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Ambreen Nabi
Krishi Vigyan Kendra Budgam, SKUAST-K, Shalimar, Srinagar, Jammu and Kashmir, India

Sabia Akhter
(Scientist Agronomy), Krishi Vigyan Kendra, Budgam, Skuast Shalimar, Jammu and Kashmir, India

Shazia Ramzan
Krishi Vigyan Kendra Budgam, SKUAST-K, Shalimar, Srinagar, Jammu and Kashmir, India

Bilal A Lone
Krishi Vigyan Kendra Budgam, SKUAST-K, Shalimar, Srinagar, Jammu and Kashmir, India

Shabeer Ahmad Ganie
Krishi Vigyan Kendra Budgam, SKUAST-K, Shalimar, Srinagar, Jammu and Kashmir, India

Bhinish Shakeel
Krishi Vigyan Kendra Budgam, SKUAST-K, Shalimar, Srinagar, Jammu and Kashmir, India

KA Zargar
Krishi Vigyan Kendra Budgam, SKUAST-K, Shalimar, Srinagar, Jammu and Kashmir, India

Iram farooq
Krishi Vigyan Kendra Budgam, SKUAST-K, Shalimar, Srinagar, Jammu and Kashmir, India

Corresponding Author:
Sabia Akhter
(Scientist Agronomy), Krishi Vigyan Kendra, Budgam, Skuast Shalimar, Jammu and Kashmir, India

Effect of temporal variability on growth, yield and economics of Moong bean (*Vigna radiata* L.)

Ambreen Nabi, Sabia Akhter, Shazia Ramzan, Bilal A Lone, Shabeer Ahmad Ganie, Bhinish Shakeel, KA Zargar and Iram Farooq

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Abstract
A field experiment was conducted in Kashmir valley during Kharif season 2022 and 2023 to study the "Effect of temporal variability on growth, yield and economics of Moong bean (*Vigna radiata* L.)" under temperate Kashmir. The experiment comprised of three treatments *viz* three sowing dates (15th May, 25th May and 5th June). The results indicated that, growth and yield and yield components were affected by different dates of sowing. The results revealed that plant height, leaf length, leaf breadth, higher number of pods per plant, number of seeds per pod, 1000-seed weight and pod length were produced by early sowing (15th May). Similarly maximum grain/seed yield (9.9 q/ha) and BC ratio (1.82) was produced by 15th May sowing (early sowing). Early planting on 15th May has taken a greater number of days to 50% flowering and maturity. On the basis of economics, sowing of Moong on 15th May was found beneficial for higher yield and net returns.

Keywords: Moong, BC Ratio, *Vigna radiata* L, sowing time, yield, temporal variability, growth, yield

Introduction
The moong bean (*Vigna radiata* L.), alternatively known as green gram, moongo bean or mongo bean, is a plant species in the legume family. The moong bean is mainly cultivated in East, Southeast and South Asia where 90% of global production currently takes place. In India moong is grown on an area of 3.55Mha with a production of 3.10 MT with productivity of 6.7q/ha (Anon, 2024). It is used as an ingredient in both savoury and sweet dishes. Moong bean is a relatively drought tolerant, marginal crop and low input crop that can provide green manure as well as livestock feed and thus is favoured by small holder farmers. India is the largest producer of pulses accounting 22 per cent of the world production but availability of pulses per capita per day in the country is much lesser The World Health Organization (WHO) states that each person needs 80g of pulse per day. However, the daily availability of pulse is 30-35g per day. Thereby around 80 million children of the country are still protein energy under-nourished. On an average pulse contain 22-24 per cent protein as against 8-10 per cent in cereals. Hence, there is a need for increasing average pulse productivity to fulfil protein requirement. Planting time is of paramount importance and it has a significant effect on growth, development and yield (Aslam *et al*., 2015; Hassan *et al*., 2020c) [6, 10]. The planting time significantly varies among cultivars; therefore proper planting times should be adopted in order to get higher productivity (Aslam *et al*., 2000) [5] After high yielding cultivars, optimum dates sowing can result in higher yields (Ali and Gupta, 2012) [3]. Significant differences in the seed yield of moong bean with variable planting times has been reported by many authors. Temperate environments having high radiation with an average daily temperature of 27 °C, a daily precipitation between 3.2 and 5 mm/day and a soil with a soil moisture level of 50% and a pH of 6.5 are most suitable for growing Moong bean. Sowing date assists to realize potential yield by ensuring total harmony between the vegetative and reproductive phases and the meteorological rhythm (Singh *et al*., 2010) [27]. The early sowing enhances yield and biomass production owing to an increase in grain weight and other production traits (Barros *et al*., 2004; Hassan *et al*., 2020) [7, 11]. The late sowing decreases the growth cycle due to reduction in time for utilizing the natural resources that decreases the accumulation of total dry matter and consequently leads to poor yield (Vega and Hall, 2002) [28]. Among the various agronomic practices, sowing time is the most important factor influencing its yield, which differs from region to region and variety to variety. But lack

of awareness among farmers about optimum sowing date is one of the reasons of its low productivity (Charan *et al*., 2024) [8]. Selection of the cultivar and appropriate sowing date is very essential to attain yield (Jan *et al*., 2002) [13]. Thus, the present study entitled "Effect of temporal variability on growth, yield and economics of Moong bean (*Vigna radiata*)" was carried out during kharif seasons of 2022 and 2023 at KVK Budgam, SKUAST-Kashmir.

Material and Methods

A field experiment was conducted during the kharif seasons (2022 and 2023) at KVK Budgam, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), Srinagar at an altitude of 1560m amsl with latitude of 34.0619^0 and longitude of 74.7090^0. The experiment was conducted on variety Shalimar Moong-2 sown in silty clay-loam soil, with neutral pH (7.08), medium in nitrogen (380 kg/ha), available phosphorus (18.2 kg/ha), and potassium (160.1 kg/ha). The experiment comprised of three sowing dates viz 15th May (D_1), 25th May (D_2) and 05th June (D_3) laid out in a randomised block design with 3 replications. Recommended dose of nitrogen (40 kg/ha), phosphorus (60 kg/ha) and potassium (45 kg/ha) through Urea, DAP and Muriate of potash respectively, was uniformly applied to each plot. Seed rate of 25 kg ha-^{1}and spacing of 30x10cm was maintained during manual sowing under rain fed conditions, although standard cultural procedures were maintained until the crop reached maturity. The data was recorded on plant height(cm), Days to 50% flowering, Days to maturity, No. of Primary Branches, No. of Secondary branches, leaf length (cm), leaf width (cm), No. of pods, Pod length (cm), No of seeds/pod, 1000 seed weight (g) and Seed yield (q/ha). The monetary parameter like cost of cultivation, gross return, net return and benefit: cost ratio was worked out as per the standard method. The economics of the treatment was calculated based on prevailing prices of input and output. Benefit: Cost ratio was calculated by dividing net return with cost of cultivation.

Net returns = Gross returns-Total Cost of cultivation
Benefit: cost ratio = Net returns ÷ Total Cost of cultivation

The data was pooled over years. The statistical analysis of the data was performed using Microsoft Excel and "Indostat" software's. Critical differences (CD) at the 0.05 probability level were used to assess the statistical significance of mean differences among treatments for different parameters

Results and Discussion

Effect on growth characters

Perusal of the data regarding growth parameters reveals that sowing date significantly influences the plant height, days to 50% flowering, days to maturity, no. of primary and secondary branches**,** leaf length and width (Table 1 and Figure 1). The earlier sowing (15th May) resulted in taller plants compared to delayed sowing because of the fact that the early sown crop got longer time period to utilize available resources. These results are in agreement with the observations of Kumar and Kumawat (2014) [14] and Akhter *et al.* (2015) [1] who reported that there was a significant decline in the plant height with the delay in the planting time. Significant decrease in plant height with delay sowing could be associated with higher temperatures at later growth stages, which limits their vegetative growth period and accumulation of assimilates because of the early maturity of plants. These results were in conformity with the results of Singh *et al*. (2010) [27]. Earlier sowing (15th May) took more number of days to 50% flowering (45 days) and maturity (99 days) as compared to 25th May (38 and 90) and 5th June (32.04 and 81). The possible reason for more number of days taken to 50% flowering and maturity in early sowing is due to favourable soil and air temperature while in case of delayed sowing, higher temperature fulfils the requirement of Growing degree days (GDD) and thermal units of crop for achieving different phenological stages in lesser days as compared to early sown crops (Akhter *et al* 2015) [1]. Sowing on 15th May (D_1) recorded higher number of primary (4.05) and secondary branches plant^{-1} (9.16) respectively. This might be due to congenial climatic conditions for better germination, growth and development of kharif black gram. These results are in conformity with the findings of Malik *et al*. (2006) [15] and Singh and Kumar (2014) [25]. Maximum leaf length and leaf width was reported from early sown crop (D_1). The early sown crop experienced better climatic conditions during the life cycle, and it produced longer leaves with maximum width, therefore, had more leaf area that will synthesise more assimilates in turn. The same result was also reported by Iraddi (2008) [12] who reported that early sowing recorded significantly higher leaf area index, which was due to better accumulation of photosynthates, favourable for increasing leaf area.

Effect on yield and yield contributing characters

The data given in Table 1 and Figure 2 revealed that sowing during 15th may (D_1) recorded maximum number of pods plant^{-1} (70), higher pod length of 9.31cm, highest number of seeds per pod (14.14), maximum 1000-grain weight (37.8g) and maximum seed yield 9.9 (q ha^{-1}) compared to 25th May and 5th June. Maximum number of pods plant-^{1} might be due to less flower drop and more fruit setting during early season. Similar results were also reported by Ali *et al*. (2014) [2] and Yagoub and Hamed (2013) [29] who inferred favourable effect of sowing time on number of pods plant^{-1} in black gram. Early sowing resulted in higher pod length and 1000-grain weight as compared to delay sowing. It might be due to reduced growing period and higher temperature which enhanced respiratory rate of plants at later stages which results in reduced net photosynthesis and its translocation from source to sink during reproductive stages. The results are in line with the study of Rafiei *et al*. (2011) [18] and Shargi *et al*. (2011) [23]. Higher number of seeds per pod may be due to more time span enjoyed by earlier planted crop to complete their vegetative and reproductive growth. Similar finding was reported by Uddin *et al.* (2013) who described higher grains count per pod (14.70) from 15th September and minimum number of seeds per pod (9.26) was obtained from 15th October sowing date. Early sowing D_1 produced higher seed yield of 9.9 (q ha-^{1}) which was significantly superior over rest of sowing dates D_2 (25th May) and D_3 (5th June), due to the favourable climatic conditions to crop. Rehman *et al*. (2009) [20] reported that by adopting optimum sowing time significantly increases the growth and yield parameters in moong bean crop. In view of overall discussion, it is clear that yield is increased by sowing crop at proper time as earlier reported by Sharma *et al*. (1989) [24], Dhanjal *et al*. (2000) [9], Sadeghipour (2008) [21], Ali and Gupta (2012) [3] and Mule *et al.* (2020) [17].

Relative Economics: The maximum gross monetary returns (Rs. 123750 ha-^{1}), net monetary returns (Rs. 84660 ha-$^{1)}$ and BC ratio of 2.16 was recorded by D_1 sowing (15th May) which was significantly superior over the D_2 (25th May) and D_3 (5th June) sowing dates due to higher yield and yield attributes. Similar results were reported by Mule *et al*., 2020 [17].

Table 1: Effect of temporal variability on growth and yield parameters in Moong (pooled over years)

Date of Sowing	Plant Height (cm)	Days to 50% flowering	Days to maturity	No of Primary Branches	No of sec branches	Leaf length (cm)	Leaf width (cm)	No of pods	Pod length (cm)	No of seeds /pod	1000 seed wt (g)	Seed yield (q/ha)
15th May(D_1)	79.35	45.00	99.00	4.05	8.00	12.42	9.94	70.00	9.31	14.14	37.8	9.90
25th May (D_2)	69.98	38.00	90.00	3.01	6.00	10.06	7.94	57.67	8.51	10.45	31.9	8.37
05th June (D_3)	48.60	32.04	81.00	2.01	5.07	9.14	7.35	47.33	8.20	9.22	30.00	7.77
CD (5%)	6.99	5.92	5.25	1.08	1.55	0.75	0.6	13.88	0.45	2.97	3.3	0.94
SD	2.14	1.57	1.26	0.33	0.35	1.72	1.8	4.26	0.14	0.91	1.0	0.29

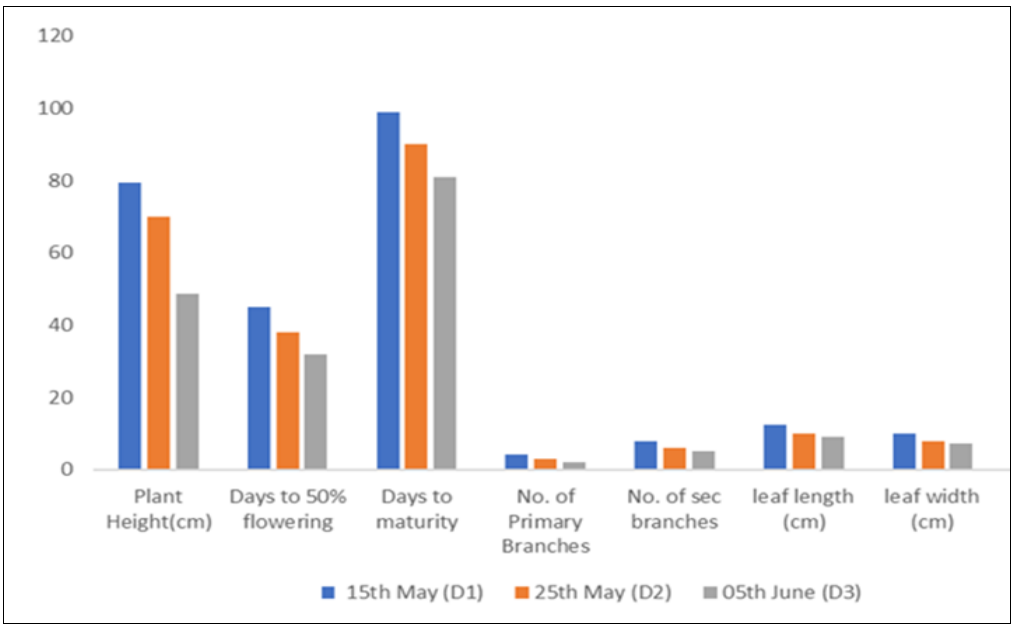

Fig 1: Effect of temporal variability on growth parameters of Moong (pooled over years)

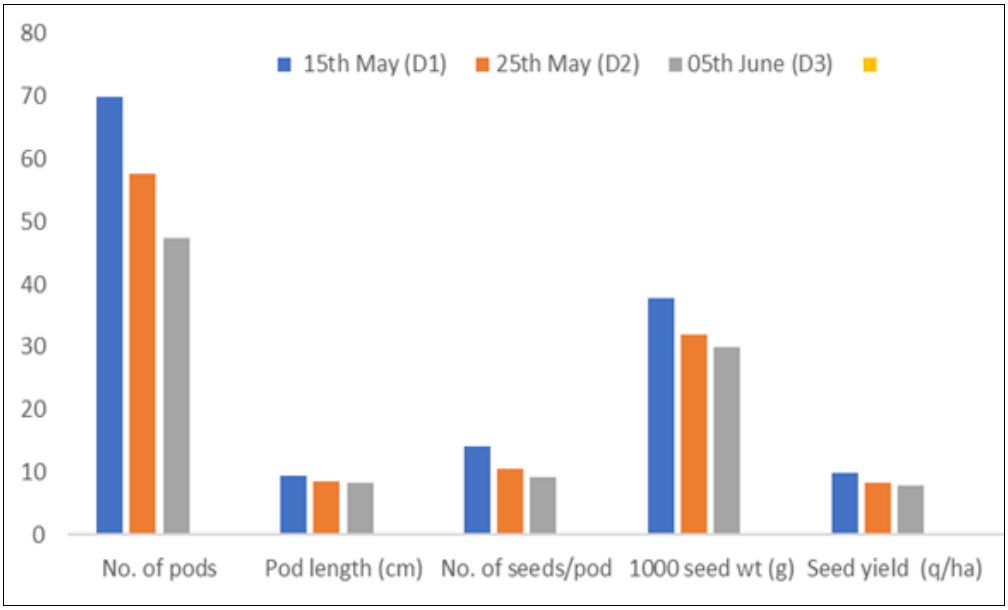

Fig 2: Effect of temporal variability on yield parameters of Moong (pooled over years)

Table 2: Effect of temporal variability on economics in Moong (pooled over years)

Date of Sowing	Cost of cultivation	Gross income	Net income	BC ratio
15th May	39,090.00	123750	84660	2.16
25th May	39,090.00	104625	65535	1.67
05th June	39,090.00	97125	58035	1.48

Sale price of Mong: Rs125/kg

Conclusion

The study on Moong cultivation has illuminated the significant impact of sowing time on both yield and economic returns. The results of the investigation conveyed that amongst different dates of sowing, D_1 (15th May) realized significantly higher yield and yield contributing characters in moong. The delay in sowing time results a decline in the yield. In view of the findings, it could be recommended that for realising

economically higher seed/grain yield and higher BC ratio, timely sowing (15th May) is suitable under temperate conditions of Kashmir valley.

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