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RESEARCH ARTICLE

# Optimizing sowing time and method for enhancing horse gram productivity in rainfed ecosystems

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## Abstract

Horse gram yield parameters are influenced by environmental factors, especially temperature and humidity, which restrict the sowing time since horse gram is a photosensitive crop. A field investigation was conducted at the Regional Research Station, Tamil Nadu Agricultural University, Paiyur, Tamil Nadu, during the northeast monsoon season (October 2017 to September 2019) to determine the optimal sowing time and suitable method of sowing. The trial was carried out using a strip plot design with three replications. Strip one consisted of six dates of sowing *viz*., $D_1$ - 43rd meteorological standard week (MSW), $D_2$ - 44th MSW, $D_3$ - 45th MSW, $D_4$ - 46th MSW, $D_5$ - 47th MSW and $D_6$ - 48th MSW. Strip two comprised of three methods of sowing *viz*., $S_1$ - Broadcasting, $S_2$ - Line sowing and $S_3$ - Seed drill sowing. The results of the field investigation revealed that higher growth parameters and yield attributes such as number of pods plant$^{-1}$, number of seeds pod$^{-1}$, 100 grain weight were recorded in horse gram sown during 40th MSW ($D_1$) than other sowing dates, which correspondingly increase higher grain yield (622 kg/ha) was noted when compared to other time of sowing. Among the different types of sowing under study, line sowing recorded a higher number of pods plant$^{-1}$, number of seeds pod$^{-1}$, 100 grain weight, grain yield and haulm yield than other methods of sowing. However, in the interaction study 40th MSW and see drill methods of sowing of horse gram recorded higher grain yield as compared with other sowing methods. Hence, it could be concluded that either line or see drill sowing during 40thMSW can produce the highest growth and yield parameters, resulting in increased yield of horse gram under rainfed conditions.

**Keywords:** broadcasting; horse gram; line sowing; MSW; seed drill

## Introduction

Among the pulses, horse gram, commonly known as "Kulthi", is an important post season Indian crops. It belongs to the Fabaceae family. Horse gram (*Macrotyloma uniflorum* [Lam.]) is an underutilized warm-season diploid legume (2*n* = 20). Because of its ability to grow under water-deficient and marginal soil conditions, horse gram is a preferred choice in the era of global climate change (1). Crop is an underutilized and unexplored arid tropical food legume (2). As a legume, horse gram maintains soil fertility through biological nitrogen fixation in root nodules and acts as a natural organic fertilizer. It is suitable as a cover crop, promotes soil and water conservation and is highly drought-tolerant (3). The crop is popular at maximum extent is Southern Indian states while to some extent in North Indian states. Its center of origin is South West India (4). Although as a pulse, whole seed of horse gram is utilized as a cattle feed which contains about 12 % of protein in fodder. Horse gram seeds comprise 57.0 % carbohydrate, 22.0 % protein and 2.5 % fat (5). Horse gram is exclusively cultivated in Karnataka, Andhra Pradesh, Odisha, Tamil Nadu, Madhya Pradesh, Chhattisgarh, Bihar, West Bengal and Jharkhand and also in foothills of Uttaranchal and Himachal Pradesh in India. In India, it covers an area of about 4.00 lakh hectares with 2.47 lakh tonnes production during 2017-18 (6). Growth and yield parameters are influenced by environmental factors such as rainfall, temperature, humidity and wind, as well as by variety, seed rate, spacing and time of sowing (7). Horse gram is typically grown in subhumid to semi-arid climates, receiving an annual rainfall of 300-600 mm (8). Conventionally, majority of farmers are growing local varieties using broadcast method of sowing which leads to an uneven population, late and non-synchronous maturity, susceptible to yellow mosaic disease and finally decreased the yield of crops. Due to concern about labour scarcity, using seed drills for sowing could increase yield. Time of sowing, plant genetic material and environmental factors decide the crop flowering, seed development, maturity period and dry matter production of the crop (9). Among these, the time of sowing is an important

and crucial factor affecting the growth and yield of the crop under rainfed condition. However, there is no specified time of sowing identified for horse gram though the crop is predominantly sown between September and November. With this background, the field experimentation was made to standardize the sowing time and method for enhancing the yield of horse gram under rainfed conditions utilizing the north east monsoon rainfall.

## Materials and Methods

The field experiment was conducted during 2017 to 2019 at Regional Research Station, Tamil Nadu Agricultural University, Paiyur of Krishnagiri District. The experimental site comes under north western zone of Tamil Nadu. It is geographically located at a latitude of 12°21′ N, longitude of 78°18′ E and altitude of 490m above mean sea level (MSL). The weekly average (two season) means minimum and maximum temperature of the cropping period (from 42$^{nd}$ week to 52$^{nd}$ week of 2017 & 2018 and from 1$^{st}$ week to 9$^{th}$ week of 2018 and 2019) was 18.7 °C and 28.9 °C, respectively. The average rainfall of two season received during the crop period was 147.6 mm with 7 rainy days.

This experiment has been laid out in split plot design with three replications and main plot treatments consist of six sowing dates and sub plot treatments consists of different sowing methods. Sowing data clearly influences the soil temperature and soil water availability experienced by germinating seeds and as a consequence, manipulating the sowing dates could be an efficient practice to help crops better escape from abiotic and biotic stresses. So, horse gram (Paiyur 2) sowing was taken at weekly interval (aims to spread the risk of crop failure due to weather variations and pest infestations. This practice helps a more reliable harvest overtime as mentioned (main plot) below. Necessary observations *viz*., growth parameters such as plant height, number of branches and number of pods per plant and number of seeds per pod and 100 seed weight and yield attributes were recorded.

The treatment details are as follows;

### Main plot (Sowing time - 6)

$D_1$ - October 21$^{st}$ - 27$^{th}$

$D_2$ - Oct 28$^{th}$ to Nov 3$^{rd}$

$D_3$ - November 4$^{th}$ - 10$^{th}$

$D_4$ - November 11$^{th}$ - 17$^{th}$

$D_5$ - November 18$^{th}$ - 24$^{th}$

$D_6$ - Nov 25$^{th}$ - Dec 1$^{st}$

### Sub plot (Sowing methods - 3)

$S_1$ - Broadcasting

$S_2$ - Line sowing

$S_3$ - Seed drill sowing

### Calibration of seed drill for horse gram

The cup feed drill was taken for sowing horse gram seeds. Initially the seed drill was evaluated to find the number of horse gram seeds taken in the cup holes of the seed drill. Hence, calibration was done by operating the cup feed seed drill on plain ground surface covered with a plastic sheet to collect the horse gram seeds metered by the machine. The horse gram (Paiyur 2), the current ruling variety is taken and required quantity is filled in the respective hopper of the cup feed seed drill. The seed drill was operated by lifting the implement so that the furrow opener was slightly above the ground. The ground wheel was lowered to transmit the drive to the metering mechanism. The quantity of horse gram seeds per cup was recorded based on the unit length of forward travel. The details of calibration of seed drill were given in Table 1.

After the calibration of the seed drill, it is observed that each cup picks around 6 numbers of seeds from the hopper and the same was dropped to the funnel for sowing. Around 12.11 kg ha$^{-1}$ of seed will be used for sowing in the field when using this modified cup feed seed drill, which was 8 kg lesser than actual recommended seed rate for sowing horse gram is 20 kg ha$^{-1}$. Using a lower seed rate for horse gram sowing can lead to reduced initial investment in seeds material and lower plant density can reduce competition among plants for resources like sunlight, nutrients and water so finally can increase the yield potential (10).

### Field evaluation

On evaluation of the performance of the cup feed seed drill, initially for the field parameters *viz*., the field capacity, field efficiency and seed rate as follows

### Theoretical field capacity (C)

It was calculated by using the below formula

$$C = \frac{S \times W}{10} \qquad \text{Eqn. 1}$$

Where, C = Theoretical field capacity; ha hr$^{-1}$

**Table 1.** Details of calibration of seed drill for horse gram sowing

| | | |
|---|---|---|
| Circumference of ground wheel (π D) | : | 3.14 × 60 = 188.40 cm = 1.88 m |
| Width of seed drill (Number of furrow opener × width of seed drill) | : | 7 × 0.30 m = 2.1 m |
| Area covered for one revolution (Circumference of ground wheel × Width of seed drill) | : | 1.88 m × 2.1 m = 3.95 m$^2$ |
| Number of turns needed/ha | : | 10000 m$^2$/3.95 m$^2$ = 2532 turns |
| Number of grains taken by the cup | : | 6 seeds<br>6 seeds/cup × 16 cup holes/rev<br>96 seeds |
| | : | 96 × 2532 = 243072 seeds/hectare |
| Therefore for 2532 turns, the number of grains to be dropped | :<br>:<br>: | 243072 seeds<br>12107 g<br>12.11 kg/ha |

S = Forward speed, km $hr^{-1}$

W= Width, m

C = 2.5 × (0.30 × 7)/10

**= 0.53 ha.$hr^{-1}$**

### Effective field capacity, EFC

The effective field capacity will include time lost during the actual field operation such as time lost due to turning, loading, adjustment and other time losses during the operation.

$$EFC = \frac{A}{T} \quad \text{(Eqn. 2)}$$

Where, EFC = Effective field capacity, ha $hr^{-1}$

A = Area, hectare

T = Time to finish the area, hr

= 0.108/0.251

**= 0.43 ha $hr^{-1}$**

### Field efficiency (FE) (%)

The field efficiency was calculated by using the expression below

$$FE = \frac{EFC}{C} \times 100 \quad \text{(Eqn. 3)}$$

Where, EFC = Effective field capacity, ha $hr^{-1}$

C = Theoretical field capacity, ha $hr^{-1}$

FE = (0.44/0.53) × 100

**= 81.1 %**

### Seeding rate (SR), kg/ha

$$SR = \frac{W}{A} \quad \text{(Eqn. 4 )}$$

Where, W = Weight of seeds, kg

A = Area, ha

Sr = 1.33/0.108

**= 12.31 kg/ha**

## Results and Discussion

Yield of crops was significantly influenced by different dates and methods of sowing. The results revealed that all the dates of sowing exhibited vegetative growth with available soil moisture. However, sowing taken during October 21st recorded higher plant height (67.6 cm), more no. of branches per plant (6.31 nos.), more no. of pods per plant (69 nos.), more no. of seeds per pod (5.13 nos.) and 100 seed weight (3.40 g) whereas November 17th took sowing recorded lower plant height (36.2 cm), minimum no. of branches per plant (4.0 nos.), minimum no. of pods per plant (30.5 nos.), minimum no. of seeds per pod (3.96 nos.) and 100 seed weight (3.40 g) and produced seeds yield due to better rainfall received during the cropping period and other conducive climate for pod setting (Table 2). Among the different sowing times sowing in October last week ($D_1$) and first week of November recorded higher mean grain yields of 622 and 597 kg $ha^{-1}$ by availing total rainfall of 162 and 125 mm during the cropping period, respectively. The higher plant height observed under $D_1$ may be attributed to the earlier sowing compared to $D_2$ and $D_3$, which favor the growth and development of horse gram (11). The $D_4$ sowing time recorded grain yield of 281 kg $ha^{-1}$ which is lesser than early sowing *viz*., October last week and November 1st week, respectively (Table 3).

Sowing after November 4th week produced only vegetative growth and ill filled pods and no yield was recorded. This might be due to increasing day length with delay in sowing. Delayed flowering under rainfed is a strong indication of susceptibility to any temperature horse gram flowering is not directly tied to a specific day length period. While it's true that horse gram is a short-day plant, meaning it needs certain duration of darkness to initiate flowering, the flowering process is also influenced by other factors like temperature and water availability (12). The tendrils act as a sink and affect the better source-sink relationship. Greater proportion of photo-assimilates is diverted for production and maintenance of vegetative plant parts (tendril in horse gram) rather than translocation to reproductive parts leads to more plant height (13). Induction of earlier flowering is an important physiological trait which directly correlated with the grain yield especially under rainfed condition (14). The results are in conformity with the previous field experiments in blackgram (15, 16). Among the different sowing methods,

**Table 2.** Influence of methods and time of sowing on yield attributes (pooled mean of 2 years) of horse gram

| Treatments | Plant height (cm) | No. of branches/plant | No. of pods/plant | No. of seeds/pod | 100 seed weight (gm) |
|---|---|---|---|---|---|
| **Sowing time** | | | | | |
| $D_1$ - Oct 21st - 27th | 67.6 | 6.31 | 69.0 | 5.13 | 3.40 |
| $D_2$ - Oct 28th to Nov 3rd | 60.9 | 4.53 | 52.7 | 4.47 | 3.24 |
| $D_3$ - Nov 4th - 10th | 46.4 | 4.42 | 41.4 | 4.22 | 3.17 |
| $D_4$ - Nov 11th - 17th | 36.2 | 4.00 | 30.5 | 3.96 | 3.04 |
| $D_5$ - Nov 18th - 24th | 33.7 | 3.29 | 0.0 | 0.0 | 0.0 |
| $D_6$ - Nov 25th - Dec 1st | 32.3 | 3.09 | 0.0 | 0.0 | 0.0 |
| **SEd** | **2.65** | **0.20** | **2.02** | **0.15** | **0.11** |
| **CD (P = 0.05)** | **5.34** | **0.40** | **4.08** | **0.30** | **0.22** |
| **Sowing methods** | | | | | |
| $S_1$ - Broadcasting | 62.7 | 6.35 | 54.3 | 4.78 | 3.33 |
| $S_2$ - Line sowing | 73.4 | 6.52 | 65.7 | 5.05 | 3.84 |
| $S_3$ - Seed drill sowing | 71.8 | 6.37 | 63.6 | 4.95 | 3.67 |
| **SEd** | **2.87** | **0.33** | **3.16** | **0.13** | **0.11** |
| **CD (P = 0.05)** | **8.39** | **NS** | **9.23** | **NS** | **0.31** |

**Table 3.** Influence of methods and time of sowing on yield (pooled mean of 2 years) and economics of horse gram

| Treatments | Grain yield (kg ha$^{-1}$) | Rainfall cropping period (mm) | Rainfall use efficiency | Net Income (Rs/ha) | B:C ratio |
|---|---|---|---|---|---|
| **Sowing time** | | | | | |
| $D_1$ - Oct 21$^{st}$ - 27$^{th}$ | 622 | 125 | 4.9 | 15550 | 2.03 |
| $D_2$ - Oct 28$^{th}$ to Nov 3$^{rd}$ | 597 | 95.6 | 5.5 | 10828 | 1.72 |
| $D_3$ - Nov 4$^{th}$ - 10$^{th}$ | 429 | 77.4 | 5.4 | 5858 | 1.41 |
| $D_4$ - Nov 11$^{th}$ - 17$^{th}$ | 281 | 77.4 | 3.8 | 705 | 1.06 |
| $D_5$ - Nov 18$^{th}$ - 24$^{th}$ | 0.0 | 67.6 | 1.3 | - | - |
| $D_6$ - Nov 25$^{th}$ - Dec 1$^{st}$ | 0.0 | 17.0 | - | - | - |
| **SEd** | **20.4** | **-** | **1.31** | **-** | **-** |
| **CD (P = 0.05)** | **41.1** | **-** | **2.84** | **-** | **-** |
| **Sowing methods** | | | | | |
| $S_1$ - Broadcasting | 377 | - | 3.1 | 4690 | 1.43 |
| $S_2$ - Line sowing | 545 | - | 3.4 | 8363 | 1.67 |
| $S_3$ - Seed drill sowing | 525 | - | 3.9 | 4864 | 1.47 |
| **SEd** | **23.2** | **-** | **0.36** | **-** | **-** |
| **CD (P = 0.05)** | **67.8** | **-** | **1.04** | **-** | **-** |

manual (line sowing) and seed drill sowing were more pronounced as against broadcasting and recorded mean grain yield of 545 and 525 kg/ha, respectively. Manual line sowing and seed drill method increased the grain yield to the tune of 44 and 40 % [(seed drill sowing-broadcasting)/ broadcasting] over broadcasting method respectively, which might be due to the fact that placing the seeds in uniform depth increases the early germination and improved the yield. Horse gram yields are generally higher when line or seed drill sowing is used instead of broadcasting because it produces more consistent plant populations, better germination and less seed waste. Conversely, poorer germination rates and uneven seed distribution brought on by broad casting may have an effect on crop productivity (17). In the interaction of two parameters, among the various treatment combinations sowing during last week of October with seed drill found to be the best and recorded the highest grain yield of 726 kg/ha as against 483 ha in broadcasting (Table 4).

## Conclusion

Horse gram has emerged as a potential commercial crop owing to its inherent ability for drought tolerance suitability for inter and mixed cropping and diversified uses as dal for a subsidiary source of protein, nutrient loaded fodder for livestock and green manuring to add fertility status of the soil. For this crop the date and method of sowing plays a dynamic role by improving seed germination and overall plant establishment and producing optimum yields. The results clearly indicated the influence of sowing dates, method of sowing and their interaction effect on the yield of rainfed horse gram. It showed that line sowing with manual and/or seed drill recorded higher yield than broadcasting. Sowing in October last week (43$^{rd}$ MSW) and 1$^{st}$ week of November (44$^{th}$ MSW) recorded highest grain yields. In the interaction study, sowing during last week of October with seed drill recorded the highest grain yield (726 kg/ha) as compared to broadcasting. So, by considering date and method of sowing, reduce the yield loss by avoiding cultivation practices during off season.

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## Authors' contributions

VM conducted field experiment and contributed to the conceptualization including writing the original draft manuscript. PCP and RS carried out data analysis. RT and AV conducted the literature search, advised on data processing and interpretation of the results. Each author examined the manuscript and participated in the data analysis. All authors have read and agreed to the published version of the manuscript.

## Compliance with ethical standards

**Conflict of interest :** Authors do not have any conflict of interest to declare.

**Ethical issues :** None

**Table 4.** Interaction of methods and time of sowing on grain yield (kg/ha)

| Treatment | $S_1$ | $S_2$ | $S_3$ | Mean |
|---|---|---|---|---|
| $D_1$ | 483 | 658 | 726 | **622** |
| $D_2$ | 454 | 715 | 623 | **597** |
| $D_3$ | 368 | 469 | 449 | **429** |
| $D_4$ | 201 | 339 | 302 | **281** |
| $D_5$ | 0 | 0 | 0 | **0** |
| $D_6$ | 0 | 0 | 0 | **0** |
| **Mean** | **377** | **545** | **525** | |

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