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Full Research Article

Impact of Temperature on the Reproductive Development in Mungbean (*Vigna radiata*) Varieties under Different Dates of Sowing

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Abstract

A two year (2010 and 2011) experiment was conducted on four mungbean varieties (V_1-Pant Mung-5, V_2-Bireswar, V_3-RMG-62 and V_4-Sukumar) sown on three different dates (D_1-15th February, D_2-1st March, D_3-15th March) in a split plot design (Main plot-dates of sowing and Sub plot-variety) in the Student's Instructional Farm, BCKV, West Bengal. The reproductive components such as bud, flower and pod numbers plant^{-1} and pod:flower ratio were recorded from 25 to 46 days after emergence (DAE). The relationship between the mean air temperature and different reproductive components were computed. Bud number per plant was maximum on 34 DAE when sown on D_2, while it was maximum on 37 DAE under D_1 and D_3 sown crops. Highest number of flower per plant was observed on 37 DAE irrespective of dates of sowing, whereas, the maximum number of pods per plant was observed on 46 DAE. Among the dates of sowing, the D_2 sown crop recorded significantly higher number of bud, flower and pod. Among the four varieties, Pant Mung-5 recorded the maximum number of bud, flower and pod per plant. Pod: flower ratio under 1st March sowing was highest under 37 to 40 DAE. With the advancement of age, the D_3 sown crop recorded highest pod:flower ratio. Number of buds per plant was found to be significantly related to the mean air temperature in 2010 under different varieties, but in 2011, it was insignificant. However, the number of flower and pod per plant were significantly related to the mean air temperature in both the year. Increased temperature increased the number of flower plant^{-1} but the reverse was true in case of pod. Increased temperature under delayed sowing significantly reduced the pod number plant^{-1}. A temperature range of 27 to 32°C was found to be congenial for the reproductive development in mungbean.

1. Introduction

Mungbean is one of the main pre-*kharif* crops, cultivated during February to April in the Gangetic plains of West Bengal. The low yield of this crop is due to the shedding of bud and flower resulting to low pod formation (Kumari and Varma, 1983). High temperature, precipitation and windspeed during the reproductive phase cause enormous bud and flower shedding (Sinha, 1997; Rainey and Griffiths, 2005). Under temperate condition, the flower and pod production are high with the high temperature, but the pod formation is low due to higher flower abortion with the high temperature. Khattak et al., (2009) observed that the high temperature (above 40°C) caused significant flower shedding in mungbean. Mungbean varieties are sown on different dates to avoid the high temperature during the reproductive phases. However, no systematic study has been conducted to analyse and quantify the impact of temperature on the reproductive behaviour of mungbean varieties sown under different dates. The present experiment has been framed to assess the impact of temperature on the reproductive behaviour of mungbean varieties sown under different dates.

2. Materials and Methods

2.1. Experimental site

The experiment was undertaken during summer seasons of 2010 and 2011 at Jaguli Instructional Farm (New Alluvial zone), Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The farm was situated at 22°56' N latitude, 88°32' E

longitude and at an altitude of 9.75 m above mean sea level.

2.2. Experimental details

The experiment was conducted under open field condition and the temperature variations during that period were completely monitored under the field condition. The experiment was laid out in a split plot design with three replications. The soil contained 0.58% organic carbon, 0.06% total nitrogen, 2.9 kg ha^{-1} available phosphorus, 136.66 kg ha^{-1} available potassium and a soil pH of 6.8. The main plot consisted of three dates of sowing (D_1: 15th February, D_2: 1st March and D_3: 15th March) and the sub plot comprised of four varieties (V_1: Pant Mung-5, V_2: Bireswar, V_3: RMG-62 and V_4: Sukumar). Seed treatment was done with *Rhizobium* culture @ 100 g ha^{-1} and sown @ 25 kg ha^{-1} at a spacing of 25×10 cm.

2.3. Fertilizer dose

FYM @ 5 t ha^{-1} was applied at the time of final land preparation. A general dose of nitrogen @ 20 kg ha^{-1} through urea, P_2O_5 @ 40 kg ha^{-1} through Single Super Phosphate and K_2O @ 40 kg ha^{-1} through Murate of Potash were applied as basal.

2.4. Method of data collection

Five plants from the middle of each plot were selected and labelled. The buds, flowers and pods were counted from each plant at three days interval. The bud, flower and pod counts were started from 25, 31 and 34 DAE, respectively and continued upto 46 DAE. The maximum and minimum temperatures of each day were collected from the adjacent meteorological observatory and the average temperature was computed for computing the relationship between the mean temperature and number of buds, flowers and pods $plant^{-1}$.

The growing degree days per day was calculated in accordance with the following formula:

GDD=[(Tmax+Tmin)/2-Tb]

Where,

Tb=Base temperature below which the crop cannot thrive (10^oC) (Kiran and Bains, 2007)

Tmax=Maximum temperature

Tmin=Minimum temperature

This minimum threshold is the temperature below which no growth takes place. The threshold value varies with the variation in plant species and for majority of the species, the value ranges from 4.5 to 12.5 °C.

3. Results and Discussion

3.1. Reproductive development in mungbean varieties under different dates of sowing

Bud number $plant^{-1}$ increased gradually from 25 to 34 DAE irrespective of varieties and date of sowing, thereafter it declined gradually upto 46 DAE (Table 1). Among the four varieties, Pant Mung-5 recorded the maximum number of bud $plant^{-1}$ which was significantly higher than other three varieties. The order of bud production upto 34 DAE was Pant Mung-5>Sukumar>Bireswar=RMG-62. On 46 DAE, the maximum bud was recorded in Sukumar. Reduction in bud number, 34 DAE onwards, was due to conversion of bud into flower because flower started to open from 31 DAE.

Number of flower $plant^{-1}$ was maximum on 27 DAE, thereafter it declined gradually (Table 1). On 46 DAE, the mean flower $plant^{-1}$ was only one irrespective of dates of sowing and varieties. The opening of flower hastened during 34 to 37 DAE, it was remarkable on 40 DAE. Therefore, it could be stated that the active flowering phase remained within 34 to 40 DAE of the crop. On the contrary, the pod appeared from 34 DAE and recorded a continuous increase upto 46 DAE (Table 1). Among three different dates of sowing, 1st March sown crop recorded the highest number of buds, flowers and pods $plants^{-1}$. The variation in dates of sowing recorded a significant variation in the number of bud, flower and pod per plant.

The pod:flower ratio was highest in Sukumar variety upto 43 DAE (Table 2). The minimum pod:flower ratio was observed in Bireswar variety, indicating higher rate of abortion of flower during this period. During 43 to 46 DAE, pod:flower ratio was very high in all the varieties and the maximum was recorded with the variety RMG-62. This showed that the conversion of flower to pod occurred during 43 to 46 DAE in case of all varieties under all dates of sowing. This might be due to the congenial temperature situation during this period.

3.2. Effect of mean temperature on buds, flowers and pods per plant in mungbean varieties

The effect of mean temperature on buds, flowers and pods per plant in mungbean varieties is presented in Figure 1. Incase of the variety Pant Mung-5, bud number significantly increased within the temperature range of 29 to 32°C in the first year, although the relationship remained non significant in the second year. The anomalies appeared due to low temperature in the second season because of substantial rainfall. The similar observations were recorded for other three varieties in 2011. The relationship clearly depicted that the number of buds per plant in mungbean varieties would be increased if the temperature remained within a range of 29 to 32°C. Below and above this temperature range, the number of buds per plant would be declined. The number of flowers $plant^{-1}$ significantly reduced with the increase in mean air temperature in all the varieties. In the first year, the mean air temperature from 29 to 30.5°C was found to be congenial for flower production, whereas in the second year, a temperature range of 27 to 28°C was found to be congenial, therefore it might be concluded that the flower production in mungbean varieties would be enhanced if the air temperature lies in between 27 to 30.5°C.

Table 1: The reproductive development in mungbean varieties under different dates of sowing

Bud number	25 DAE				28 DAE				31 DAE				34 DAE				37 DAE				40 DAE				43 DAE				46 DAE			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D1	D2	D3	Mean	D1	D2	D3	Mean	D1	D2	D3	Mean	D1	D2	D3	Mean	D1	D2	D3	Mean	D1	D2	D3	Mean
V_1	4	10	7	7	18	25	20	21	32	41	29	34	39	42	39	40	42	39	40	40	33	33	38	35	24	28	25	26	19	20	16	18
V_2	4	5	6	5	17	19	18	18	29	35	28	31	34	38	39	37	36	32	36	35	29	27	26	27	20	23	23	22	19	18	19	18
V_3	2	3	3	3	15	19	14	16	26	33	22	27	36	40	35	37	39	33	36	36	33	29	30	31	29	26	25	27	18	20	16	18
V_4	3	6	3	4	13	21	16	17	26	40	27	31	38	43	37	39	43	38	41	41	31	33	37	34	24	27	25	25	19	20	18	19
Mean	3	6	5		16	21	17		28	37	26		37	41	37		40	36	38		31	30	33		24	26	24		19	19	17	
	D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V	
SEm±	0.04	0.04	0.08		0.11	0.09	0.16		0.09	0.08	0.13		0.05	0.03	0.06		0.06	0.09	0.16		0.06	0.07	0.12		0.05	0.07	0.12		0.06	0.06	0.10	
CD (p=0.05)	0.13	0.13	0.22		0.36	0.26	0.45		0.29	0.22	0.38		0.17	0.09	0.16		0.20	0.27	0.47		0.19	0.20	0.34		0.18	0.21	0.36		0.20	0.16	0.28	

Flower number	31 DAE				34 DAE				37 DAE				40 DAE				43 DAE				46 DAE			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
V_1	3	4	3	3	9	12	11	10	13	13	12	12	10	10	7	9	3	4	3	4	1	2	1	1
V_2	1	2	1	2	6	10	10	9	10	10	10	10	7	7	6	7	2	2	3	2	0	1	1	1
V_3	2	2	2	2	7	11	12	10	11	10	9	10	9	6	6	7	3	3	2	2	2	0	1	1
V_4	2	3	2	3	10	12	11	11	10	10	11	10	7	9	4	6	3	3	3	3	1	2	1	1
Mean	2	3	2		8	11	11		11	11	10		8	8	6		3	3	3		1	1	1	
	D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V	
SEm±	0.01	0.02	0.04		0.04	0.04	0.07		0.04	0.03	0.06		0.03	0.04	0.06		0.03	0.02	0.04		0.03	0.02	0.04	
CD (p=0.05)	0.04	0.06	0.10		0.12	0.12	0.20		0.12	0.10	0.17		0.08	0.10	0.18									

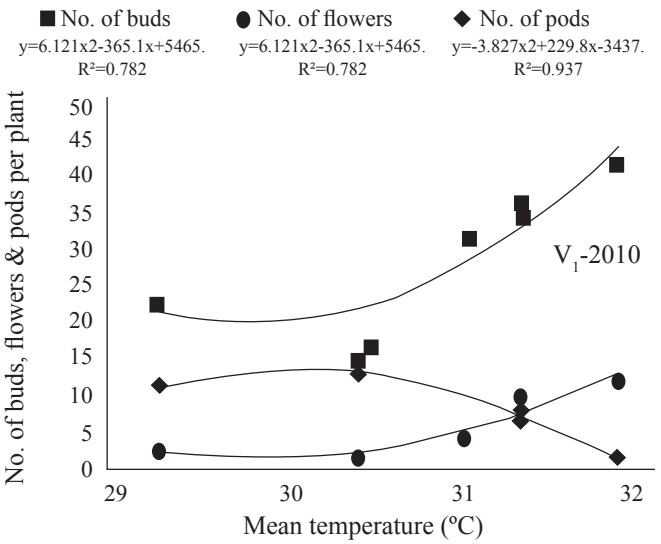
Pod number	34 DAE				37 DAE				40 DAE				43 DAE				46 DAE			
	D_1	D_2	D_3	Mean	D1	D2	D3	Mean	D1	D2	D3	Mean	D1	D2	D3	Mean	D1	D2	D3	Mean
V_1	2	3	2	2	6	7	5	6	9	9	8	9	10	12	13	12	13	14	13	14
V_2	1	2	1	1	4	5	3	4	5	7	6	6	9	9	9	9	10	12	11	11
V_3	1	1	1	1	3	5	5	4	7	8	6	7	10	10	9	10	12	13	12	12
V_4	1	2	2	2	5	5	6	5	9	9	7	8	12	12	11	12	12	14	13	13
Mean	1	2	1		4	5	5		7	8	7		10	11	10		12	13	12	
	D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V	
SEm±	0.01	0.01	0.02		0.07	0.06	0.10		0.04	0.04	0.07		0.03	0.06	0.10		0.04	0.05	0.09	
CD (p=0.05)	0.04	0.03	0.05		0.23	0.16	0.28		0.12	0.12	0.20		0.10	0.16	0.28		0.13	0.14	0.25	

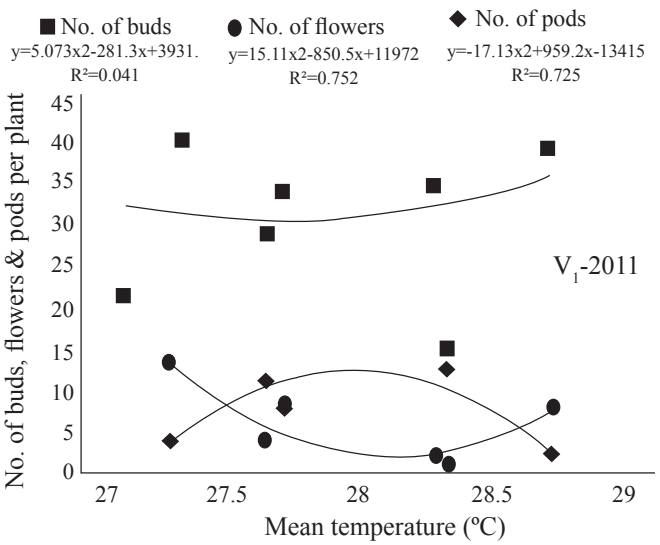
D_1-15th February, D_2-1st March, D_3-15th March; V_1-Pant Mung-5, V_2-Bireswar, V_3-RMG-62 and V_4-Sukumar; DAE- Days after emergence

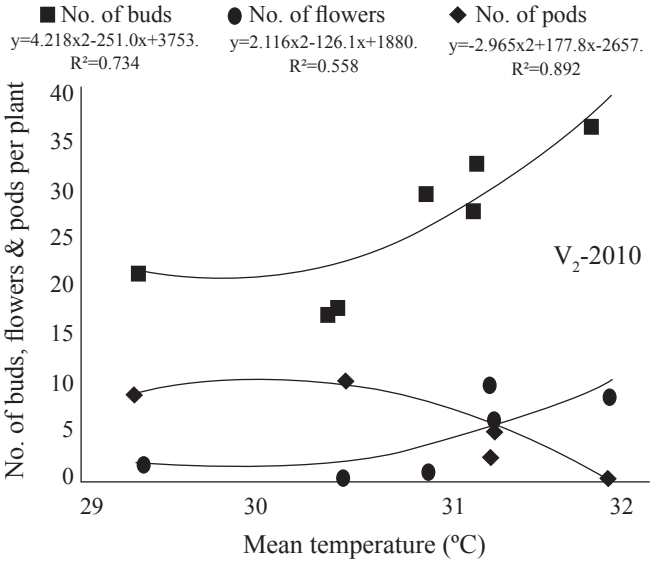
Table 2: Pod: flower ratio in mungbean varieties under different dates of sowing

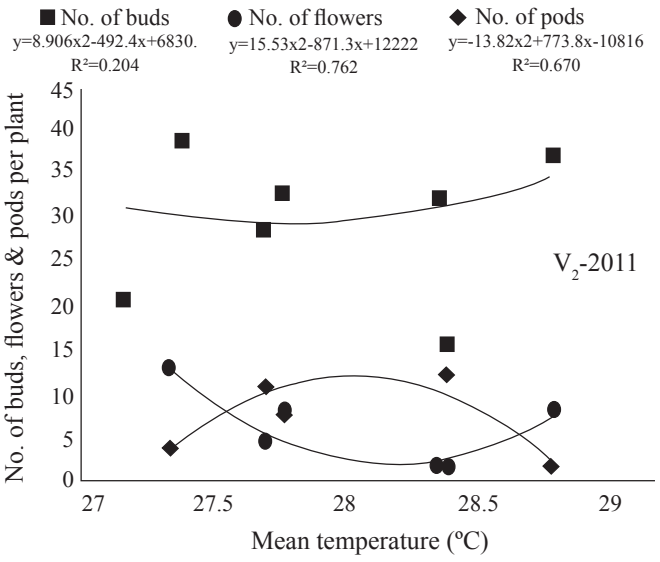
Pod: flo-wer ratio	31-34 DAE				34-37 DAE				37-40 DAE				40-43 DAE				43-46 DAE			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
V_1	0.53	0.70	0.56	0.60	0.61	0.58	0.49	0.56	0.70	0.71	0.71	0.71	1.06	1.16	2.01	1.41	3.96	3.22	5.62	4.27
V_2	0.28	0.64	0.49	0.47	0.55	0.47	0.34	0.45	0.57	0.72	0.55	0.61	1.31	1.24	1.56	1.37	4.95	5.69	4.28	4.97
V_3	0.22	0.43	0.69	0.45	0.44	0.45	0.42	0.44	0.64	0.82	0.74	0.73	1.17	1.91	1.46	1.51	4.87	7.05	6.76	6.22
V_4	0.43	0.64	1.34	0.80	0.56	0.45	0.55	0.52	0.87	0.88	0.70	0.81	1.79	1.36	2.71	1.95	4.72	4.14	5.08	4.65
Mean	0.37	0.61	0.77		0.54	0.49	0.45		0.70	0.78	0.68		1.33	1.42	1.94		4.62	5.02	5.43	
	D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V		D	V	D*V	
SEm±	0.007	0.006	0.011		0.007	0.006	0.010		0.005	0.004	0.007		0.006	0.013	0.022		0.080	0.092	0.160	
CD (p=0.05)	0.024	0.018	0.031		0.023	0.017	0.030		0.016	0.012	0.021		0.018	0.037	0.064		0.263	0.265	0.459	

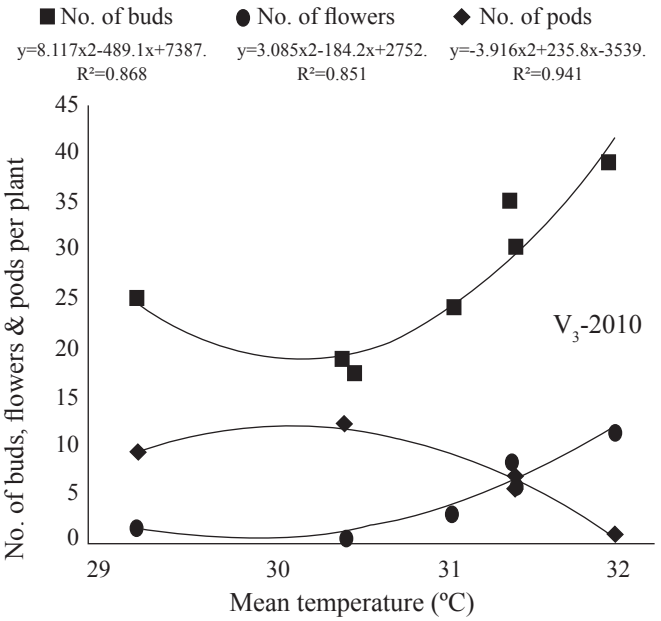
D_1-15th February, D_2-1st March, D_3-15th March; V_1-Pant Mung-5, V_2-Bireswar, V_3-RMG-62 and V_4-Sukumar; DAE- Days after emergence


No. of buds
y=6.121x2-365.1x+5465.
R²=0.782
No. of flowers
y=6.121x2-365.1x+5465.
R²=0.782
No. of pods
y=-3.827x2+229.8x-3437.
R²=0.937
No. of buds, flowers & pods per plant
V1-2010
Mean temperature (ºC)


No. of buds
y=5.073x2-281.3x+3931.
R²=0.041
No. of flowers
y=15.11x2-850.5x+11972
R²=0.752
No. of pods
y=-17.13x2+959.2x-13415
R²=0.725
No. of buds, flowers & pods per plant
V1-2011
Mean temperature (ºC)


No. of buds
y=4.218x2-251.0x+3753.
R²=0.734
No. of flowers
y=2.116x2-126.1x+1880.
R²=0.558
No. of pods
y=-2.965x2+177.8x-2657.
R²=0.892
No. of buds, flowers & pods per plant
V2-2010
Mean temperature (ºC)


No. of buds
y=8.906x2-492.4x+6830.
R²=0.204
No. of flowers
y=15.53x2-871.3x+12222
R²=0.762
No. of pods
y=-13.82x2+773.8x-10816
R²=0.670
No. of buds, flowers & pods per plant
V2-2011
Mean temperature (ºC)


No. of buds
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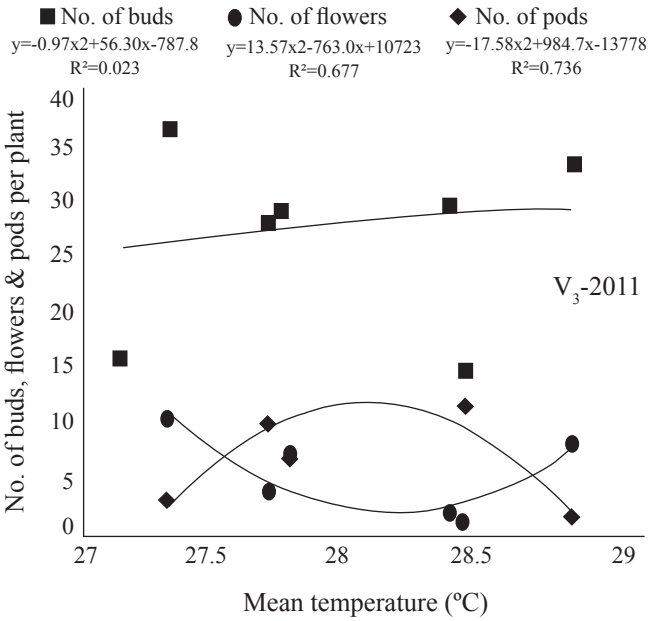
R²=0.868
No. of flowers
y=3.085x2-184.2x+2752.
R²=0.851
No. of pods
y=-3.916x2+235.8x-3539.
R²=0.941
No. of buds, flowers & pods per plant
V3-2010
Mean temperature (ºC)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y=-0.97x2+56.30x-787.8
R²=0.023
No. of flowers
y=13.57x2-763.0x+10723
R²=0.677
No. of pods
y=-17.58x2+984.7x-13778
R²=0.736
No. of buds, flowers & pods per plant
V3-2011
Mean temperature (ºC)

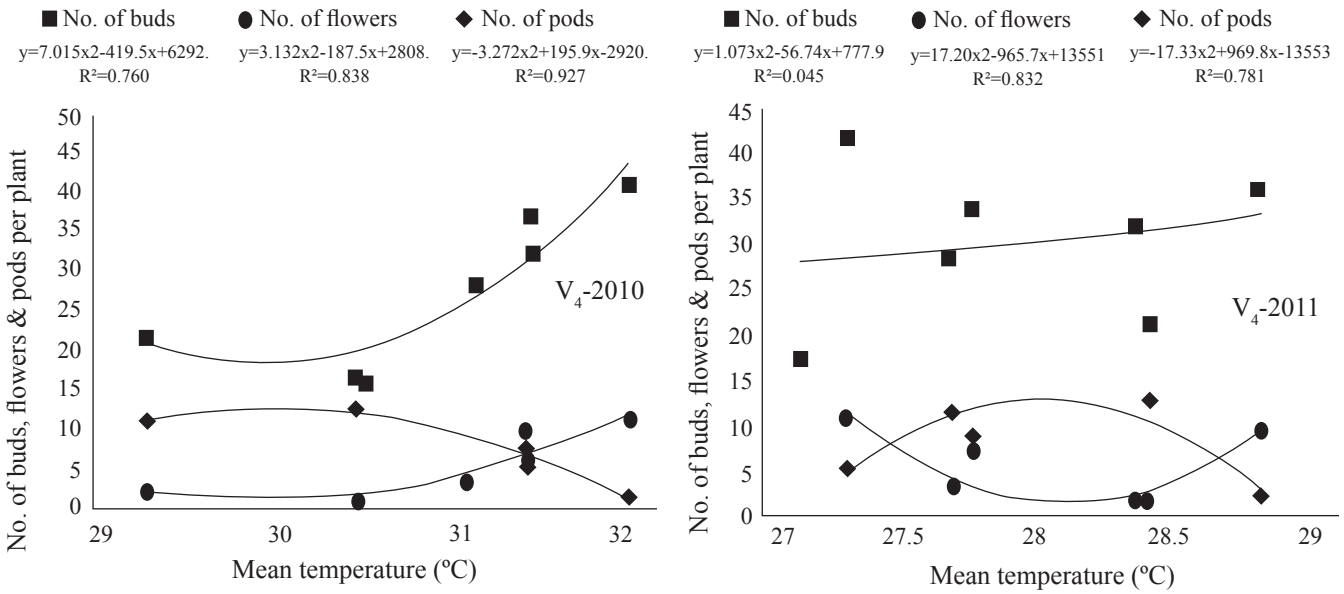

Figure 1: Effect of mean temperature on bud, flower and pods per plant in mungbean varieties

Jaiswal (1995) observed that 15th March sown greengram recorded higher number of flower plant^{-1}. Khattak et al., (2009) observed that the temperature above 40°C increased the shedding of flower in mungbean crop.

The formation of pod significantly increased with the increase in temperature from 29 to 30°C in the first year, whereas in the second year, the pod formation declined when the temperature exceeded 27.5°C. The difference in pod formation in two different years was due to the rainfall pattern in this two year. If there is rainfall during flowering, the number of aborted flower would be more if the temperature increases. The results showed that the temperature range of 27 to 32°C is crucial for the reproductive development in mungbean crop.

The GDD requirement for reproductive development was generally highest during germination to 25 DAE and 37 to 46 DAE respectively. The total heat unit requirement increased gradually from D_1 to D_3 (Table 3). Incidentally, the heat unit requirement during 37 to 46 DAE for the 15th March sown crop showed a decreasing trend in both the years and this might have been attributed to the higher amount of rainfall received during that period but nonetheless, it recorded a high GDD value under both dates of sowing. The first year experiment recorded higher GDD requirement than the second year, indicating higher atmospheric temperature in the first year. The second year crop required less GDD because it received more rainfall. Das et al (2002) observed that the rainfed crops required more GDD for the onset of phenological stage in mungbean in comparison to irrigation and mulch crop. The rainfall brings down the atmospheric temperature, thus increasing the length of the phenophase. That's why the GDD requirement was brought down in comparison to no rainfall crops.

Table 3: GDD requirement for reproductive development in mungbean varieties under different dates of sowing

	2010								
	G-25 DAE	25-28 DAE	28-31 DAE	31-34 DAE	34-37 DAE	37-40 DAE	40-43 DAE	43-46 DAE	TOTAL
D_1	430.60	55.55	61.05	61.90	59.35	64.35	64.50	64.80	862.10
D_2	581.65	64.35	64.50	64.80	65.35	66.15	65.80	65.80	1038.40
D_3	515.05	66.15	65.40	69.00	67.20	61.95	56.45	61.00	962.20
	2011								
	G-25 DAE	25-28 DAE	28-31 DAE	31-34 DAE	34-37 DAE	37-40 DAE	40-43 DAE	43-46 DAE	TOTAL
D_1	392.65	53.10	58.05	51.40	50.35	51.30	56.70	48.10	761.65
D_2	439.70	48.15	55.00	50.50	52.25	53.20	58.20	55.60	812.60
D_3	505.55	58.20	55.60	55.55	55.55	49.55	52.75	55.00	887.75

D_1-15th February, D_2-1st March, D_3-15th March
DAE- Days after emergence

4. Conclusion

Mungbean if sown by the end of February to first week of March, the reproductive development will be better under West Bengal situation. A temperature range of 27 to 32 °C is congenial for the reproductive development. Among the four varieties, Pant Mung-5 and Sukumar were found suitable for sowing under West Bengal situation.

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