot length, more leaves, and higher number of fruiting parts compared to other genotypes. Similar variations in dry weight among genotypes were also supported by the findings of Summy *et al.* (2015), Siddique *et al.* (2006), Malik *et al.* (2008) and Rahim *et al.* (2010).

Yield and harvest index: Crop yield and harvest index of crops were significantly affected by irrigation schedules. Among Irrigation schedules, two irrigations (at grand growth and flowering) recorded 18.4/0.8, 28.6/8.9 and 63.6/35.0 per cent, significantly higher seed/biological yield compared to one irrigation at flowering, one irrigation at grain filling and no post sowing irrigation, respectively (Table 3). One irrigation at flowering and one at the grain filling stage resulted in 38.2/33.9 and 27.2/24.0 per cent higher seed/biological yield over no post-sowing irrigation. One irrigation at flowering obtained 8.6/8.0 per cent higher seed/biological yield than one at grain filling. A similar trend of observations was also obtained in the harvest index. Two irrigations (at grand growth and flowering) and no post-sowing irrigation recorded significantly higher and lower harvest indexes over other irrigation schedules, respectively. One irrigation at grand growth and one at flowering differed non-significantly regarding harvest index. The higher yield obtained by two irrigations (at grand growth and flowering) might be credited to higher water status, resulting in proper biomass partitioning, higher yield attributes, better grain filling and comparatively better growth and development compared to other irrigation schedules. These results are in line with the findings of Summy *et al.* (2015), Ibrahim *et al.* (2017), Sadeghipour (2009), and Mondal *et al.* (2018). According to Assaduzaman *et al.* (2008), T2 in the current study's more outstanding dry matter production eventually partitioned to pods per plant, seeds per pod, and 1000-seed weight, producing the highest possible seed output. The results are supported by Assaduzaman *et al.* (2008). They observed that irrigation boosted pod initiation and growth rates during the flowering and pod-filling phases, raising the harvest index as a result. Genotypes had a big impact on harvest index, biological yield, and seed production. Among genotypes, MH 1871 and MH 1142 recorded substantially higher (1125 and 3097 kg/ha) and lower (663 and 1809 kg/ha) yields (seed and biological), respectively. MH 1871 produced 15.7/1.82, 27.9/20.8, 32.6/44.7 and 69.7/71.1 per cent higher seed/biological yield than MH 1762, MH 1703, MH 1468 and MH 1142, respectively. The significantly higher seed and biological yield obtained with MH 1871 followed by MH 1762 might be due to substantially higher yield attributes (branches and pods per plant, seeds per pod and 100 seed weight) and better growth compared to other genotypes. Among genotypes, significantly higher and lower harvest indexes were recorded by MH 1468 and MH 1762, respectively. Similarly, Summy *et al.* (2015), Siddique *et al.* (2006), Malik *et al.* (2008), and Rahim *et al.* (2010) also observed variation in yield among various cultivars due to genetic divergence. The ICC 4958 showed greater promise thanks to its higher seed output, improved plant water status, reduced membrane injury, and cooler canopy temperature (Summy *et al.,* 2015).

Yield attributes: All yield attributes *viz.* branch production, seeds per pod, pods, and test weight showed significant variations among irrigation schedules (Table 3). Among irrigation schedules, two irrigations (at grand growth and flowering) and no irrigation post sowing recorded significantly higher and lower yield attributes, respectively. All yield attributes except pods per plant showed non-significant variation between one irrigation at grand growth and one irrigation at grain filling. However, numerically higher yield attributes were recorded with one irrigation at grand growth compared to one irrigation at the flowering stage. Two irrigations (at grand growth and flowering) recorded 91.5, 77.8, 15.6, 20.9 and 19.0 per cent higher branches per plant, pods per plant, seeds per

Table 2: Effect of Irrigation levels on dry weight (g/plant) of different plant parts of green gram genotypes

Treatments	Dry weight at 30 D.A.S.				Dry weight at 45 D.A.S.					Dry weight at harvest				
	Root	Stem	Leaf	Total	Root	Stem	Leaf	Pod	Total	Root	Stem	Leaf	Pod	Total
A) Irrigation														
No post sowing irrigation	0.14	0.15	0.29	0.58	0.45	0.82	1.37	0.42	3.40	0.41	0.70	0.81	3.79	5.72
One irrigation at flowering stage	0.13	0.15	0.29	0.58	0.78	1.36	1.92	0.21	4.70	0.54	0.85	1.07	7.14	9.59
One irrigation at pod filling stage	0.13	0.15	0.29	0.58	0.71	1.05	1.83	0.31	3.94	0.58	0.90	1.15	5.06	7.71
One irrigation each at flowering and pod filling stage	0.14	0.15	0.29	0.58	0.73	1.83	2.09	0.21	4.13	0.75	1.14	1.37	7.64	10.92
SEm±	0.003	0.004	0.004	0.005	0.01	0.01	0.01	0.03	0.12	0.006	0.01	0.03	0.09	0.50
CD (P=0.05)	NS	NS	NS	NS	0.03	0.05	0.05	0.11	0.43	0.02	0.04	0.10	0.33	1.79
B) Genotypes														
MH 1142	0.07	0.07	0.13	0.28	0.45	0.67	1.16	0.18	2.48	0.40	0.54	0.61	3.42	4.98
MH 1468	0.15	0.08	0.15	0.38	0.49	0.98	1.54	0.24	4.18	0.42	0.68	0.97	4.61	8.88
MH 1703	0.16	0.12	0.27	0.55	0.73	1.45	1.88	0.20	3.56	0.61	0.92	1.07	6.82	7.21
MH 1762	0.15	0.21	0.36	0.74	0.74	1.58	2.07	0.35	4.75	0.65	1.12	1.34	7.27	10.39
MH 1871	0.15	0.26	0.54	0.96	0.93	1.66	2.35	0.47	5.23	0.78	1.23	1.52	7.42	10.95
SEm±	0.008	0.008	0.008	0,01	0.01	0.02	0.02	0.02	0.12	0.008	0.01	0.03	0.14	0.86
CD (P=0.05)	0.02	0.02	0.02	0.04	0.04	0.08	0.07	0.08	0.37	0.02	0.05	0.09	0.43	2.51

Table 3: Effect of Irrigation on yield and yield attributes of green gram genotypes

Treatments	Yield (kg/ha)		H.I. (%)	Branches/plant	Pods/plant	Seeds/pod	Pod length (cm)	100 seed weight (g)
	Seed	Biological						
A) Irrigation								
No post sowing irrigation	678.8	2046.9	33.6	3.20	22.1	10.2	7.08	3.46
One irrigation at flowering stage	938.2	2742.3	35.8	4.60	32.1	10.7	8.26	3.89
One irrigation at pod filling stage	863.8	2538.2	35.4	4.40	27.4	10.7	8.26	3.66
One irrigation each at flowering and pod filling stage	1110.8	2763.7	40.9	6.13	39.3	11.8	8.56	4.12
SEm±	16.2	30.6	0.47	0.19	0.57	0.27	0.03	0.07
CD (P=0.05)	57.2	108.0	1.68	0.66	2.04	0.97	0.13	0.27
B) Genotypes								
MH 1142	663.2	1809.6	36.6	3.16	22.4	10.1	7.11	3.80
MH 1468	848.7	2101.8	40.3	4.91	28.1	10.8	7.95	3.84
MH 1703	879.5	2562.7	34.3	4.41	29.7	11.2	8.00	3.71
MH 1762	972.2	3042.1	32.2	5.16	33.9	11.1	8.41	3.65
MH 1871	1125.7	3097.7	36.8	5.25	37.1	11.2	8.74	3.91
SEm±	7.6	33.3	0.51	0.21	0.42	0.25	0.11	0.03
CD (P=0.05)	22.0	96.5	1.48	0.63	1.23	0.74	0.33	0.11

Table 4: Effect of Irrigation on Chlorophyll content and Canopy Temperature Depression (CTD) in green gram genotypes

Treatments	**Chlorophyll content**	**Canopy Temperature (° C)**	**CTD (-° C)**	**Ambiant Temperature (° C)**
A) Irrigation				
No post sowing irrigation	30.1	35.1	0.66	35.7
One irrigation at flowering stage	32.8	34.8	1.74	36.5
One irrigation at pod filling stage	32.7	33.6	2.40	35.9
One irrigation each at flowering and pod filling stage	33.8	33.5	3.52	37.1
SEm±	0.57	0.21	0.05	0.15
CD (P=0.05)	2.0	0.7	0.18	0.54
B) Genotypes				
MH 1142	29.8	35.0	1.40	36.41
MH 1468	30.0	34.5	2.12	36.83
MH 1703	31.0	34.4	2.22	36.33
MH 1762	35.1	33.8	2.30	36.08
MH 1871	35.7	33.5	2.36	35.91
SEm±	0.41	0.28	0.05	0.23
CD (P=0.05)	1.1	0.8	0.15	NS

Table 5: Effect of Irrigation on economics of green gram genotypes

Treatments	**Total cost (Rs. /ha)**	**Variable cost (Rs. /ha)**	**Total Returns (Rs./ha)**	**Net Returns (Rs./ha)**	**B:C**
A) Irrigation					
No post sowing irrigation	38635	20513	52271.3	13635.6	1.35
One irrigation at flowering stage	39639	21516	70364.4	30725.4	1.77
One irrigation at pod filling stage	39639	21516	65175.0	25536.0	1.64
One irrigation each at flowering and pod filling stage	40642	22519	82403.3	41761.1	2.02
SEm±			1132.8	1132.6	0.02
CD (P=0.05)	-	-	3996.4	3995.5	0.10
B) Genotypes					
MH 1142	39639	21516	51186.6	11547.7	1.28
MH 1468	39639	21516	64125.3	24486.3	1.61
MH 1703	39639	21516	66270.1	26631.1	1.66
MH 1762	39639	21516	72739.4	33100.4	1.83
MH 1871	39639	21516	83446.0	43807.0	2.09
SEm±			532.1	532.1	0.01
CD (P=0.05)	-	-	1539.9	1539.8	0.03

pod, pod length and 100 seed weight, respectively over no irrigation post sowing. While compared to one irrigation at grand growth / one irrigation at flowering the percentage increase of branches per plant, pods per plant, seeds per pod, pod length and 100 seed weight with two irrigations (at grand growth and flowering) was 33.2/39.3, 22.4/43.1, 10.2/10.2, 4.7/4.7 and 5.9/12.5, respectively. Significantly higher yield attributes recorded with two irrigations (at grand growth and flowering) compared to other irrigation schedules might be attributed to better vegetative and reproductive growth, proper biomass partitioning among plant parts and higher grain filling under favorable water status. Sangakara (1994) studied the effects of soil water content on crop yield and the quality of mung beans. He reported that the yield from irrigated plots had a better weight owing to heavier cotyledons. Khan (2001) also reported that irrigation levels significantly affected 1000-seed weight. A similar increase in yield attributes under irrigated conditions over no irrigation was also drawn by Ibrahim *et al.* (2017), Sadeghipour (2009), and Mondal *et al.* (2018).

All yield attributes showed significant variation among genotypes. Among genotypes, MH 1871 was statistically at par with MH 1762 and MH 1468 recorded significantly higher branches per plant and seeds per pod over MH 1142 and MH 1703. Significantly higher and lower yield attributes except 100 seed weight were reported with MH 1871 and MH 1142, respectively. MH 1762 recorded 66.1, 65.6, 10.8, 22.9 and 2.8 per cent higher branches per plant, pods per plant, seeds per pod, pod length and 100 seed weight, respectively over MH 1142. Relatively higher yield attributes in MH 1871 might be credited to its genetic constitution and better biomass partitioning over other genotypes. These qualities' high heritability and genetic progress are signs that they can be passed down readily to following generations and will hold steady under a variety of environmental conditions. The genotypes as a whole demonstrated a lot of genetic diversity that may be used in a breeding effort (Sheoran *et al.,* 2021, 2022, 2022a, 2022b). The considerable relationship between days to flowering and days to maturity, test weight and grain yield will lead to a direct or indirect improvement in earliness and grain output. Such variations of yield attributes among green gram genotypes were also reported by Siddique *et al.* (2006), Malik *et al.* (2008) and Rahim *et al.* (2010).

Chlorophyll content and Canopy Temperature Depression (CTD): Chlorophyll content and CTD showed significant variation among irrigation schedules (Table 4). Among irrigation schedules, two irrigations (at grand growth and flowering) statistically at par with one irrigation at grand growth/ flowering recorded 12.2 per cent significant higher chlorophyll content over no post-sowing irrigation. Water stress resulted in an increment in the production of reactive oxygen radicals in plants leading to a decreased amount of chlorophyll contents, pointing out the degree of oxidative damage. This reduction may be also caused by chlorophyll biosynthesis route prevention. Chlorophyll content was impacted by water stress, which eventually has an impact on seed output. Mung beans were also found to have such a reduction in total chlorophyll concentration as a result of drought stress, reported by Ibrahim *et al.* (2017), Rambhu *et al.* (2016) and Lalinia *et al.* (2012). Two irrigations (at grand growth and flowering) recorded 46.6, 102.2 and 433.3 per cent significantly higher CTD compared to one irrigation at grain filling, one irrigation at flowering and no post-sowing irrigation, respectively. A reverse trend of canopy temperature was observed among irrigation schedules. One irrigation at flowering recorded a 37.9 per cent cooler canopy compared to one irrigation at grand growth. While compared to no post-sowing irrigation treatment, one irrigation at grand growth or flowering stage recorded 163.6 or 263.6 per cent higher cool canopy, respectively. Significantly higher cool canopy and chlorophyll content recorded with irrigated over non-irrigated environments might be attributed to higher internal water balance which resulted in proper physiological processes and cool microclimatic conditions. Similar variations in CTD were also reported by Summy *et al.* (2015) and Ghassemi-Golezani *et al.* (2014). Decreased stomatal conductance and transpiration may be linked to an increase in leaf temperature brought on by water stress (Siddiaue *et al.,* 2000).

Chlorophyll content and CTD were significantly affected by genotypes. Among genotypes, MH 1871 was statistically at par with MH 1762 recorded with 19.7 and 68.5 per cent significantly higher chlorophyll content and CTD compared to

MH 1142, respectively. Such type chlorophyll content variations among crop plants were also supported by findings of Savaliya *et al.* (2019). While canopy temperature recorded with MH 1871 was 4.2 per cent lower than MH 1142. Significant variations among genotypes for chlorophyll content and CTD might be credited to differences in their genetic ability to utilize resources and to maintain internal water status and balance between different physiological processes viz. photosynthesis, respiration and transpiration. A similar finding among different genotypes of chickpea was observed by Summy *et al.* (2015).

Economics: Total/ Variable cost incurred on no post-sowing irrigation was 2.5/4.8 and 5.1/9.7 per cent lower than one irrigation at grand growth or flowering and two irrigations (at grand growth and flowering), respectively (Table 5). Among irrigation schedules, two irrigations (at grand growth and flowering) recorded 17.1, 26.4 and 57.6 per cent higher total returns while 35.9, 63.5 and 206.2 per cent higher net returns compared to one irrigation at grand growth, one irrigation flowering and no post sowing irrigation, respectively. One irrigation at grand growth was recorded with 7.9, 20.3 and 7.9 per cent higher total return, net return and B: C over one irrigation at flowering, respectively. While one irrigation at grand growth recorded 34.6, 125.3 and 31.1 per cent higher total return, net return and B: C over no post sowing irrigation, respectively. Significantly higher B: C (2.02) with a percentage increase of 14.1, 23.1 and 49.6 per cent over one irrigation at grand growth, one irrigation flowering and no post-sowing irrigation, respectively was recorded with two irrigations (at grand growth and flowering). Significantly higher economics recorded with irrigated plots might be attributed to relatively higher yield levels in irrigated treatments over the non-irrigated condition. These findings are in collaboration with the finding of Chaudhary *et al.* (2014) and Sihag *et al.* (2015).

Total returns, net returns and B: C varied significantly among genotypes. Among genotypes, MH 1871 and MH 1142 resulted in significantly higher and lower returns (total and net) and B: C, respectively. MH 1871 followed by MH 1762 recorded 63.0, 279.3 and 63.2 per cent higher total returns, net returns and B: C, respectively over MH 1142.

Conclusion

Based on the findings of the above investigation, the green gram growers may be recommended to obtain a higher yield of green gram; genotype MH 1871 be taken with two irrigations (each at flower initiation and pod filling stage). This cultivar proved to be higher productive, improved yield parameters with efficient utilization of available resources including water, nutrient, solar radiation etc. Further, with application of two irrigations at reproductive stages proved to be economically beneficial for the producers in the semi-arid regions of northern India.

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Conflict of interest

The authors declare that they have no conflict of interest.

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