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Research Article

Increasing the productivity of rajma through proper sowing date and plant geometry

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ABSTRACT

Rajma (*Phaseolus vulgaris* L.) cultivation is gaining popularity in Terai to Hills of Nepal. The poor plant establishment and yield due to the results of unsuitable sowing time and row spacing are the main reasons for lower productivity of it. Therefore, the date of sowing and row spacing trials were conducted in two consecutive years, 2017 and 2018 at the Grain Legumes Research Program, Khajura, Banke. A widespread and registered variety of rajma PDR 14 was used in the experiment. The experiment was laid out in a split-plot design with four sowing dates (a) 11th October, (b) 26th October, (c) 10th November and (d) 25th November as the main-factor, and three rows spacing (a) 30 cm, (b) 40 cm and (c) 50 cm as the sub-factor, consisted of three replications. The effect of the date of sowing on all the yield and yield attributing characters was found significant at a one percent significance level. Similarly, row spacing has resulted in a significant difference in grain yield. Rajma sown on 26th October (*Kartik* 9) produced 12, 38 and 64% higher grain yield than sown on 11th October, 10th November and 25th November, respectively. Moreover, rajma seeds sown on 26th October with 30 cm × 10 cm plant geometry produced the highest grain yield (2185 kg/ha). The narrow row spacing seemed well than the wider row in rajma production. There is a great potential to increase the production and productivity of rajma through an appropriate time of sowing and row spacing.

Keywords: Rajma, seeding date, plant geometry, crop establishment

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INTRODUCTION

Grain legumes are the fundamental part of the Nepalese agricultural systems, as the source of protein, income and soil fertility improvement. These crops occupy about 11% of the country's total cultivated land and fourth place in area and production after rice, maize and wheat (Pokhrel *et al.*, 2018). These are cultivated in about 340692 ha with a productivity of 1186 kg/ha (MoALD, 2021). The limited cultivated areas and productivity of the legume crops in the country is enhancing the national imports of grain legumes. The importation of grain legumes contributes about 9% (more than NRs 8 billion) in the total import value of the agricultural commodities, and has caused a heavy drain of scare foreign exchange in the

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country (Pokhrel *et al.*, 2018). There is a need to increase its production and productivity to ensure food, feed and nutritional security in addition a means of to increasing soil productivity.

French bean (*Phaseolus vulgaris* L.) is one of the most important legume crops, popularly known as kidney bean and rajma in Nepal. This crop is widely cultivated in Terai region of Nepal as a winter crop. But, due to its good market demand and value, it is also gaining popularity in high hills, where it is grown in the summer season. Not much net data on area and production of rajma are available in the country, but based on the MoALD (2021) the beans are grown in an area of 36785 ha that produced 41674 t with the productivity of 1133 kg/ha. Though, there is an increasing trend in the area of beans however, its productivity is very low and has been stagnant over the 15 years (Pokhrel *et al.*, 2018).

There are various factors for the low productivity of rajma, among them the inappropriate sowing time (Basnet *et al.*, 2022; Kaul *et al.*, 2018; Kalita *et al.*, 2016; Yadav *et al.*, 2015; Moniruzzaman *et al.*, 2007) and planting spacing (Kalita *et al.*, 2016; Kebede *et al.*, 2015; Mureithi *et al.*, 2012; Abubaker, 2008) are common that influence on rajma production. Different sowing dates and planting densities demonstrated varied and inconstant effects on rajma production (Abubaker, 2008). A non-monetary agriculture resource, the time of planting plays a vital role in the successful production of any crops (Basnet *et al.*, 2022). Hall (2004) also reported the significant yield reduction of legume crops from the poor vegetative growth and reproductive development due to inappropriate sowing time. The optimum date of sowing and planting spacing plays decisive roles in the growth and development of the rajma crop.

Therefore, it is important to study the influence of sowing date and planting spacing on the yield and yield attributing characters of rajma. The main objective of this study is to identify the appropriate seeding date and planting geometry for rajma cultivation in the western Terai region of Nepal.

MATERIALS AND METHODS

The experiments were carried out at the Grain Legumes Research Program (GLRP), Khajura, Banke located at 28° 06" 45' N latitude, 81° 35" 58' E longitude and 182 masl during the winter season of two consecutive years of 2017/18 and 2018/19. The experiment was laid out in a split-plot design with four sowing dates (a) 11th October, (b) 26th October, (c) 10th November and (d) 25th November as the main-factor, and three row to row spacing (a) 30 cm, (b) 40 cm and (c) 50 cm maintaining 10 cm plant to plant spacing as the sub-factor, consisted of three replications. The size of an individual plot was 4.8 m2, where a widespread variety PDR 14 was planted. Fertilizers were applied @ 100:60:40 kg N:P_2O_5:K_2O per ha and the remaining cultural practices like weeding and irrigation were adopted as per needed.

Soil characteristics

The soil of the experimental plots was found to be sandy loam with a neutral pH (6.6) that contains a low amount of organic matter (1.67%) and nitrogen (0.08%) but a high level of phosphorous (123.7 kg/ha) and potassium (283.3 kg/ha).

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Climatic condition of the study area

During October to April, the study area received 85.6 mm (2017/18) and 151.7 mm (2018/19) rainfall, where December and January are the coolest months. The mean minimum temperature, maximum temperature and rainfall of the study area are presented in Table 1.

Table 1: Average temperatures and rainfall during study periods of the year 2017/18 and 2018/19

	2017/18			2018/19		
Month	**Min Tem (°C)**	**Max Tem (°C)**	**Rainfall (mm)**	**Min Tem (°C)**	**Max Tem (°C)**	**Rainfall (mm)**
October	21.3	33.0	47.9	13.9	30.4	0.0
November	13.2	28.3	0.0	10.5	25.7	0.0
December	10.7	23.5	0.0	5.9	22.8	6.7
January	9.7	19.0	9.7	8.8	21.8	60.8
February	10.7	25.9	12.8	12.1	25.4	38.1
March	14.5	33.2	5.3	17.2	32.8	2.5
April	24.1	36.9	9.9	20.9	38.1	43.6

Statistical analysis

The data on yield and yield attributing parameters were analyzed statistically at a probability level of ≤ 0.05.

RESULTS AND DISCUSSION

Growth and yield attributing parameter

A combined result of 2017/18 and 2018/19 on the growth and development parameters of rajma affected by the sowing dates and row spacing are presented in Table 2. The results indicated a significant difference at $p \leq 0.01$ in days to flowering (DTF), days to maturity (DTM), plant height (PH), pods per plant (PPP), seeds per ten pods (SPTP) and hundred seeds weight (HSW) as influenced by the sowing dates, while the seed per ten pods was only significantly affected at $p \leq 0.05$ by row spacing, among the growth and yield attributing parameters in rajma production.

The development parameters, the days to flowering ranged from 55 days (11th October) to 75 days (25th November), while it was found between 64 days (30 and 40 cm) to 65 days (50 cm), due to the effect of sowing date and row spacing, respectively. Similarly, days to maturity were found longer (125 days) at seeded on 10th November and shorter in 11th October (114 days) seeded rajma, while it was found non-qualifiedly differed (120 to 121 days) due to plant geometry.

The growth parameter, the plant height of the rajma plant was found to be considerably longest (39.1 cm) under 11th October sown condition, while it was observed shortest (23.4 cm) under 25th November sown situation. But, the plant height of rajma was not significantly ($p \leq 0.05$) affected by the planting spacing, 30 (31.6 cm), 40 (31.4 cm) and 50 cm (30.3 cm).

In the case of yield attributing characters, the pods per plant were observed from 3 (25th November) to 7 (11th and 26th October) sowing conditions, while it was not significantly affected by the row spacing (5-6) in rajma cultivation. Similarly, the number of seeds per ten pods was recorded significantly maximum at $p \leq 0.01$ in 11th October (34) sown condition,

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while it was observed lowest under 25th November (28) sown rajma. The number of seeds per ten pods was noted to be significantly highest in wide-spaced, 50 cm (32) condition as compared to 30 cm (28) and 40 cm (31) spaced situations. Likewise, hundred seed weight of rajma was recorded significantly highest on 10th November (44.9 g) followed by 26th October (36.7 g) and 11th October (36.5 g) sown conditions, but, the planting of rajma with maintaining difference spacing viz., 30, 40 and 50 cm did not affect the hundred seed weight (36.8–38.2 g) of rajma.

Table 2: Effect of different sowing dates and row spacings on rajma production (pooled data of 2017/18 and 2018/19)

SN	Factors	Levels	DTF	DTM	PH	PPP	SPTP	HSW
1	Sowing date							
		11th October	55	114	39.1	7	34	36.5
		26th October	60	121	37.8	7	30	36.7
		10th November	69	125	24.1	5	32	44.9
		25th November	75	120	23.4	3	28	32.4
F-test			**	**	**	**	**	**
LSD $_{(0.05)}$			1.25	1.22	2.02	0.99	2.52	2.29
2	Row spacing							
		30 cm	64	120	31.6	5	28	37.4
		40 cm	64	121	31.4	6	31	36.8
		50 cm	65	120	30.3	6	32	38.2
F-test			ns	ns	ns	ns	*	ns
LSD (0.05)			1.09	1.06	1.74	0.86	2.18	1.98
CV (%)			2.0	1.0	6.6	18.8	8.4	6.3

DTF-days to flowering, DTM-days to maturity, PH-plant height in cm, PPP-pods per plant, SPTP-seeds per ten pods, HSW-hundred seeds weight in gram.

All the growth (plant height), development (days to flowering, days to maturity) and yield attributing parameters (pods per plant, seed per ten pods, hundred seed weight) of rajma in the study were affected significantly by the sowing dates, while seed per ten pods only affected significantly due to the effect of row spacing. The reason for variation in growth, development and yield attributing characters of rajma might be due to variation in growing environments. The earlier sowing might be created more vegetative growth, while the later sown of rajma results poor vegetative growth.

Earlier seeded rajma poses earlier flowering and maturity, long plant, higher number of pods per plant and seeds per pod, and higher seed weight, might be because of its suitability to temperatures and growing environment. Similar, observations were also made by Kaul *et al.* (2018) and Yadav *et al*. (2015). Vishwanath *et al.* (2004) also reported that the variation in pods per plant, seeds per pod and seed weight might be due to different sowing times in rajma.

Grain yield

The results of the experiments indicated that the grain yield of rajma influenced significantly by the sowing dates and row spacing (Table 3). A combined result of 2017/18 and 218/19 indicated that the significantly higher grain yield at $p \leq 0.01$ was obtained in 26th October (2046 kg/ha) seeded rajma than early, 11th October (1803 kg/ha) and late sown, 10th November (1271 kg/ha) and 25th November (736 kg/ha) sown conditions. In both the years of the experiment, the maximum yield of rajma was recorded with 26th October sowing, as

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compared to earlier and later sown conditions. The grain yield of rajma was ranged from 728 kg/ha (25th November) to 1316 kg/ha (26th October) in the year, 2017/18, while it was noted from 743 kg/ha (25th November) to 2777 kg/ha (26th October) in the year, 2018/19.

Similarly, a combined result of 2017/18 and 218/19 on the effect of different row spacing on rajma yield point ousted the significant difference at one percent level of significance ($p \leq 0.01$). The grain yield of rajma was obtained maximum when seeded with 30 cm row spacing (1648 kg/ha) as compared to 40 cm (1477 kg/ha) and 50 cm (1267 kg/ha). In both the years of the experiment, maximum yield of rajma was recorded with 30 cm row spacing as compared to 40 and 50 cm row spacings. The grain yield of rajma was ranged from 1049 kg/ha (50 cm) to 1150 kg/ha (30 cm) in the year, 2017/18, while it was noted from 1485 kg/ha (50 cm) to 2147 kg/ha (30 cm) in the year, 2018/19.

Table 3: Effect of date of seeding and row spacing on rajma yield

SN	Factors	Levels	Grain yield (kg/ha)		
			2017/18	**2018/19**	**Combined**
1	Seeding date				
		11th October	1119	2487	1803
		26th October	1316	2777	2046
		10th November	1190	1353	1271
		25th November	728	743	736
Mean			1088	1840	1464
F-test			**	**	**
LSD (0.05)			86.31	347.83	181.91
SEM			29.42	118.59	62.03
2	Row spacing				
		30 cm	1150	2147	1648
		40 cm	1064	1889	1477
		50 cm	1049	1485	1267
Mean			1088	1840	1464
F-test			*	**	**
LSD (0.05)			74.74	301.23	157.53
SEM			25.48	102.71	53.71
CV (%)			8.1	17.3	12.7

The grain yield of rajma due to the interaction effect of date of seeding and row spacing found non-significantly differed (Table 4). The result of the experiment showed that the rajma produced the maximum grain yield (2185 kg/ha) while seeded on 30 cm row spacing. On all the sowing dates, rajma produced a higher yield on 30 cm row spacing than 40 and 50 cm of row spacing. The grain yield ranged from 1550 kg/ha (50 cm) to 2072 kg/ha (30 cm) under 11th October condition, 1887 kg/ha (50 cm) to 2185 kg/ha (30 cm) under 26th October, 1008 kg/ha (50 cm) to 1478 kg/ha (30 cm) under 10th November and 624 kg/ha (50 cm) to 857 kg/ha (30 cm) under 25th November seeded conditions.

In the present study, more grain yield of rajma was obtained with an early seeded condition whereas, a lower yield was obtained with the late sown conditions. On the 26th of October seeded rajma produced 12%, 38% and 64% more grain yield as compared to rajma seeded earlier, 11th October) and later, 10th November and 25th November, respectively. The reason for variation in rajma yield in different sowing dates may be attributed to variation in climatic condition, particularly the temperature. The higher yield in earlier sowing rajma might be due to the suitability of temperature and growing environments for producing more flowers, pods, seeds and seed weight, as well. These results are in line with the findings of Kaul *et al.* (2018), Kalita *et al.* (2016) and Moniruzzaman *et al.* (2007). In contrast of the result, Basnet *et al.* (2022) reported higher grain yield of rajma under 5th November (2.16 t/ha) sown condition than 21st October (2.00 t/ha) and 20th November (1.75 t/ha).

Similarly, narrow space seeded rajma produced a higher grain yield than wide rows. Rajma seeded on 30 cm row spacing produced the 12% and 30% more yield than 40 cm and 50 cm row spacing. The higher grain yield of rajma might be due to the extensively use of crop production resources like light, water, fertilizers, etc., for synthesis and distribution of assimilates. Kalita *et al.* (2016) and Kebede *et al.* (2015) were also noted the higher yield and net benefit with seeding of rajma by maintaining 30 × 10 cm crop geometry. In contrast to this experiment's result, Abubaker (2008) reported higher yield of rajma with planting spacing of 20 × 30 cm and 30 × 30 cm.

Table 4: Interaction effect of date of seeding and row spacing on rajma yield (pooled data of 2017/18 and 2018/19)

Sowing date	Row spacing		
	30 cm	40 cm	50 cm
11th October	2072	1787	1550
26th October	2185	2067	1887
10th November	1479	1327	1008
25th November	857	725	624

GM = 1464
F-test = ns
LSD (0.05) = 315.07
SEM = 107.43

CONCLUSION

Rajma cultivation would be the primary concern in recent years due to changing climatic conditions, as a significant amount of yield may be reduced by only fluctuations of climatic factors. An appropriate seeding time and plant geometry are the major factors for the efficient use of production inputs in rajma cultivation. Based on the results of the experiment, it could be concluded that 3rd or 4th week of October was the most suitable time for rajma production in the western Terai region of Nepal, where the planting spacing of 30×10 cm is the most suitable to obtain a good yield. The results of the study needed to be undertaken over different locations and cropping systems for further verification and recommendation.

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Authors' Contributions

A. Pokhrel arranged the research concept, design, data analysis and writing the manuscript. SR Dangi had contributed recording and entry of data of the experiment.

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Conflict of Interest

The authors of the paper declare that there is no conflict of interest for the publication of this manuscript.

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