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Effect of dates of sowing and spacing on rajmah (*Phaseolus vulgaris*) varieties under the climatic conditions of Central Brahmaputra Valley Zone of Assam

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ABSTRACT

A field study was conducted at RARS, Shillongani during the rabi 2008-09 to 2011, to identify the yield potentials of rajmah varieties at different sowing dates and spacing in CBVZ, Assam. Rajmah varieties 'HUR 301'and 'HUR 203' were evaluated for yields under different weather conditions by adopting sowing dates viz, 13th , 23th November and 3rd December. Among sowing dates, the highest grain yield (1231.94 kg ha-1) was recorded for 23 November for all varieties. On 23 November, 'HUR-301' had recorded the highest yield (1275 kg ha-1) followed by 'HUR-203'. Similar results were also observed under sowing on 13th November and 3rd December sowing. Among varieties, 'HUR 301' recorded higher yield in comparison to 'HUR 203'. The benefit-cost ratio was found considerably high (1.97) in 23rd November sowing. November 23rd sown crop from sowing to physiological maturity had highest accumulated GDD of 1325^{0}C-days which indicated longer crop duration. This resulted in maximum dry matter accumulation during both vegetative and reproductive phases. The temperature, bright sunshine hours (BSSH), GDD and accumulated HTU were positively correlated with grain yield from sowing to branching, branching to flowering and flowering to pod initiation but negatively correlated with yield from pod development to maturity stages. Both the varieties performed well when sown maintaining 30 ×10 cm spacing. Higher temperature during the initial stage of growth invited higher incidence of leaf crinkle virus disease (18.83 per cent) in 13th November sown crop.

***Keywords*:** Bright sunshine hours, GDD, grain yield, leaf crinkle virus, sowing date, temperature

Rajmah or french bean (*Phaseolus vulgaris*) is also popularly known as Rajma, haricot bean, kindey bean, snap bean, navy bean, field bean, dry bean, pole bean etc. It was domesticated since 6000 years ago in Central and South America (Chatterjee and Bhattachryya, 1986). In India, it is grown mainly in Jammu and Kashmir, Himachal Pradesh, UP and some parts of Maharastra, Andhra Pradesh, Western and Eastern Ghats and North-East plains where winter are mild and frost free as a winter crop. The growth and development of any crop is primarily governed by the environmental conditions of the soil and climate. The success or failure of farming is intimately related to the prevailing weather conditions. Rajmah is one of the most important pulse crops in our country which is affected by weather. Among other major physical factors temperature is one which influences the rate of growth and development in a particular agroclimatic condition. Kay (1979) reported that the optimum temperature required for the growth and development of rajmah is 16-24^{o}C. The rate of crop growth and development are also function of energy receipt in any given crop-growth season like the thermal regime. Temperature based agroclimatic indices such as growing degree days (GDD) and heliothermal unit (HTU) can be quite useful in predicting growth and yield of crops. Growing degree days are based on the concept that, real time to attain a phenological stage is linearly related to temperature range between base temperature (Tb) and optimum temperature. Influence of different time of sowing as well as temperature on phenology and yield of crop plants can be studied under field conditions through the accumulated heat units system (Chakravarty and Sastry, 1983; Rajput *et al*., 1987; Bishnoi *et al*., 1995). Farmers can avoid some losses through simple changes of planting dates, Rajmah varietal types and plant population. Sowing time is the most critical factor for achieving higher productivity of Rajmah. Advanced or delayed sowing may cause substantial reduction in yield. Ali and Lal (1991) reported that for higher yield, French bean should be sown at row to row spacing of 30 cm with plant to plant spacing of 10 cm at a depth of 8-10 cm. The maximum yield of Rajmah recorded with spacing of 30×10 cm was at par with that of 25 × 15 cm spacing (Sardana *et al.,* 2000). Hence, an attempt has been made to study how the different weather parameters are related to growth and development of rajmah crop with respect to different dates of sowing, varietal variation as well as spacing in the Central Brahmaputra Valley zone of Assam.

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MATERIALS AND METHODS

The experiment was conducted during the *rabi* 2008-09 to 2010-11, to identify the yield potentials of the different rajmah varieties at different dates of sowing and spacing on sandy loam soil of RARS, Shillongani farm of Assam Agricultural University (26.21° N, 92.65° E, 50.2 m above mean sea level). The climate of the station is subhumid. The treatments were tested in a Randomized Block Design with three replications**.** The soil was sandy loam having pH 5.5, available N 275.1 kg ha^{-1}, available P_2O_5 24.3 kg ha^{-1} and available K_2O 138.0 kg ha^{-1} in 2008-09, and pH 5.4, available N 274.8 kg ha^{-1}, available P_2O_5 22.0 kg ha^{-1} and available K_2O 136.6 kg ha^{-1} in 2009-10 and pH 5.5, available N 275.6 kg ha^{-1}, available P_2O_5 23.3 kg ha^{-1} and available K_2O 137.0 kg ha^{-1} in 2010-11. Two varieties *viz*, 'HUR 301' and 'HUR 203' were sown at three dates i.e. 13th November, 23rd November and 3rd December maintaining spacing of 30×10 cm and 30×20 cm. On an average the crop duration of 'HUR301' and 'HUR 203' was 113 and 114 days, respectively. Due to variation of sowing dates, the crop was exposed to different weather conditions during its various phenological stages recommended packages of practices were followed in raising the crop. The average rainfall received during the crop growth period (2008-09 to 2010-11) was 70.47 mm. Crop was harvested at physiological maturity stage. The incidence of leaf crinkle virus disease was recorded during third week after sowing and then dimethoate 30EC @ 0.05% was sprayed to control the vector 'white fly'.

Based on visual observations, different phenological stages like sowing to branching (S to B), branching to flowering (B to F), flowering to pod initiation (F to PI), pod initiation to pod development (PI to PD) and pod development to maturity (PD to M) were identified. Growing degree days (GDD) were computed considering base temperature as 8^0C (Thavaprakaash *et.al*, 2007). In present study, different thermal indices like growing degree days (GDD), heliothermal unit (HTU) were calculated to find the relationship of these thermal indices with different phenological stages. The agroclimatic indices were computed as follows:

Growing degree day (GDD) = {(Tmax+Tmin)/2}-Tb, Tb is base temperature

Heliothermal unit (HTU) = GDD x BSS, BSS is bright sunshine hour

RESULTS AND DISCUSSION

Weather

Results revealed that the varieties 'HUR 301' and 'HUR 203' sown on 13th November, 23rd November and 3rd December were exposed to varying weather conditions during the crop growth period. The ranges of maximum and minimum temperature were 25.1^0C to 26.6^0C and 12.5^0C to 14.0^0C, respectively. Early sown crop experienced higher temperature as compared to late sown crop. Pooled analysis of three years data revealed that temperature recorded during sowing to maturity at different phenological stages varied from 16.7 to 22.0°C during esperimentation (Table 1). Similar result was also reported by Rangaswamy (1975) that the optimum temperature required for better growth, pod set and crop maturity is between 15.6-21.1°C.

Table 1: Variations in temperature and bright sunshine hours at different phenophases of rajmah varieties (pooled)

Treatment	Temperature					BSSH				
	S to B	B to F	F to PI	PI to PD	PD to M	S to B	B to F	F to PI	PI to PD	PD to M
Date of sowing										
13th Nov	21.1	18.6	16.7	17.6	20.3	6.1	6.6	6.2	5.3	5.8
23rd Nov	19.9	17.1	17.0	18.8	21.4	5.9	7.0	5.2	5.8	5.7
3rd Dec	18.9	16.5	18.1	19.9	22.0	6.0	5.5	5.9	5.9	5.9
Variety										
HUR301	20.0	17.4	17.3	18.8	21.2	6.0	6.4	5.8	5.7	5.8
HUR203	20.4	18.1	18.5	20.0	21.2	5.9	6.3	5.6	5.8	5.8

In case of bright sunshine hours (BSSH) almost similar data 5.8 to 6.0 were recorded among different dates of sowing. In case of accumulated growing degree days (AGDD), crop sown on 23rd November from sowing to physiological maturity had highest value of 1325^0C-days which was more by 45^0C and 73^0C-days from 13th November and 3rd December sown crops (Table 2). This indicated the longer crop duration

Table 2: Variations in AGDD and HTU at different phenophases of rajmah varieties (pooled)

Treatment	GDD					AGDD	HTU					AHTU
	S to B	B to F	F to PI	PI to PD	PD to M		S to B	B to F	F to PI	PI to PD	PD to M	
Date of sowing												
13th Nov	418	159	146	148	409	1280	2593	1047	944	815	2379	1556
23rd Nov	417	142	139	168	459	1325	2467	1003	774	977	2663	1577
3rd Dec	356	115	145	174	462	1252	2099	657	831	1023	2764	1475
Variety												
HUR301	397	139	143	163	443	1285	2386	902	850	938	2602	1536
HUR203	380	149	144	163	435	1272	3097	881	834	877	2511	1640

The variety 'HUR 301' required 1285°C accumulated GDD which was 13°C days more than that for 'HUR 203' during entire growth stages. The trend was similar in case of accumulated helio-thermal unit during the crop growth period. In 2nd date of sowing, HTU values were higher as compared to 1st and 3rd dates of sowing. Again, phenophase wise weather parameters and indices were correlated with yield data which revealed that the thermal indices during sowing to maturity period were important weather parameters influencing yield (Table 3). Some very good correlation were existed in case of pod initiation to pod development and pod development to maturity except at sowing to branching, branching to flowering and flowering to pod initiation where negative correlation existed. Overall, the yields were well correlated with thermal indices for whole crop growth stage.

Table 3: Correlation of weather parameters with yield at different stages of crop growth

Stages	Temperature	BSSH	GDD	HTU
S to b	-0.098	0.274	0.092	0.048
b to F	-0.220	0.452	0.047	0.381
F to PI	-0.478	-0.094	-0.757	-0.137
PI to PD	0.154	0.104	0.073	0.493
PD to M	0.211	0.601	0.549	0.453

Grain yield

Study revealed that rajmah variety 'HUR 301'and 'HUR 203' yielded statistically equally (Table 4) in all the years. There was no significant variation in yield due to interaction between variety and date of sowing (Table 5). However, both the varieties gave higher yield when sown on 23rd November. A significant decline in grain yield was observed when sowing was delayed from 23rd November to 3rd December or advanced to 13rd November (Table 4, 5). Grain yield of 1231.94 was recorded when the crop was sown on 23rd November, which is significantly higher than that under other dates of sowing. Again, the crop gave significantly higher grain yield under 30 cm x10 cm spacing than that under 30×20 cm. Similar results were also reported by Ali and Lal (1991). Both the varieties performed well under this spacing that for higher yield, French bean should be sown at row to row spacing of 30 cm with plant to plant spacing of 10 cm (Table 6). The variety 'HUR 301', 23 November sowing and 30×10 cm spacing recorded higher B:C ratio as compared to their respective variables (Table 7).

Effect on Leaf crinkle disease incidence

The leaf crinkle disease of rajmah is caused by the virus, which is transmitted by white fly in pulses (Binyamin *et al.*, 2011). In the present study, disease incidence did not differ considerably due to variation in variety and spacing. However, date of sowing had tremendous effect on it. The crop sown on 13th November, had highest incidence of leaf crinkle disease being, 18.83 per cent. Whereas, there was 5.42 per cent incidence in 23 November sown crop and 2.83 per cent in the crop sown on 3 December. The reducing incidence might be attributed to falling temperature towards the end of November. Ashfaq *et al.* (2008) reported that high incidence of this disease had significant correlation with maximum and minimum temperature. At Ludhiana, crop sown earlier than last week of September was severely attacked by leaf crinkle virus owing to higher temperature (Sardana *et al.*, 2000). The lower incidence of this disease and conducive weather parameters led to significantly high grain yield and income when the crop was sown on 23rd November.

Table 4: Grain yield (kg ha^{-1}) of rajmah under different treatments

Treatment	2008-09	2009-10	2010-11	Pooled
Variety				
HUR301	818.06	1334.26	1152.78	1101.70
HUR203	709.72	1238.43	1045.37	997.84
LSD (0.05)	**101.27**	**23.27**	**52.27**	**NS**
Sowing date				
13th Nov	904.86	1101.39	740.28	915.51
23rd Nov	852.08	1461.11	1382.64	1231.94
3rd Dec	534.72	1296.53	1174.31	1001.85
LSD (0.05)	**124.03**	**28.5**	**64.02**	**167.53**
Spacing				
30×10cm	855.56	1346.76	1162.96	1121.76
30×20cm	672.22	1225.93	1035.19	977.78
LSD (0.05)	**101.27**	**23.27**	**52.27**	**136.79**

Table 5: Interaction effect of variety and sowing time on grain yield (kg ha^{-1}) of rajmah

Variety	Sowing date	2008-09	2009-10	2010-11	Pooled
HUR 301	Nov.13	961.11	1163.89	827.78	984.26
	Nov. 23	923.61	1505.56	1395.83	1275.00
	Dec. 03	569.45	1333.33	1234.72	1045.83
HUR 203	Nov.13	848.61	1038.89	652.78	846.76
	Nov. 23	780.56	1416.67	1369.45	1188.89
	Dec. 03	500.00	1259.72	1113.89	957.87
LSD (0.05)		**NS**	**NS**	**NS**	**NS**

Table 6: Interaction effect of variety and spacing on grain yield of rajmah

Variety	Spacing	2008-09	2009-10	2010-11	Pooled
HUR 301	30×10cm	909.26	1396.30	1125.20	1176.85
	30×20cm	726.85	1272.22	1080.56	1026.54
HUR 203	30×10cm	801.85	1297.22	1100.93	1066.67
	30×20cm	617.59	1179.63	989.82	929.01
LSD (0.05)		**NS**	**NS**	**73.91**	**NS**

Table 7: Economics of different treatments

Treatment	Gross Return (Rs. ha^{-1})	Cost (Rs. ha^{-1})	Net Return (Rs. ha^{-1})	B:C
Variety				
HUR 301	44068	16571	27497	1.65
HUR 203	39913	16571	23342	1.40
Sowing date				
13th Nov	36620	16571	20049	1.20
23rd Nov	49277	16571	32706	1.97
3rd Dec	40074	16571	23503	1.42
Spacing				
30×10cm	44870	16931	27939	1.65
30×20cm	39911	16811	22300	1.32

Table 8: Incidence of leaf crinkle virus disease

Treatment	Incidence (%)
Variety	
HUR 301	8.66
HUR 203	9.38
Date of sowing	
13th Nov	18.83
23rd Nov	5.42
3rd Dec	2.83
Spacing	
30×10cm	9.11
30×20cm	8.94

The optimum temperature required for better growth, pod set and crop maturity of rajmah is ranged between 16.7 to 22.0°C and thermal indices *viz.* GDD and HTU during sowing to maturity period are important weather parameters influencing growth and yield of rajmah. The analysis indicates that different dates of sowing, varietal variation as well as spacing are most critical factors for achieving higher productivity of rajmash. The best time of sowing of rajmah would be November 20-30 instead of mentioning a particular date; we should give the farmers a range within the already recommended time from mid October to end of November in Assam. Again, the spacing 30×10 cm is most suitable to get good yield.

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