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**Anbarasu M**
Research Scholar
Tamil Nadu Agricultural University, Tamil Nadu, India

**NS Venkataraman**
Professor and Head (Agronomy), Tamil Nadu Agricultural University, Tamil Nadu, India

**R Amutha**
Professor (Crop Physiology), Agricultural College and Research Institute, Madurai and Tamil Nadu Agricultural University, Tamil Nadu, India.

**P Kathirvelan**
Assistant Professor (Agronomy) Tapioca and Castor Research Station, Yethapur, Tamil Nadu Agricultural University, Tamil Nadu, India

**Correspondence**
**Anbarasu M**
Research Scholar
Tamil Nadu Agricultural University, Tamil Nadu, India

# The effect of crop geometry on physiological characters to influence of seed and oil yield of hybrid castor

**Anbarasu M, NS Venkataraman, R Amutha and P Kathirvelan**

**Abstract**
Castor (*Ricinus communis* L.) is one of the oldest cultivated crops, but currently it represents only 0.15% of the vegetable oil produced in the world. Castor oil is continuing importance to the global speciality of chemical industry because it is the only commercial source of a hydroxylated fatty acid. An experiment was carried out during August 2016 to February 2017 at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, to study the effect of crop geometry on physiological characters and yield of hybrid castor (YRCH 1). The soil of the experimental field was sandy clay loam and experiment was laid out in Randomized Block Design (RBD) with comprised of eight treatments were replicated thrice viz., $G_1$ - 150 × 120 cm (5,555 plants $ha^{-1}$), $G_2$ - 120 × 120 cm (6,944 plants $ha^{-1}$), $G_3$ - 120 × 90 cm (9,259 plants $ha^{-1}$), $G_4$ - 120 × 60 cm (13,888 plants $ha^{-1}$), $G_5$ - 90 × 90 cm (12,345 plants $ha^{-1}$), $G_6$ - 90 × 60 cm (18,518 plants $ha^{-1}$), $G_7$ - 90 × 45 cm (24,691 plants $ha^{-1}$) and $G_8$ - 75 × 75 cm (17,777 plants $ha^{-1}$). Among the different crop geometry, 120× 120 cm spacing registered higher dry matter production (DMP) and Leaf area index (LAI), the spacing of 150 × 120 cm recorded higher crop growth rate, total chlorophyll content, relative leaf water content. Significantly seed and oil content was registered in wider spacing (120× 120 cm), which provides a favorable environment to each and every plant parts as compared to narrow crop geometry of 75 × 75 cm.

**Keywords:** Castor, geometry, dry matter production, crop growth rate and seed yield

## Introduction
*Ricinus communis* L. castor plant is a species of flowering plant in the spurge family; *Euphorbiaceae*, which contains a vast number of plants mostly native to the tropics (Moshkin, 1986) [6]. It belongs to a monotypic genus *Ricinus*. The name *Ricinus* is a *latin* word for tick. The plant is named probably because it seed has markings and a dump at the end that resemble certain tick (Weiss, 2000) [13]. The common name castor oil comes from its uses as a replacement for a perfume base made from dried perinea glands of beaver. In order to study the influence of crop geometry on the physiological growth parameters and its effect on seed and oil yield of castor plants. The adaptation of this crop to different environments and conditions that potentially impact the seed yield received special focus. Assuming that, increasing castor productivity is a highly important demand, for complexity of seed yield determination was discussed considering the influence of genetic factors, environment control, and crop management interventions (Evans, 1993) [2]. Because of these interventions, to understanding of many issues related to castor growth and development were discussed and emphasized especially on optimizing crop geometry in hybrid castor.

## Materials and methods
A field experiment was carried out during *kharif* (August 2016 to February 2017) in Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai. The soil of the experimental field was sandy clay loam in texture, taxonomically classified as Typic Udic Haplustalf with pH- 7.4, Organic carbon - 0.48 % and EC - 0.42 dS $m^{-1}$.
The experiment was laid out in Randomized Block Design (RBD), comprised of eight treatments were replicated thrice viz., $G_1$ - 150 × 120 cm (5,555 plants $ha^{-1}$), $G_2$ - 120 × 120 cm (6,944 plants $ha^{-1}$), $G_3$ - 120 × 90 cm (9,259 plants $ha^{-1}$), $G_4$ - 120 × 60 cm (13,888 plants $ha^{-1}$), $G_5$ - 90 × 90 cm (12,345 plants $ha^{-1}$), $G_6$ - 90 × 60 cm (18,518 plants $ha^{-1}$), $G_7$ - 90 × 45 cm (24,691 plants $ha^{-1}$) and $G_8$ - 75 × 75 cm (17,777 plants $ha^{-1}$). The castor hybrid YRCH 1 was used as a test cultivar.

The recommended dose of fertilizer was followed 90:45:45 NPK ha$^{-1}$, full dose of phosphorus and 50% N and K was applied as basal at the time of sowing and remaining N and K was applied in two equal splits at 30 and 60 days after sowing of castor. Five plants were randomly selected from net plot area and tagged. Plant physiological parameters observations were recorded at different growth stages *viz*., 90 and 135 DAS stages respectively.

## Results and discussion

The crop geometry treatment expressed a prominent variation on the physiological characters of castor at different growth stages (90 and 135 DAS). The crop grown at 120 x 120 cm had attained higher DMP (1560 and 3111 kg ha$^{-1}$) at 90 and 135 DAS respectively. It was followed by 120 x 90 cm. LAI had registered perceptibly higher LAI of 3.90 and 4.77 at 120 x 120 cm during 90 and 135 DAS respectively, and it was followed by 150 × 120 cm. The crop has attained higher crop growth rate of 7.87 and 10.90 g m$^{-2}$ day$^{-1}$ grown at 150 x 120 cm, between 45-90 DAS and 90-135 DAS and the specific leaf weight was obtained as 8.78 and 8.21 mg cm$^{-2}$. Relative leaf water content (76.15 and 75.15 percent) and total chlorophyll content (3.28 and 2.13 mg g$^{-1}$) during 90 and 135 DAS were also higher at 150× 120 cm. It was followed by 120 x 120 cm for both the stages of castor. Among the all physiological characters registered lower values were recorded at 75 x 75 spacing cm during 90 and 135 DAS (Table 1).

The wider spacing of 120 ×120 cm was recorded maximum DMP and LAI as compared to closer spacing (75×75 cm). This might be due to exposure of all leaves to sunlight under wider spacing accelerated the process of photosynthesis and enhanced the crop growth rate. Further less competition between plants for moisture, nutrient and light in wider spaced plants. Put forth more specific leaf weight and relative water content in leaf tissue. In red gram, significantly more dry matter production, leaf area index, number of branches and crop growth rate observed at wider spacing (60 x 10 cm) over narrow planting of 45 ×10 cm (Birendra Tigga *et al*, 2017) [1]. The more number of branches plant$^{-1}$ in wider spacing might be due to better growth of plant due to utilization of optimum growth resources available to individual plant and their maximum utilization occurred throughout the growth periods as per need of the crop. Plants per unit area increases intra (within the plant among the plant components) and inter plant (among the plants in the area) competition for the growth resources (space, moisture, sunlight and $CO_2$). There is always competition for growth resources at all levels (micro and macro) in the field. It has established that arrangement of plants (number) per unit area should be in such a way that all plants get equal opportunity to harness the available growth resources so that variety can express their potential with respect to health and vigour which finally reflected on yield. Singh *et al.* (2012) [10] also noted that significant differences in plant population due to variation in seed rate. Similar results were also recorded by Pavan *et al.*, (2011) [7], Meena *et al.*, (2011) [5] Subramani *et al.*, (2002) [12] and Rasul *et al.*, (2012) [8].

Wider spacing of 150×120 cm recorded more of total chlorophyll; content might be due to equal opportunity uses of growth resources by each and every leaf. Every single leaf of castor, contribute maximum amount of carbon assimilation through photosynthesis due to more interception of light from sunlight. In an ideal scenario, a leaf would be photosynthesizing at maximum capacity during all of its lifespan. However, at field conditions, the leaf are under suboptimal conditions, much of the time, the maximum carbon assimilation capacity is not realized.

**Table 1:** Effect of crop geometry on physiological characters of Dry matter production (kg ha$^{-1}$), Leaf area index, Crop growth rate (g m$^{-2}$ day$^{-1}$), Total chlorophyll content (mg g$^{-1}$), Specific leaf weight (mg cm$^{-2}$), RWC in leaf tissue (%), Seed yield (kg ha$^{-1}$) and Oil yield (kg ha$^{-1}$) of hybrid castor during 90 and 135 DAS

| 90 DAS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatments** | | **Dry matter production (kg ha$^{-1}$)** | **Leaf area index** | **Crop growth rate (g m$^{-2}$ day$^{-1}$)** | **Total chlorophyll content (mg g$^{-1}$)** | **Specific leaf weight (mg cm$^{-2}$)** | **RWC in leaf tissue (%)** | **Seed yield (kg ha$^{-1}$)** |
| $G_1$ | 150 × 120 cm | 1334 | 2.84 | 7.87 | 3.28 | 8.78 | 76.15 | 1825 |
| $G_2$ | 120 × 120 cm | 1560 | 3.90 | 7.49 | 3.28 | 8.60 | 77.69 | 2153 |
| $G_3$ | 120 × 90 cm | 1493 | 1.95 | 5.37 | 3.16 | 8.24 | 75.38 | 2010 |
| $G_4$ | 120 × 60 cm | 1274 | 1.26 | 3.09 | 3.08 | 7.60 | 72.93 | 1637 |
| $G_5$ | 90 × 90 cm | 1192 | 1.31 | 3.25 | 3.03 | 7.49 | 72.41 | 1540 |
| $G_6$ | 90 × 60 cm | 1164 | 0.81 | 2.25 | 2.97 | 7.23 | 71.61 | 1327 |
| $G_7$ | 90 × 45 cm | 1060 | 0.56 | 1.44 | 2.92 | 7.18 | 70.76 | 1044 |
| $G_8$ | 75 × 75 cm | 1008 | 0.66 | 2.00 | 2.87 | 7.09 | 69.17 | 1002 |
| SEd | | 62 | 0.30 | 0.09 | 0.07 | 0.37 | 2.40 | 58 |
| CD (P = 0.05) | | 133 | 0.62 | 0.20 | 0.15 | 0.77 | 5.03 | 124 |
| Treatments | | | 135 DAS | | | | | Oil yield (kg ha$^{-1}$) |
| $G_1$ | 150 × 120 cm | 2680 | 4.21 | 10.90 | 2.13 | 8.21 | 75.15 | 838 |
| $G_2$ | 120 × 120 cm | 3111 | 4.77 | 10.05 | 2.05 | 8.00 | 73.70 | 988 |
| $G_3$ | 120 × 90 cm | 2840 | 2.62 | 6.54 | 2.03 | 7.93 | 73.52 | 914 |
| $G_4$ | 120 × 60 cm | 2486 | 1.69 | 3.92 | 1.98 | 7.35 | 72.40 | 736 |
| $G_5$ | 90 × 90 cm | 2272 | 1.64 | 3.93 | 1.96 | 7.00 | 71.50 | 688 |
| $G_6$ | 90 × 60 cm | 2215 | 1.01 | 2.55 | 1.93 | 7.05 | 71.00 | 589 |
| $G_7$ | 90 × 45 cm | 2191 | 0.71 | 2.06 | 1.94 | 6.55 | 69.84 | 461 |
| $G_8$ | 75 × 75 cm | 2157 | 0.80 | 2.90 | 1.62 | 6.35 | 65.60 | 442 |
| SEd | | 104 | 0.08 | 0.12 | 0.03 | 0.41 | 2.41 | 18 |
| CD (P = 0.05) | | 224 | 0.16 | 0.26 | 0.07 | 0.86 | 5.04 | 40 |

Also, the photosynthetic rate is not linearly proportional to the leaf area because different leaves are not exposed to equal environmental conditions (radiation intensity and quality, temperature, air humidity, etc.) and have heterogeneous physiological conditions (stomata conductance, nutritional status, leaf age, source sink regulation, etc.) (Stockle and Kemanian, 2009) [11]. The photosynthesis cannot be assumed as homogeneous even in a single leaf because the leaf blade can also be exposed to variable conditions due to uneven light distribution, heterogeneous phloem loading, stomatal opening, variation in chlorophyll content, and air turbulence (Schurr *et al*., 2000) [9].

Castor plants are more competition for water in the vegetative stage of growth. The wider spacing (150×120 cm) of castor registered higher leaf weight and relative leaf water content mainly through less competition of water availability between the plants. If more number of plants per unit area leads to more competition of water and its produces small leaves, less specific leaf weight and relative leaf water content. Further in closer spacing, at the cellular level, limitation of water is reduced the callus initiation, nitrate reductase activity and the chlorophyll content (Manjula *et al*., 2003) [4]. Water deficit increases cuticular wax load (Lakshmamma *et al*., 2003) [3] and abscisic acid concentration in the phloem sap (Zhong *et al*., 1996) [14]. Therefore optimum wider spacing not only responded more yield but it also accommodate to limited irrigation. Induced physiological parameters lead to enhanced seed (2153 kg $ha^{-1}$) and oil (988 kg $ha^{-1}$) yield at 120 x 120 cm spacing. Further due to higher plant density utilized all natural resources like solar radiation, moisture, nutrient and space. Maximum LAI increased the photosynthesis and utilized for more seed development which ultimately improved the seed filling and oil content.

## Conclusions

The experiment was concluded that under optimum crop geometry (120 × 120 cm) more castor yield was obtained due to equal distribution of available growth resource which intern enhances the leaf weight, relative leaf water content, chlorophyll content, crop growth rate, leaf area index and dry matter production. At the same time less response of physiological parameters due to more density per unit area (75× 75 cm) was obtained and recorded lower yield.

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