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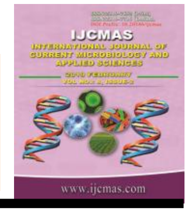

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Influence of Irrigation Levels and Row Spacings on Yield and Yield Attributing Characters of Mungbean Varieties (*Vigna radiata* L.) in Middle Gujarat Agro-climatic Zone

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A B S T R A C T

Field experiments were conducted for two consecutive years during summer season of 2015 and 2016 to study the effect of different irrigation regimes (I_1- 0.8 IW: CPE, I_2- 0.6 IW: CPE and I_3- 0.4 IW: CPE) and row spacing (S_1- 45 cm and S_2- 30 cm) on varieties (V_1- Meha and V_2- GM 4) of mungbean crop. Results found that higher grain yield (1380 kg ha^{-1} and 1437 kg ha^{-1}) was found in I_1 followed by I_2 and I_3 in both the years of experiments. Pooled results revealed increase in grain yield in irrigation level I_1 was to the tune of 18.5 and 83.8 per cent higher over irrigation levels I_2 and I_3, respectively. Cv. Meha produced higher grain yield (1178 kg ha^{-1} and 1234 kg ha^{-1}) while 30 cm spacing found higher grain yield (1162 kg ha^{-1} and 1188 kg ha^{-1}) during both the years of experiment.

Introduction

Mungbean (*Vigna radiata* L.) is an important pulse crop and short duration grain legume with wide adaptability, low input requirement and have the ability to improve soil fertility by fixing atmospheric nitrogen. Mungbean is a native of India and Central Asia (Vavilov, 1926). In India, mungbean is grown on about 3.70 million hectares with annual production of 1.57 million tons. India is the largest producer of mungbean and account 54 per cent of the world production and covers 65% of the world acreage. In Gujarat, pulse crops grown on 7.0 lac ha out of which mungbean occupies more than 2.5 lac ha area with average *kharif* productivity of about 500 to 600 kg ha^{-1}.

Moisture stress during crop growth plays important role in productivity of mungbean. During summer season mungbean is cultivated under irrigated condition. Soil moisture stress causes increase in leaf and canopy temperature resulted in drying of leaves during vegetative stage resulted in poor and slow vegetative growth. While moisture stress at the reproductive stage of cropping season cause drying of leaves, flower abortion and dropping which leads to forced maturity with poor biomass and grain yield. If crops are exposed to soil moisture stress reducing grain yields more than 50%.The summer mungbean productivity is 1000 to 1200 kg ha^{-1}. During summer season, productivity of mungbean is low due to improper irrigation management and injudicious use of available water. It ranks second to drought resistance after soybean (Ali *et al.,* 2001). On an average, it fixes atmospheric nitrogen @ 300 kg ha^{-1} annually (Sharar *et al.,* 2001). The nutritive value of mungbean lies in its high and easily digestible protein and contains approximately 25-28 per cent protein, 1.0 per cent oil, 3.5-4.5 per centfibre, 4.5-5.5 per cent ash and 62-65 per cent carbohydrates on dry weight basis. New released varieties with optimum water supply as per the water requirement of variety and optimum plant population can give productivity of 1400 to 1600 kg ha^{-1}.

Materials and Methods

The experiment was laid out at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat during summer seasons of 2015 and 2016 in split plot design with irrigation levels as main plot (I_1- 0.8 IW: CPE, I_2- 0.6 IW: CPE and I_3- 0.4 IW: CPE), spacing (S_1: 45 cm and S_2: 30 cm) and variety (V_1: Meha and V_2: GM 4) as sub plot treatments. The soil type of the experimental site is sandy loam a true representative soil of the region. Recommended agronomic practices were followed to raise the crop. The cumulative pan evaporation values were calculated from daily pan evaporation measured with the help of USWB class 'A' open pan evaporimeter installed at meteorological observatory, which was in the proximity of the experimental plot. The quantity of irrigation water applied in surface flooding was measured by 7.5 cm head Parshall flume. Yield and yield attributes observations were taken from 10 selected plants from each plot. Grain and biological yields were recorded from individual plots and expressed in kg ha^{-1}.

Results and Discussion

Number of pods plant^{-1}

The results presented in Table 1 indicated that irrigation regimes exerted significant effect on average number of pods plant^{-1}. Irrigation level I_1 (0.8 IW: CPE ratio) recorded significantly higher (20.10) average number of pods plant^{-1} which was found to be at par with irrigation levels I_2 (0.6 IW: CPE ratio) in 2015, 2016 and pooled results. Significantly the lowest (15.87) average number of pods plant^{-1} was observed with irrigation level I_3 (0.4 IW: CPE ratio). This might be due to increase in number of irrigation at shorter intervals and total consumptive use of water. This situation avoided moisture stress and thus, provided very favourable conditions for moisture and nutrient availability. These results are in accordance with results those of Tank *et al.,* (1992), Arya and Sharma (1994), Trivedi *et al.,* (1994), Vijayalakshmi and Rajagopal (1995), Dabhi *et al.,* (2000), Idnani and Gautam (2008) and Patel *et al.,* (2016). An appraisal of data presented in Table 1 showed that the variety Meha (V_1) recorded significantly higher number of pods per plant than variety GM-4 (V_2) in 2016, 2017 and pooled results. Present results are in accordance with the results reported by Chovatia *et al.,* (1993) and Tekale *et al.,* (2011) for different varieties of green gram crop.

The differences due to row spacing were observed in number of pods per plant. The treatment 45 cm row spacing (S_1) recorded significantly higher pods per plant (19.70) compared to 30 cm row spacing in both the years as well as in pooled analysis. The results had good agreement with the results of

Shukla and Dixit (1996) in green gram crop. Interaction effect between irrigation regimes, variety and row spacing on average number of pods plant^{-1} recorded at harvest of mungbean was found to be non-significant in both the years as well as pooled results (Table 1).

Seed weight plant^{-1}

The results revealed that irrigation regimes had significant effect on average seed weight plant^{-1}. Irrigation level I_1 (0.8 IW: CPE ratio) recorded significantly the highest (5.31 g plant^{-1}) average seed weight over irrigation levels I_2 (0.6 IW: CPE ratio) and I_3 (0.4 IW: CPE ratio) in both years as well as in pooled results. Significantly the lowest (2.96) average seed weight plant^{-1} was observed with irrigation level I_3 (0.4 IW: CPE ratio) in year 2015, 2016 and pooled results, while the variety Meha (V_1) recorded significantly higher seed weight per plant than variety GM-4 (V_2) in 2015, 2016 and pooled results. The differences due to row spacing were observed in seed weight per plant. The treatment 45 cm row spacing (S_1) recorded significantly higher seed weight per plant (4.89) compared to 30 cm row spacing in both the years as well as in pooled analysis.

Interaction effect between irrigation regimes, variety and row spacing on average seed weight per plant recorded at harvest of mungbean was found to be non-significant in both the years as well as pooled results (Table 1).

Test weight

Data given in Table 1 revealed that the differences in test weight of mungbean were significantly affected due to irrigation regimes. Irrigation level I_1 (0.8 IW: CPE ratio) recorded significantly the highest (38.05 g) test weight of mungbean, in pooled analysis. Which was remained at par with irrigation levels I_2 (0.6 IW: CPE ratio) in year 2016. The lowest (31.25 g) test weight of mungbean was obtained in irrigation level I_3 (0.4 IW: CPE ratio) in year 2015, 2016 and pooled results. This might be due to the severe water stress committed when the IW: CPE ratio become narrow. Water deficit during pod filling stage might have contributed towards the shrivelled seed. Further, continuous pod formation and excessive growth might have reduced the size of seed.

The results are in good conformity with those by Prasad and Yadav (1990), Arvadiya (1992) Dabhi *et al.,* (2000) and Patel *et al.,* (2016).The data presented in Table 1 indicated that the variety GM-4 (V_2) recorded significantly higher test weight than variety Meha (V_1) in year 2015, 2016 and pooled analysis. This was due to GM-4 was genetically bold seeded variety and size was larger than Meha variety. The differences due to row spacing were observed in test weight. The treatment 45 cm row spacing (S_1) recorded significantly higher test weight as compared to 30 cm row spacing (S_2) in both the years as well as in pooled analysis. This might be due to 45 cm row spacing caused lower plant population per unit area provided more moisture and nutrients to less number of grains resulted in more test weight compared to 30 cm row spacing. Similar results were reported by *Rasul et al.,* (2012).

Interaction effect as presented in Table 2 revealed that the interaction between irrigation regimes and variety for test weight recorded at harvest of mungbean was found to be significant in year 2015 as well as pooled results. However, interactions were found non-significant during year 2016. The treatment combination I_1V_2 produced significantly the highest test weight whereas the lowest was registered under treatment I_3V_1 in year 2015 as well as poled results.

Seed yield

Data pertaining to seed yield in kg ha^{-1} as influenced by the different irrigation regimes, varieties and row spacing are presented in Table 3.

An appraisal of data in the table indicated that the grain yields were significantly affected by different irrigation regimes during 2015 and 2016 as well as in the pooled results. The treatment I_1 (0.8 IW: CPE ratio) was statistically superior (1408 kg ha^{-1}) over I_2 and I_3 treatments in both years and pooled results. Treatment I_2 (0.6 IW: CPE ratio) recorded significantly higher grain yield over I_3 (0.6 IW: CPE ratio) in both years and pooled results. The increase in seed yield in irrigation level I_1 (0.8 IW: CPE ratio) was to the tune of 18.5 and 83.8 per cent higher over irrigation levels I_2 (0.6 IW: CPE ratio) and I_3 (0.4 IW: CPE ratio), respectively. The increase in seed yield with irrigation level I_1(0.8 IW: CPE ratio) might be due to increase in growth and yield attributes and also increase in irrigation frequency and total amount of water on account of increased ratio. Thus, there was progressive increase in seed yield due to favourable moisture condition and better availability of soil moisture at higher frequency of irrigation throughout the growth period which remarkably stimulated the yield attributing characters such as number of pods $plant^{-1}$, number of seeds pod^{-1} and test weight. Another reason may be due to adequate supply of moisture favorably improved nutrient uptake and translocation which ultimately linked with growth and development. Beneficial effects of these parameters resulted in higher seed yield. The lowest seed yield (766 kg ha^{-1}) with irrigation level I_3 (0.4 IW: CPE ratio) might be due to unsaturated soil moisture environment, a vapour gap would formed around the roots by their turgor pressure under water stress. Such a gap if ever present would reduce the availability of nutrients to the roots probably due to lesser contact between roots and water particle causing drastic reduction in dry matter production and uptake of nutrients. This might be the major reason for lower yield of crop with high moisture stress. The results are in close agreement with those reported by Vasimalai and Subramanian (1980), Prasad *et al.,* (1990), Arvadiya (1992), Tank *et al.,* (1992), Trivedi *et al.,* (1994), Shukla and Dixit (1996), Dabhi *et al.,* (2000), Bhadoria and Bhadoria (2002), Mitra and Bhattacharya (2005), Kumbhar *et al.,* (2005), Idnani and Gautam (2008), *Rasul et al.,* (2012), Mukesh Kumar (2016), Patel *et al.,* (2016) and Bhardwaj and Hamama (2016).

The differences in the yield were also observed in the different varieties in both the years under study as well as in pooled results. The results showed that variety Meha (V_1) produced significantly higher grain yield (1206 kg ha^{-1}) over variety GM-4 in both the years as well as in pooled data. The per cent increase in seed yield by Meha was 14.64 per cent higher over GM-4 variety. The reason for higher grain yield in Meha variety might be due to the attribution of their resistance to yellow vain mosaic disease and ability to escape water stressed condition during the reproductive stage and adopted slow early growth and later vigorous growth resulted in high seed yield. This is due to cumulative effect of improvement in growth and yield attributes such as number of pods per plant (Table 1), number of seeds per pod (Table 3) and seed weight per plant (Table 3). These findings in the present investigation are in accordance with the findings of Faroda *et al.,* (1983), Chovatia *et al.,* (1993) and Tekale *et al.,* (2009) for the greengram. The results presented in Table 2 indicated significant variations on seed yield by different spacing. Treatment 30 cm row spacing (S_2) produced significantly higher seed yield (1175 kg ha^{-1}) over 45 cm row to row spacing (S_1) in both the years and pooled results. This might be due to higher leaf area produced under 30 cm spacing then 45 cm spacing in both the years. The consequence of higher vegetative biomass production and thereafter their partitioning in the seed yield production. The findings of the present investigation are similar to those reported by Rasul *et al.,* (2012). These results are in close agreement with the findings of Singh and Yadav (1994) and Mitra and Bhattacharya (2005).

The interaction effects revealed that I X S interaction effect was found significant in year 2016 and pooled results. The treatment combination I_1S_2 produced significantly the highest seed yield whereas the lowest was registered under treatment combinations of I_3S_2.

Straw yield

Data pertaining to straw yield in kg ha^{-1} as influenced by the different irrigation regimes, varieties and row spacing are presented in Table 3 The significant differences in the biomass yields were observed in the different irrigation regimes, varieties and row spacings in both the 2015 and 2016 years as well as in pooled results.

The data revealed that the treatment I_1 (0.8 IW: CPE ratio) was found statistically superior (2468 kg ha^{-1}) over I_2 (0.6 IW: CPE ratio) and I_3 (0.4 IW: CPE ratio) treatments in year 2015 and pooled results. Treatment I_2 (0.6 IW: CPE ratio) recorded significantly higher straw yield over I_3 (0.4 IW: CPE ratio) treatment in year 2015, 2016 and pooled results. In year 2016 treatment I_1 (0.8 IW: CPE ratio) and I_2 (0.6 IW: CPE ratio) were at par and both were significantly superior over treatment I_3 (0.4 IW: CPE ratio). The reason might be due to the optimum utilization of soil moisture and nutrients which have contributed in increasing leaf area and biomass which ultimately resulted in accumulation more biomass yield under I_1 and I_2 treatments. This might be due to adequate moisture supply throughout the entire growth period which resulted in to better growth and development. The lowest (1721 kg ha^{-1}) straw yield was recorded with irrigation level I_3 (0.4 IW: CPE ratio). A remarkable reduction in straw yield with limited water supply was explained on the basis of internal water status in relation to different physiological processes taking place in the plant. The results are conformity with those reported by Prasad and Yadav (1990), Tank *et al.,* (1992), Dabhi *et al.,* (2000), Kumbhar *et al.,* (2005), Idnani and Gautam (2008), Patel *et al.,* (2016) and Mukesh *et al.,* (2016). Water deficit affects every aspect of plant life and inhibits growth, development and productivity. The retardation of plant growth under water stress is attributed to reduced accumulation of dry biomass due to inhibition of physiological processes (Singh and Yadav, 2000).

The differences in the straw yield were observed in the different varieties in both the years as well as in pooled results. The results showed that variety Meha (V_1) produced significantly higher straw yield (2243 kg ha^{-1}) over variety GM-4 (V_2) in both the years as well as in pooled data. The per cent increase in straw yield by Meha was 7 per cent over the GM-4 variety in pooled results. The reason for higher grain yield in Meha variety might be due to the attribution of their resistance to yellow vain mosaic disease and ability to sustain water stressed condition. Meha showed slow early growth and later vigorous growth resulted in high biomass accumulation. These results are in close agreement with the findings of Chovatia *et al.,* (1993) and Dhanga (2006) for mungbean crop. The significantly higher straw yield

(2316 kg ha^{-1}) was recorded under 30 cm spacing (S_2) over 45 cm (S_1) row to row spacing in both years as well as in pooled results. This may be due to higher leaf area produced under 30 cm spacing then 45 cm spacing in the both years. The higher plant population resulted in more biomass accumulation. The research of the present investigation is similar to those reported by Rasul *et al.,* (2012). These results are in close agreement with the findings of Mansoor *et al.,* (2010).

The interaction effects as presented in Table 4 revealed that interaction effects were found non significant in 2015, 2016 and pooled results. These results are in close agreement with the findings of Chovatia *et al.,* (1993) for green gram crop.

Table.1 Influence of irrigation levels and spacing on yield attributes of mungbean

Treatment	Pods $plant^{-1}$			Seed weight $plant^{-1}$ (g)			Test weight (g)		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
I_1 (0.8 IW:CPE)	20.1	20.2	20.1	4.91	5.71	5.31	37.25	38.84	38.04
I_2 (0.6 IW:CPE)	18.1	20.2	19.3	4.30	4.67	4.48	35.72	37.01	36.36
I_3 (0.4 IW:CPE)	15.2	16.5	15.9	2.94	2.99	2.96	32.15	30.36	31.25
S.Em.±	0.64	0.45	0.38	0.10	0.15	0.09	0.37	0.51	0.44
CD at 5%	2.50	1.75	1.26	0.38	0.60	0.29	1.47	2.00	1.45
CV %	12.39	8.10	10.33	8.23	11.83	10.38	3.70	4.97	4.39
V_1 (Meha)	18.7	20.1	19.3	4.31	4.59	4.44	32.13	30.20	31.16
V_2 (GM – 4)	16.8	18.1	17.4	3.79	4.33	4.06	37.96	40.61	39.28
S.Em.±	10.39	0.26	0.23	0.08	0.08	0.05	0.29	0.29	0.58
CD at 5%	1.15	0.76	0.66	0.24	0.25	0.16	0.86	0.86	1.83
S_1 (45 cm)	18.9	20.4	19.7	4.66	5.14	4.89	36.42	36.57	36.49
S_2 (30 cm)	16.5	17.7	17.1	3.44	3.78	3.61	33.66	34.24	33.95
S.Em.±	0.39	0.26	0.23	0.08	0.08	0.05	0.29	0.29	0.50
CD at 5%	1.15	0.76	0.66	0.24	0.25	0.16	0.86	0.86	1.43
CV %	9.24	5.60	7.55	8.31	8.01	8.15	3.48	3.47	3.48
Interaction table	NS	NS	NS	NS	NS	NS	I x V	NS	I x V

Table.2 Interaction effects on test weight between irrigation levels and variety (I x V) of Mungbean

Treatment	Test weight			
	2015		**Pooled**	
	V_1 (Meha)	**V_2 (GM – 4)**	**V_1 (Meha)**	**V_2 (GM – 4)**
I_1 (0.8 IW:CPE)	34.19	40.31	34.06	42.03
I_2 (0.6 IW:CPE)	31.73	39.70	31.70	41.02
I_3 (0.4 IW:CPE)	30.45	33.85	27.72	34.79
S.Em.±	0.41		0.501	
CD at 5%	1.21		1.43	

Table.3 Influence of irrigation levels and spacing on yield of mungbean

Treatment	Seed yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index (%)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
I_1 (0.8 IW:CPE)	1380	1437	1408	2325	2610	2468	37.2	35.5	36.3
I_2 (0.6 IW:CPE)	1128	1247	1188	2118	2504	2311	34.7	33.2	33.9
I_3 (0.4 IW:CPE)	758	764	761	1565	1876	1721	33.0	29.8	31.4
S.Em.±	25.5	31.1	20.1	39.8	61.8	37.7	0.49	0.48	0.63
CD at 5%	100.1	122.3	62.4	156.3	192.6	120.0	1.93	1.88	2.07
CV %	8.4	9.3	8.9	8.3	10.8	9.9	4.39	4.56	4.47
V_1 (Meha)	1178	1234	1206	2058	2428	2243	35.3	33.4	34.3
V_2 (GM – 4)	1038	1065	1052	1914	2299	2106	33.9	31.0	32.4
S.Em.±	20.3	17.7	13.4	29.7	28.2	20.6	0.44	0.44	0.31
CD at 5%	60.4	52.6	38.6	88.5	84.5	59.1	1.32	1.32	0.90
S_1 (45 cm)	1054	1111	1082	1924	2341	2122	35.4	32.8	34.1
S_2 (30 cm)	1162	1188	1175	2146	2486	2316	33.7	31.6	32.7
S.Em.±	20.3	17.7	13.4	29.7	28.2	20.6	0.44	0.44	0.31
CD at 5%	60.4	52.6	38.6	88.5	84.5	59.1	1.32	NS	0.90
CV %	8.1	6.5	7.3	7.63	6.13	6.81	4.84	5.16	5.00
Interaction table	I x S	I x S	I x S	NS	NS	NS	I x S	I x S	I x S

Table.4 Interaction effects on seed yield between irrigation levels and row spacing (I x S) of mungbean

Treatment	Seed yield (kg ha^{-1})			
	2016		2016	
	S_1 (45 cm)	S_1 (45 cm)	S_1 (45 cm)	S_1 (45 cm)
I_1 (0.8 IW:CPE)	1346	1527	1335	1482
I_2 (0.6 IW:CPE)	1206	1288	1127	1249
I_3 (0.4 IW:CPE)	781	748	770	761
S.Em.±	30.6		23.3	
CD at 5%	91.1		67.0	

Table.5 Interaction effects on harvest index irrigation levels and row spacing (I x S) of Mungbean

Treatment	Harvest index (%)			
	2015		2015	
	S_1 (45 cm)	S_1 (45 cm)	S_1 (45 cm)	S_1 (45 cm)
I_1 (0.8 IW:CPE)	36.5	35.4	36.1	35.9
I_2 (0.6 IW:CPE)	34.6	34.8	33.7	34.2
I_3 (0.4 IW:CPE)	35.0	31.1	32.6	29.9
S.Em.±	0.57		0.54	
CD at 5%	1.70		1.55	

Harvest index

The treatment I_1 (0.8 IW: CPE ratio) was significantly superior over I_2 (0.6 IW: CPE ratio) and I_3 (0.4 IW: CPE ratio) treatments in year 2015, 2016 and pooled results. Treatment I_2 recorded significantly higher harvest index in 2016 as well as in the pooled results, however, in 2015 I_2 and I_3treatments were found at par. The reason might be due to the lowest grain yield and excessive vegetative growth might have attributed towards decrease in harvest index. These findings are in agreement with Khade *et al.*, 1986, Hossain *et al.*, 2005, Akhter *et al.*, 2007. Patel *et al.*, (2016) also reported that stress during pod filling phase reduced pod initiation and pod growth rate and thereby reduced the harvest index (Table 3).

The results showed that variety Meha (V_1) recorded significantly superior harvest index over GM-4 (V_2) in both the years as well as in pooled data (Table 2). The reason might be due longer duration and higher growth rates produced higher seed yield resulted in higher harvest index by variety Meha.

The results presented in Table 5 indicated significant variations in harvest index by different row spacing. Treatment with 45 cm row spacing (S_1) recorded significantly higher harvest index over 30 cm (S_2) row to row spacing in both years and pooled results. This might be due to under 30 cm row spacing occupied higher plant population per unit area produced more straw yield under 30 cm row spacing then 45 cm row spacing in both the years and pooled results. The consequence of higher vegetative biomass production had reduced harvest index. The finding of the present investigation is similar to those reported by Mitra and Bhattacharya (2005), Mansoor *et al.*, (2010) and Rasul *et al.*, (2012).

The interaction effects as presented in Table 5 revealed that I X S interaction effect was found significant in year 2015 and pooled results. The treatment combination I_1S_1 produced the highest harvest index while lowest recorded in I_3S_2 it was at par with I_1S_2 treatment in 2015 and pooled results. The lowest was registered under treatment combinations of I_3S_2.

The present study concluded that irrigation at 0.8 IW: CPE ratio for mungbean exhibited significantly higher yield for both variety due to optimal soil moisture for various plant process. Between varieties, variety Maha produced significantly higher grain yield over variety GM-4. Between two row spacing, row spacing 30 cm exhibited higher seed yield due to higher leaf area production and biomass production resulted in higher yield the crop.

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