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**Zuby Gohar Ansari**
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

**AS Gontia**
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

**SD Upadhyaya**
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

**Anubha Upadhyay**
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

**Yogendra Singh**
Department of Plant Breeding & Genetics, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

**Correspondence Author:**
**Zuby Gohar Ansari**
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

# Effect of staggered date of sowing on yield, yield attributing traits and dry matter partitioning in summer mungbean (*Vigna radiata* (L.) R. Wilczek) genotypes

**Zuby Gohar Ansari, AS Gontia, SD Upadhyaya, Anubha Upadhyay and Yogendra Singh**

**Abstract**
A field experiment was conducted to study the effect of staggered dates of sowing on yield and yield contributing characters and dry matter partioning in different varieties of summer mungbean under terminal heat and water stress conditions during *summer* seasons of 2017-18 and 2018-19 at Research Farm, Department of Plant Physiology Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur (Madhya Pradesh). The experiment was laid out in a factorial randomized block design replicated thrice. The treatments consisted of three sowing environments *viz*., Feb 12$^{th}$, Feb 27$^{th}$ and Mar 14$^{th}$ and five mungbean varieties *viz*., PDM139, Pusa Ratna, Pusa Vishal, Pusa1431 and TJM3. Thus the study revealed that genotype PDM139 had a comparatively higher dry matter accumulation in leaves (1.63g plant$^{-1}$), stem (0.939 g plant$^{-1}$), pods weight (6.87 g plant$^{-1}$) as well as total dry matter (.79 g plant$^{-1}$) reflected in its maximum economic yield (5.78 g plant$^{-1}$ and 787.74 Kg ha$^{-1}$). Sowing carried out on 27$^{th}$ Feb produced maximum seed yield due to enhancement of dry matter production and partioning of photo-assimilates in economic sinks as a result of favourable environment. Genotype PDM139 sown on 27$^{th}$ Feb outyielded (6.79 g plant$^{-1}$ and 880.10 Kg ha$^{-1}$) other treatment combinations.

**Keywords:** Mungbean, varieties, TDM, yield, yield attributing traits

## Introduction
Mungbean (*Vigna radiata* (L.) R. Wilczek) a proteinaceous catch crop among pulses has grown in kharif as well as summer seasons. India ranks first in the world in pulse production contributing 25% globally. Total pulse area in India is more than 29 million hectares and the production were 25.23 million tonnes at a productivity level of 841 Kg ha$^{-1}$ in the year 2017-18. (Min. of Agri. & FW (DAC&FW), GOI 2017) [13]. Summer mungbean stands third after chickpea and pigeon pea among pulses (Tamang *et al*., 2015) [22]. It occupies 4.26 million area and contributes 2.01 million tonnes in pulse production in the country in the year 2017-18 (Min. of Agri. & FW (DAC&FW), GOI 2017) [13]. Madhya Pradesh contributes 5.47 per cent of total mungbean area in India i.e., 2.97 lakh hectare area with 2.20 lakh tons of production which contributes 11.57 per cent of total mungbean production in India in 2017-18 (Min. of Agri. & FW (DAC&FW), GOI 2017) [13]. This crop contains 51% carbohydrate, 24–26% protein, 4% mineral, and 3% vitamins (Mondal *et al*., 2012) [14].
Atmospheric temperatures are expected to increase in future due to potential climatic changes one of the greatest dangers is the vulnerability of agriculture to climate change, especially in developing countries. Drought problems for mungbean are worsening with the rapid expansion of water stressed areas of the world including 3 billion people by 2030 (Postel, 2000) [16]. There was flower drop and reduced pod set with increase in day temperatures (Singh and Singh, 2011) [21]. As the climate shifts, the synchrony between climate and crop commonly disrupted (Biyan *et al*., 2009) [2]. In order to realize the potential yield of summer mungbean, sowing date plays an important role (Panwar and Sharma, 2004; Singh *et al.*, 2010) [15, 20]. Delayed sowing after March, and early sowing before February, reduced the yield of summer mungbean (Dharmalingam and Basu, 1993) [3]. It has been observed that extreme temperatures and erratic distribution of rainfall drastically affected the productivity and caused heavy losses (Upadhyaya and Agarwal, 2014) [23].
Temperature stress is more atrocious limiting growth and grain yield world-wide causing more than 60% yield losses (Saha *et al*., 2010) [17]. Araujo *et al*. (2015) [1] emphasizes the need to address current demands on modern agriculture and food production activities impaired by

global climate change. It mostly focused on main crops like chickpea, pea, soybean and cowpea but apparently less on abiotic stresses tolerance on other legumes like mungbean and black gram due to sparse availability of information on diverse stress responses and mechanism of tolerance in these legumes. Dry matter production and its proper partitioning into economic sinks play a crucial role in determining yield which are subjected to be affected by climate changes. Keeping in view of the above facts the present investigations were undertaken.

## Material and Methods

A field experiment was conducted to investigate the effect of staggered dates of sowing on yield and yield attributing characters and dry matter partioning in different varieties of summer mungbean under terminal heat and water stress conditions during *summer* seasons of 2017-18 and 2018-19 at Research Farm, Department of Plant Physiology Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur (Madhya Pradesh). The experiment was laid out in factorial randomized block design with three replications. Treatments comprised of three sowing environments *viz*., Feb 12$^{th}$, Feb 27$^{th}$ and Mar 14$^{th}$ and five mungbean varieties *viz*., PDM139, Pusa Ratna, Pusa Vishal, Pusa1431 and TJM3. For estimating the dry matter production five continuous plants were removed from the field and partitioned into main stem, leaves and branches and kept in an electric oven at 80 $^{0}$C for about 48 hrs till constant weight. The dry weight of individual plant part as well as total was recorded separately. Yield and yield components viz; pod length (cm), width (mm), girth (mm), pod weight (g plant$^{-1}$) no. of pods plant$^{-1}$, no. of seeds pod$^{-1}$, seed index (g), biological yield (g plant$^{-1}$ or Kg ha$^{-1}$), seed yield (g plant$^{-1}$ or Kg ha$^{-1}$) and harvest index (H.I.) were quantified from five plants after threshing and sun drying.

## Results and Discussion

### Dry matter partioning and accumulation

#### Leaves (g plant$^{-1}$)

The leaf dry matter was found to be enhanced as the age of the crop advanced till 50 DAS thereafter it declined in subsequent growth phases. The decline was attributed the translocation of photo-assimilates from the source to the sink (Goswami *et al.*, 2010) [5]. PDM139 (Table no 1) had an average maximum (1.46 g) leaves dry matter accumulation while, Pusa 1431 (1.41 g) recorded the lowest. The highest leaf dry matter production in genotype PDM139 revealed higher production efficiency of assimilatory apparatus an important trait for breeding point of view. On the other hand sowing carried out on 27$^{th}$ Feb ($D_2$) resulted in an average maximum (4.42 g) leaf dry matter (Table no 1) which may be attributed to the availability of all growth factors which might have enhanced the photosynthetic ability of moongbean.

Among interactions (Table no 1) sowing of variety PDM139 on 27$^{th}$ Feb recorded the maximum (2.71 g) ($V_1D_2$) dry matter partitioning in leaves and Pusa1431 sown on 14$^{th}$ Mar (0.94 g) noted the minimum ($V_4D_3$).

#### Stem (g plant$^{-1}$)

The stem dry matter was increased continuously with the growth span of crop till harvesting phase. The increment was due to non-synchronous maturity, more vegetative growth upto maturity phase was also reported by Durga (2012) [4] and Shihabuddin *et al.* (2013) [19]. PDM139 (Table no 1) possessed maximum (0.939 g) stem dry matter accumulation and while, Pusa 1431 (0.711 g) recorded the lowest. On the other hand sowing carried out on 27$^{th}$ Feb ($D_2$) resulted in an average maximum (1.34 g) stem dry matter (Table no 1) which may be attributed to the availability of all growth factors and also mobilization of dry matter from other parts to stem also.

**Table 1:** Dry Matter partioning in summer mungbean varieties under staggered dates of sowing

| Factor A | Leaves (g plant$^{-1}$) | | | | | | Stem (g plant$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 DAS | 30 DAS | 40 DAS | 50 DAS | At Harvest | Mean | 20 DAS | 30 DAS | 40 DAS | 50 DAS | At Harvest | Mean |
| V1 | 0.146 | 0.298 | 1.534 | 3.297 | 2.883 | 1.63 | 0.062 | 0.159 | 0.685 | 1.527 | 2.262 | 0.939 |
| V2 | 0.144 | 0.294 | 1.511 | 3.254 | 2.847 | 1.61 | 0.061 | 0.158 | 0.679 | 1.52 | 2.262 | 0.936 |
| V3 | 0.13 | 0.265 | 1.361 | 2.92 | 2.557 | 1.45 | 0.049 | 0.128 | 0.551 | 1.232 | 1.822 | 0.757 |
| V4 | 0.128 | 0.258 | 1.329 | 2.85 | 2.497 | 1.41 | 0.046 | 0.121 | 0.519 | 1.16 | 1.711 | 0.711 |
| V5 | 0.136 | 0.278 | 1.429 | 3.06 | 2.7 | 1.52 | 0.053 | 0.135 | 0.581 | 1292 | 1.916 | 0.795 |
| SEm± | 0.007 | 0.013 | 0.07 | 0.161 | 0.007 | 0.078 | 0.003 | 0.008 | 0.034 | 0.078 | 0.119 | 0.048 |
| C.D.(P=0.05) | - | - | - | - | 0.022 | - | 0.009 | 0.023 | 0.1 | 0.227 | 0.347 | 0.14 |
| Factor B | | | | | | | | | | | | |
| D1 | 0.129 | 0.155 | 0.844 | 2.35 | 1.9 | 1.077 | 0.032 | 0.114 | 0.468 | 1.204 | 2.215 | 0.806 |
| D2 | 0.163 | 0.457 | 2.378 | 5.09 | 4.42 | 2.501 | 0.095 | 0.225 | 1.031 | 2.259 | 3.072 | 1.336 |
| D3 | 0.118 | 0.223 | 1.076 | 1.79 | 1.77 | 0.994 | 0.036 | 0.082 | 0.309 | 0.576 | 0.697 | 0.34 |
| SEm± | 0.006 | 0.01 | 0.054 | 0.125 | 0.006 | 0.06 | 0.002 | 0.006 | 0.027 | 0.06 | 0.092 | 0.037 |
| C.D.(P=0.05) | 0.017 | 0.03 | 0.158 | 0.363 | 0.017 | 0.175 | 0.007 | 0.017 | 0.078 | 0.176 | 0.269 | 0.109 |

**Table 1:** Interactions

| Treatment Combinations | Leaves | | | | | | Stem | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 DAS | 30 DAS | 40 DAS | 50 DAS | At Harvest | Mean | 20 DAS | 30 DAS | 40 DAS | 50 DAS | At Harvest | Mean |
| V1D1 | 0.138 | 0.165 | 0.90 | 2.51 | 2.03 | 1.15 | 0.036 | 0.128 | 0.525 | 1.35 | 2.485 | 0.905 |
| V1D2 | 0.177 | 0.495 | 2.57 | 5.5 | 4.78 | 2.71 | 0.11 | 0.26 | 1.193 | 2.612 | 3.552 | 1.545 |
| V1D3 | 0.123 | 0.234 | 1.13 | 1.88 | 1.84 | 1.04 | 0.041 | 0.09 | 0.338 | 0.618 | 0.748 | 0.367 |
| V2D1 | 0.136 | 0.163 | 0.89 | 2.48 | 2.00 | 1.13 | 0.037 | 0.134 | 0.549 | 1.412 | 2.59 | 0.946 |
| V2D2 | 0.174 | 0.487 | 2.53 | 5.42 | 4.71 | 2.66 | 0.107 | 0.252 | 1.157 | 2.534 | 3.45 | 1.499 |
| V2D3 | 0.121 | 0.231 | 1.11 | 1.87 | 1.83 | 1.03 | 0.04 | 0.088 | 0.332 | 0.613 | 0.74 | 0.363 |
| V3D1 | 0.124 | 0.149 | 0.81 | 2.27 | 1.83 | 1.04 | 0.029 | 0.103 | 0.423 | 1.088 | 2.00 | 0.729 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V3D2 | 0.153 | 0.427 | 2.22 | 4.75 | 41.3 | 2.34 | 0.087 | 0.205 | 0.943 | 2.065 | 2.81 | 1.222 |
| V3D3 | 0.114 | 0.217 | 1.05 | 1.74 | 1.71 | 0.97 | 0.032 | 0.076 | 0.287 | 0.543 | 0.66 | 0.319 |
| V4D1 | 0.122 | 0.147 | 0.8 | 2.23 | 1.80 | 1.02 | 0.026 | 0.094 | 0.387 | 0.996 | 1.83 | 0.667 |
| V4D2 | 0.149 | 0.416 | 2.16 | 4.63 | 4.02 | 2.27 | 0.082 | 0.194 | 0.889 | 1.947 | 2.65 | 1.152 |
| V4D3 | 0.112 | 0.213 | 1.02 | 1.7 | 1.67 | 0.94 | 0.03 | 0.074 | 0.279 | 0.539 | 0.65 | 0.315 |
| V5D1 | 0.125 | 0.15 | 0.82 | 2.28 | 1.84 | 1.04 | 0.031 | 0.111 | 0.456 | 1.172 | 2.16 | 0.785 |
| V5D2 | 0.165 | 0.462 | 2.40 | 5.14 | 4.47 | 2.53 | 0.09 | 0.213 | 0.976 | 2.137 | 2.91 | 1.264 |
| V5D3 | 0.117 | 0.222 | 1.07 | 1.77 | 1.79 | 0.98 | 0.037 | 0.083 | 0.31 | 0.567 | 0.69 | 0.337 |
| SEm± | 0.013 | 0.023 | 0.12 | 0.279 | 0.01 | 0.134 | 0.005 | 0.013 | 0.06 | 0.135 | 0.206 | 0.083 |
| C.D. (P=0.05) | - | - | - | - | 0.038 | - | - | - | - | - | - | - |

Among interactions (Table no 1) sowing of variety PDM139 on 27th Feb recorded the maximum (1.55 g) ($V_1D_2$) dry matter partitioning in stem and Pusa1431 sown on 14th Mar (0.32 g) noted the minimum ($V_4D_3$).

**Root (g plant$^{-1}$)**

The root dry matter increased during the growth span of plant till 50 DAS thereafter it declined in subsequent growth phases. Root DM decreased in late sowing was attributed to scarcity of water and extreme temperature fluctuations in summer mungbean as also observed by Gupta (2008) [6] and Kumar *et al*. (2013) [10]. Pusa Ratna (Table no 2) had maximum (0.223 g) root dry matter accumulation while, Pusa 1431 (0.17 g) recorded the lowest. The highest root dry matter production in genotype Pusa Ratna revealed higher capacity of absorption of water, mineral, salts and ions which might have led to better crop canopy. Besides, the higher dry matter partioning in roots in genotype Pusa Ratna revealing its drought resistant trait which may be used for inducing drought resistant in moongbean.

On the other hand sowing carried out on 12th Feb ($D_1$) resulted in maximum (0.261 g) root dry matter (Table no 2) and on 14th Mar ($D_3$) recorded the minimum (0.11 g).

Among interactions (Table no 2) sowing of variety Pusa Ratna on 12th Feb recorded the maximum (0.30 g) ($V_2D_1$) dry matter partitioning in root and Pusa1431 on 14th Mar (0.091 g) noted the minimum ($V_4D_3$).

**Pod dry weight (g plant$^{-1}$)**

The pod dry matter was found to be enhanced as the age of the crop advanced till harvesting stage. Pod weight increases as the translocation of photosynthates occurred from source to sink as also reported by Samant (2017) [18]. PDM139 recorded (Table 2b) highest pod dry weight (6.87 g plant$^{-1}$), while Pusa1431 noted lowest (5.70 g plant$^{-1}$).

On the other hand sowing carried out on 27th Feb ($D_2$) resulted in maximum (6.72 g plant$^{-1}$) pod dry matter (Table no 2b) and on 14th Mar ($D_3$) recorded the minimum (5.69 g plant$^{-1}$).

Among interactions (Table no 2b) sowing of variety PDM139 on 27th Feb recorded the maximum (7.70 g plant$^{-1}$) ($V_1D_2$) dry matter partitioning in pod and Pusa1431 on 14th Mar (4.94 plant$^{-1}$) noted the minimum ($V_4D_3$).

**Total dry matter accumulation (TDM g plant$^{-1}$)**

The TDM was increased with advancement of crop growth from early growth phase onwards till harvesting phase. Under timely sown of green gram, plant growth reached at optimum level and resulted in higher dry matter accumulation than later sowing schedules. Green gram sown on later dates experienced high temperatures during later growth stages, which resulted in quick desiccation of leaves, unbalanced ratio of photosynthesis and respiration which ultimately resulted in low dry matter accumulation also reported by Meena *et al.* (2017) [12] and Samant (2017) [18]. PDM139 (Table no 2) possessed maximum (2.79 g) total dry matter accumulation and while, Pusa 1431 (2.29 g) recorded the lowest.

On the other hand sowing carried out on 27th Feb ($D_2$) resulted in an average maximum (4.06 g) total dry matter (Table no 2) which may be attributed to the translocation of more photo-assimilates from source to the sink enhancing the yield attributing traits and subsequently yield in moongbean.

Among interactions (Table no 2) sowing of variety PDM139 on 27th Feb recorded the maximum (4.50 g) ($V_1D_2$) total dry matter partitioning and Pusa1431 on 14th Mar (1.35 g) noted the minimum ($V_4D_3$).

**Yield and yield attributing parameters**

Kaur *et al.* (2015) [8] reported that the rise in temperatures as a result of climate change will have adverse effects on various crops. Mungbean (*Vigna radiata* L.) is grown as a summer-season crop in many parts of the world. Hence the effects of high temperatures (>40/25 ◦C; day/night) are intensified during reproductive growth phase in mungbean. The high yielding genotypes were found to possess higher pod length, no. of pods plant$^{-1}$ and no. of seeds pod$^{-1}$ (Khan *et al.*, 2016 and Jalali *et al.*, 2017) [9, 7]. The higher yield was obtained in timely sowing, due to favourable temperature and humidity during their growth period and nodulation formation stage resulting in better growth also reported by Meena *et al.* (2017) [12]. Malik *et al.* (2008) [11] also noted that pods plant$^{-1}$, no. of seeds pod$^{-1}$ and biological yield plant$^{-1}$ showed highly significant and positive correlation with seed yield showing that these traits have good positive effect on seed yield. Selection of genotypes on the basis of these traits can be useful.

**Table 2:** Dry matter partitioning (g) and total dry matter accumulation (g) in summer mungbean genotypes under staggered dates of sowing

| Factor A | Root (g plant$^{-1}$) | | | | | | Total Dry matter accumulation (g plant$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 DAS | 30 DAS | 40 DAS | 50 DAS | At Harvest | Mean | 20 DAS | 30 DAS | 40 DAS | 50 DAS | At Harvest | Mean |
| V1 | 0.026 | 0.064 | 0.193 | 0.455 | 0.374 | 0.222 | 0.234 | 0.521 | 2.41 | 4.78 | 6.01 | 2.79 |
| V2 | 0.027 | 0.067 | 0.192 | 0.454 | 0.374 | 0.223 | 0.232 | 0.519 | 2.38 | 4.74 | 5.97 | 2.77 |
| V3 | 0.021 | 0.052 | 0.156 | 0.371 | 0.305 | 0.181 | 0.2 | 0.445 | 2.07 | 4.09 | 5.11 | 2.38 |
| V4 | 0.017 | 0.047 | 0.145 | 0.343 | 0.282 | 0.167 | 0.19 | 0.426 | 1.99 | 3.94 | 4.91 | 2.29 |
| V5 | 0.022 | 0.057 | 0.167 | 0.396 | 0.325 | 0.193 | 0.211 | 0.47 | 2.18 | 4.3 | 5.38 | 2.51 |
| SEm± | 0.002 | 0.005 | 0.01 | 0.023 | 0.019 | 0.011 | 0.008 | 0.014 | 0.07 | 0.14 | 0.176 | 0.08 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C.D.(P=0.05) | 0.005 | 0.013 | 0.028 | 0.066 | 0.055 | 0.033 | 0.022 | 0.041 | 0.2 | 0.4 | 0.511 | 0.23 |
| Factor B | | | | | | | | | | | | |
| D1 | 0.021 | 0.075 | 0.233 | 0.532 | 0.443 | 0.261 | 0.182 | 0.344 | 1.55 | 3.55 | 5.1 | 2.14 |
| D2 | 0.025 | 0.057 | 0.171 | 0.478 | 0.377 | 0.222 | 0.283 | 0.739 | 3.58 | 7.06 | 8.64 | 4.06 |
| D3 | 0.021 | 0.041 | 0.107 | 0.201 | 0.176 | 0.109 | 0.175 | 0.346 | 1.49 | 2.51 | 2.69 | 1.44 |
| SEm± | 0.001 | 0.004 | 0.008 | 0.018 | 0.015 | 0.009 | 0.006 | 0.011 | 0.05 | 0.11 | 0.14 | 0.06 |
| C.D.(P=0.05) | - | 0.101 | 0.022 | 0.051 | 0.042 | 0.026 | 0.017 | 0.031 | 0.154 | 0.311 | 0.396 | 0.18 |

**Table 2:** Interactions

| Treatment Combinations | Root (g plant$^{-1}$) | | | | | | Total Dry matter accumulation (g plant$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 DAS | 30 DAS | 40 DAS | 50 DAS | At Harvest | Mean | 20 DAS | 30 DAS | 40 DAS | 50 DAS | At Harvest | Mean |
| V1D1 | 0.022 | 0.076 | 0.261 | 0.595 | 0.496 | 0.29 | 0.195 | 0.369 | 1.68 | 3.87 | 5.59 | 2.34 |
| V1D2 | 0.031 | 0.068 | 0.19 | 0.531 | 0.417 | 0.247 | 0.318 | 0.822 | 3.95 | 7.81 | 9.58 | 4.50 |
| V1D3 | 0.026 | 0.048 | 0.128 | 0.24 | 0.21 | 0.13 | 0.19 | 0.373 | 1.59 | 2.67 | 2.87 | 1.54 |
| V2D1 | 0.026 | 0.091 | 0.265 | 0.604 | 0.503 | 0.298 | 0.199 | 0.388 | 1.70 | 3.91 | 5.68 | 2.38 |
| V2D2 | 0.029 | 0.064 | 0.185 | 0.526 | 0.414 | 0.244 | 0.31 | 0.803 | 3.87 | 7.66 | 9.39 | 4.41 |
| V2D3 | 0.025 | 0.047 | 0.124 | 0.233 | 0.205 | 0.127 | 0.186 | 0.366 | 1.57 | 2.65 | 2.84 | 1.52 |
| V3D1 | 0.02 | 0.07 | 0.217 | 0.494 | 0.412 | 0.243 | 0.173 | 0.322 | 1.45 | 3.33 | 4.76 | 2.01 |
| V3D2 | 0.023 | 0.051 | 0.158 | 0.442 | 0.348 | 0.205 | 0.263 | 0.684 | 3.32 | 6.54 | 8 | 3.76 |
| V3D3 | 0.019 | 0.035 | 0.093 | 0.176 | 0.154 | 0.095 | 0.165 | 0.329 | 1.43 | 2.40 | 2.58 | 1.38 |
| V4D1 | 0.018 | 0.064 | 0.197 | 0.45 | 0.375 | 0.021 | 0.167 | 0.305 | 1.38 | 3.17 | 4.51 | 1.91 |
| V4D2 | 0.014 | 0.044 | 0.147 | 0.412 | 0.324 | 0.188 | 0.245 | 0.653 | 3.20 | 6.29 | 7.69 | 3.61 |
| V4D3 | 0.018 | 0.034 | 0.089 | 0.167 | 0.147 | 0.091 | 0.16 | 0.321 | 1.39 | 2.35 | 2.52 | 1.35 |
| V5D1 | 0.021 | 0.073 | 0.227 | 0.517 | 0.431 | 0.254 | 0.177 | 0.335 | 1.50 | 3.44 | 4.96 | 2.08 |
| V5D2 | 0.027 | 0.059 | 0.172 | 0.482 | 0.38 | 0.224 | 0.282 | 0.733 | 3.55 | 6.98 | 8.52 | 4.01 |
| V5D3 | 0.02 | 0.038 | 0.101 | 0.189 | 0.166 | 0.103 | 0.174 | 0.342 | 1.48 | 2.47 | 2.65 | 1.42 |
| SEm± | 0.003 | 0.008 | 0.017 | 0.039 | 0.033 | 0.02 | 0.013 | 0.024 | 0.12 | 0.24 | 0.3 | 0.14 |
| C.D. (P=0.05) | - | - | - | - | - | - | - | - | - | - | - | - |

**Table 2b:** Pod dry weight (g plant$^{-1}$) in summer mungbean genotypes under staggered dates of sowing

| Fator A | 40 DAS | 50 DAS | At harvest |
|---|---|---|---|
| V1 | 1.15 | 3.00 | 6.87 |
| V2 | 1.29 | 2.81 | 6.71 |
| V3 | 0.74 | 1.88 | 5.85 |
| V4 | 0.67 | 1.68 | 5.70 |
| V5 | 0.89 | 2.23 | 6.20 |
| SEm± | 0.01 | 0.03 | 0.05 |
| C.D. (P=0.05) | 0.03 | 0.09 | 0.16 |
| Factor B | | | |
| D1 | 1.12 | 2.21 | 6.41 |
| D2 | 1.49 | 3.00 | 6.72 |
| D3 | 0.63 | 1.58 | 5.69 |
| SEm± | 0.01 | 0.03 | 0.05 |
| C.D. (P=0.05) | 0.03 | 0.08 | 0.14 |

**Table 2b:** Interactions

| Treatment combinations | 40 DAS | 50 DAS | At harvest |
|---|---|---|---|
| V1D1 | 1.52 | 2.72 | 6.82 |
| V1D2 | 1.82 | 3.02 | 7.70 |
| V1D3 | 0.86 | 2.06 | 5.87 |
| V2D1 | 1.36 | 2.56 | 6.77 |
| V2D2 | 1.74 | 2.94 | 7.61 |
| V2D3 | 0.81 | 2.01 | 5.73 |
| V3D1 | 1.11 | 2.31 | 6.24 |
| V3D2 | 1.45 | 2.65 | 7.08 |
| V3D3 | 0.5 | 1.7 | 5.09 |
| V4D1 | 0.96 | 2.16 | 6.18 |
| V4D2 | 1.37 | 2.57 | 6.92 |
| V4D3 | 0.35 | 1.55 | 4.94 |
| V5D1 | 1.22 | 2.42 | 6.49 |
| V5D2 | 1.59 | 2.79 | 7.50 |
| V5D3 | 0.68 | 1.88 | 5.42 |
| SEm± | 0.008 | 0.025 | 0.041 |
| C.D. (P=0.05) | 0.024 | 0.073 | 0.12 |

The present investigations revealed that among varieties $V_1$ PDM139 (Table no 3) out yielded (5.78g plant$^{-1}$ and787.74 Kg ha$^{-1}$). others owing to its maximum no. of pods plant$^{-1}$ (20.78), pod weight (6.87 g plant$^{-1}$) and biological yield (16.16 g plant$^{-1}$ and 2421.79 Kg ha$^{-1}$) resulted in turn had highest yield. However, lowest yield (4.65 g plant$^{-1}$ and 571.62 Kg ha$^{-1}$) was noticed in $V_4$ Pusa 1431 due to poor performance of yield components which might be a result of decline in kinetics of physiological mechanisms and parameters. The highest seed index (47.16 g) recorded in Pusa Vishal may be used for the improvement of crop varieties in mungbean.

Sowing carried out on 27$^{th}$ Feb ($D_2$) recorded the maximum economic yield (6.12 g plant$^{-1}$ and 792.33 Kg ha$^{-1}$) due to its maximum pod length (8.19 cm), pod width (4.88 mm), pod girth (30.66 mm), pod weight (6.72 g plant$^{-1}$), no. of pods plant$^{-1}$ (20.93), no. of seeds pod$^{-1}$ (10.60), seed index (44.99 g) and biological yield (14.61g plant$^{-1}$ and 2526.37 Kg ha$^{-1}$). The enhancement of higher temperature beyond this period might be the reason of declined yield in third sowing (4.30 g plant$^{-1}$ and 531.04 Kg ha$^{-1}$). Higher temperatures have been reported to reduce the yields due to leaf senescence and mobilization of photosynthates decline in sinks.

Among interactions $V_1D_2$ (PDM139 at second date of sowing) noted highest seed yield (6.79 g plant$^{-1}$ and 880.10 Kg ha$^{-1}$) due to maximum no. of pods plant$^{-1}$ (24.33), pod weight (7.70s g plant$^{-1}$) and biological yield (18.41 g plant$^{-1}$ and 2710.38 Kg ha$^{-1}$). Pusa1431 sown on 14$^{th}$ Mar revealed poor seed yield (3.84 g plant$^{-1}$ and 437.23 Kg ha$^{-1}$) due to lowest performance of yield attributing traits.

Thus the study revealed that genotype PDM139 had a comparatively higher dry matter accumulation in leaves (1.63g plant$^{-1}$), stem (0.939 g plant$^{-1}$), pods weight (6.86 g plant$^{-1}$) as well as total dry matter (.79 g plant$^{-1}$) reflected in its maximum economic yield (5.78 g plant$^{-1}$ and 787.74 Kg ha$^{-1}$). Sowing carried out on 27$^{th}$ Feb produced maximum seed yield due to enhancement of dry matter production and partioning of photo-assimilates in economic sinks as a result of favourable environment. Genotype PDM139 sown on 27$^{th}$ Feb out yielded (6.79 g plant$^{-1}$ and 880.10 Kg ha$^{-1}$) other treatment combinations.

**Table 3:** Yield and yield components of summer mungbean genotypes under staggered dates of sowing

| Factor A | Pod Length (cm) | Pod Width (mm) | Pod Girth (mm³) | No. of pods plant$^{-1}$ | No. of seeds pod$^{-1}$ | Seed Index (g) | Seed Yield (g plant$^{-1}$) | Seed Yield(Kg ha$^{-1}$) | Biological yield (g plant$^{-1}$) | Biological yield (Kg ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| V1 | 8.23 | 4.529 | 28.3 | 20.78 | 10.45 | 39.81 | 5.78 | 787.74 | 16.16 | 2421.79 | 32.37 |
| V2 | 8.93 | 5.02 | 31.52 | 20.67 | 10.89 | 45.47 | 5.61 | 754.22 | 15.37 | 2298.09 | 32.73 |
| V3 | 7.65 | 4.91 | 30.81 | 18 | 10 | 47.16 | 4.99 | 624.12 | 12.58 | 2073.94 | 30.01 |
| V4 | 7.42 | 4.66 | 29.3 | 16.89 | 9.67 | 46.14 | 4.65 | 571.62 | 12.45 | 1994.71 | 28.4 |
| V5 | 7.82 | 4.66 | 29.31 | 17.33 | 10.22 | 40.28 | 5.19 | 651.47 | 13.22 | 2113.33 | 30.74 |
| SEm± | 0.035 | 0.068 | 0.172 | 0.169 | 0.069 | 0.153 | 0.002 | 0.035 | 0.101 | 0.576 | 0.002 |
| C.D. (P=0.05) | 0.101 | 0.197 | 0.501 | 0.492 | 0.2 | 0.444 | 0.005 | 0.102 | 0.295 | 1.676 | 0.006 |
| Factor B | | | | | | | | | | | |
| D1 | 8.02 | 4.8 | 30.04 | 18.68 | 10.33 | 44.08 | 5.32 | 710.15 | 13.93 | 2098.29 | 33.65 |
| D2 | 8.19 | 4.88 | 30.66 | 20.93 | 10.60 | 44.99 | 6.12 | 792.33 | 14.61 | 2526.37 | 31.31 |
| D3 | 7.82 | 4.59 | 28.84 | 16.6 | 9.80 | 42.25 | 4.30 | 531.04 | 13.33 | 1916.47 | 27.59 |
| SEm± | 0.027 | 0.052 | 0.133 | 0.131 | 0.053 | 0.118 | 0.001 | 0.027 | 0.079 | 0.446 | 0.002 |
| C.D. (P=0.05) | 0.078 | 0.152 | 0.388 | 0.381 | 0.155 | 0.344 | 0.004 | 0.079 | 0.229 | 1.298 | 0.005 |

**Table 3:** Interactions

| Treatment combinations | Pod Length (cm) | Pod Width (mm) | Pod Girth (mm³) | No. of pods plant$^{-1}$ | No. of seeds pod$^{-1}$ | Seed Index (g) | Seed Yield (g plant$^{-1}$) | Seed Yield (Kg ha$^{-1}$) | Biological yield (g plant$^{-1}$) | Biological yield (Kg ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| V1D1 | 8.01 | 4.53 | 28.47 | 19.67 | 10.67 | 42.50 | 5.81 | 861.11 | 14.86 | 2344.99 | 36.72 |
| V1D2 | 8.23 | 4.66 | 27.99 | 24.33 | 9.67 | 39.34 | 6.79 | 880.10 | 18.41 | 2710.38 | 32.47 |
| V1D3 | 8.45 | 4.49 | 28.38 | 18.33 | 11.00 | 37.58 | 4.75 | 622.01 | 15.21 | 2209.99 | 27.93 |
| V2D1 | 8.82 | 4.76 | 29.91 | 18.67 | 11.00 | 44.02 | 5.72 | 812.23 | 14.72 | 2264.86 | 35.93 |
| V2D2 | 9.14 | 5.29 | 33.20 | 22.33 | 10.00 | 48.16 | 6.43 | 861.57 | 16.51 | 2621.41 | 32.86 |
| V2D3 | 8.82 | 4.67 | 28.31 | 21.00 | 11.67 | 44.23 | 4.69 | 588.88 | 14.89 | 2008.01 | 29.42 |
| V3D1 | 7.41 | 5.12 | 32.01 | 19.33 | 10.33 | 45.72 | 5.08 | 637.04 | 12.73 | 1965.46 | 32.39 |
| V3D2 | 7.62 | 5.15 | 32.36 | 20.00 | 9.67 | 49.70 | 5.89 | 738.60 | 12.56 | 2444.44 | 30.20 |
| V3D3 | 7.92 | 4.79 | 30.06 | 14.67 | 10.00 | 46.06 | 3.99 | 496.74 | 13.25 | 1811.94 | 27.44 |
| V4D1 | 7.17 | 4.66 | 29.26 | 18.67 | 9.33 | 49.18 | 4.88 | 566.29 | 12.42 | 1904.79 | 29.72 |
| V4D2 | 7.32 | 4.88 | 30.67 | 19.67 | 10.00 | 45.28 | 5.25 | 711.33 | 12.21 | 2378.08 | 29.94 |
| V4D3 | 7.77 | 4.45 | 27.97 | 12.33 | 9.67 | 43.96 | 3.84 | 437.23 | 11.93 | 1701.27 | 25.53 |
| V5D1 | 7.68 | 4.75 | 29.85 | 17.00 | 10.33 | 38.99 | 5.12 | 674.07 | 12.72 | 2011.34 | 33.49 |
| V5D2 | 7.80 | 4.82 | 30.29 | 18.33 | 9.67 | 44.45 | 6.25 | 770.02 | 13.34 | 2477.51 | 31.07 |
| V5D3 | 7.97 | 4.42 | 27.78 | 16.67 | 10.67 | 37.41 | 4.21 | 510.31 | 13.59 | 1851.15 | 27.65 |
| SEm± | 0.06 | 0.117 | 0.298 | 0.293 | 0.119 | 0.264 | 0.003 | 0.061 | 0.176 | 0.997 | 0.004 |
| C.D. (P=0.05) | 0.17 | 0.341 | 0.868 | 0.852 | 0.347 | 0.77 | 0.009 | 0.177 | 0.512 | 2.903 | 0.011 |

**Abbreviations**

$V_1$- PDM139, $V_2$- Pusa Ratna, $V_3$- Pusa Vishal, $V_4$- Pusa 1431 and $V_5$-TJM3

$D_1$- First date of sowing (12th Feb), $D_2$- Second date of sowing (27th Feb) and $D_3$- Third date of sowing (14th Mar)

DM- Dry matter

TDM- Total dry matter

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