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Research Note

# Determination of optimum plant characters in safflower (*Carthamus tinctorious* L) under rice based late sown condition

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**Abstract**
The current experiment consisting of 19 elite safflower genotypes along with three checks (A-1, PBNS-12 and DSH 185) were sown in randomized block design in three replications. Genotypic correlation studies established a positive association between the number of capitulum per plant, the number of seeds per plant, the weight of 100 seeds per plant and the seed yield per plant. As a result, selecting genotypes based on these traits may help to enhance seed yield. Days to maturity and the number of seeds per capitulum had a positive association with oil content, indicating that delayed maturity contributed to enhance oil content. Similarly, the number of seeds/capitulum contributed to improve the oil content. Days to 50% flowering, number of capitulum /plant, number of seeds /capitulum, 100 seed weight and oil percentage appeared to have the most direct effects on seed yield. Oil content per plant had a significant effect on traits such as days to 50% flowering, days to maturity, and 100 seed weight, whereas seed yield had a negative direct effect towards oil content. The path analysis results showed that increased rosette period helped plants establishing good root system at an early stage of growth, delayed days to 50% flowering and maturity strongly affecting the source and sink, which converted into the number of capitulum per plant and 100 seed weight. These characters showed a positive relationship as well as direct effects on seed yield and oil content. As a result, a plant with delayed maturity (130-135 days), medium plant height (110cm), 30-35 seeds per capitulum, 100 seed weight (4.5-5 g) and oil content (32-33 %) would be considered as the model plant type for late sown irrigated conditions in Chhattisgarh plain.

**Keywords**: Model plant type, source, sink, correlation, path analysis

Safflower (*Carthamus tinctorius* L.) is one of the oldest domesticated oilseed crops. It has been grown since ancient times both as a dye as well as an oilseed crop in a wide range of geographical regions (Knowles, 1976). It is a member of the family *Compositae* or *Asteraceae,* genus- *Carthamus*, tribe-*Tubiflorae,* sub division-Angiosperm of division- *Phanerogams.* Kusum (India, Pakistan), derived from the Sanskrit word *Kusumbha* (Chavan, 1961) and *Honghua* (red flower) in China are the most common names of safflower. India's safflower crop area is shrinking rapidly. This crop was planted on 707,000 hectares in 1977-78, but by 2018-19, only 46,000 ha remained. Similarly, crop production in 1977-78 was 188000 tonnes and it remained 25000 tonnes in 2018-19. However, crop productivity was 266 kg/ha in 1977-78 and has now increased to 537 kg/ha in 2018-19. Safflower is grown in Chhattisgarh with an area of 270 hectares producing 110 tons and 811 kg/ha productivity (Anonymous, 2020).

In rice growing states like Chhattisgarh the sowing of *rabi* crops is always delayed due to late rice harvest. Safflower

is an oilseed crop and the late sown condition is favorable for its growth but not all varieties perform well. There is a need to identify a plant type that is better for yield as well as oil content in late sown conditions. Keeping this in mind, a study was conducted to identify a Safflower plant type that is suitable for late sown conditions.

The research was carried out at the Indira Gandhi Krishi Vishwavidyalaya, Research cum Instructional Farm, Raipur, Chhattisgarh during *rabi,* 2019-20. The experimental material consisted of 19 elite safflower genotypes along with three checks (A-1, PBNS-12 and DSH 185). The crop was grown using a Randomized Block Design (RBD) with three replications, with the plot size for each entry being1.35 m×5 m. For each replication, the row to row spacing was 45 cm and the plant to plant spacing was 20 cm. All standard agronomical practices were followed. The characters chosen for the observations were rosette period (days), days to 50% flowering, days of maturity, the number of branches per plant, plant height (cm), the number of capitulum per plant, the number of seeds per capitulum, 100 seed weight (g), seed yield/plot and oil content (%).

Rosette period demonstrated a significant negative correlation with days to maturity, plant height and number of capitulum per plant. Days to 50% flowering expressed a highly significant and positive association with days to maturity, plant height and the number of seeds per capitulum, indicated that delayed flowering exposed for more photosynthesis which increases the number of seeds per capitulum. Delayed flowering also increased plant height and days to maturity. This was in agreement with findings of Alizadeh and Carpentian, (2006), Mahasi *et al*. (2006), Shivani *et al*. (2010) and Purkayastha *et al*. (2017). Days to maturity revealed a highly significant and positive correlation with plant height and 100 seed weight, whereas a significant negative association with the number of seeds per capitulum and oil content. The number of branches per plant revealed a highly significant and positive association with the number of capitulum per plant and 100 seed weight whereas a significant negative correlation with the number of seeds per capitulum and seed yield.

Plant height demonstrated a significant positive association with the number of seeds per capitulum. The number of capitulum per plant revealed a significant positive correlation with seed yield. The number of seeds per capitulum expressed a highly significant and positive association with oil content along with a significant negative correlation with 100 seed weight. 100 seed weight revealed a highly significant and positive correlation with seed yield and a significant negative association with oil content (**Table 1**). These findings were confirming the study of Ekshinge *et al.* (1994), Patil (1998), Chavan *et al.* (1999), Reddy *et al.* (2003), Anjani (2005), Dalvi *et al.* (2005) and Valli *et al.* (2016).

The highest positive direct effect on seed yield was estimated with oil content (2.533) followed by the number of seeds per capitulum (2.009), 100 seed weight (1.369) and the number of capitulum per plant (1.289), days to 50% flowering (1.070) and days to maturity (0.451).

**Table 1. Correlation analysis of yield and its contributing traits in safflower**

| Traits | | Days to 50% flowering | Days to maturity | Number of branches /plant | Plant height | Number of capitulam/ plant | Number of seeds / capitulam | 100 Seed weight | Seed yield | Oil content |
|---|---|---|---|---|---|---|---|---|---|---|
| Rosette period | G | -0.154 | -0.420** | -0.021 | -0.339** | -0.332** | 0.192 | -0.110 | -0.151 | 0.194 |
| | P | 0.079 | -0.164 | -0.197 | -0.241 | -0.188 | 0.202 | -0.072 | -0.129 | 0.070 |
| Days to 50% flowering | G | | 0.688** | -0.172 | 0.369** | -0.049 | 0.275* | -0.144 | 0.111 | -0.146 |
| | P | | 0.507** | -0.253* | 0.217 | -0.076 | 0.231 | -0.133 | -0.132 | 0.101 |
| Days to maturity | G | | | -0.149 | 0.519** | -0.153 | -0.295* | 0.332** | 0.107 | 0.602** |
| | P | | | -0.063 | 0.378** | -0.123 | -0.217 | 0.278* | -0.002 | 0.449** |
| Number of branches / plant | G | | | | -0.300* | 0.556** | -0.344** | 0.401** | -0.499** | 0.017 |
| | P | | | | -0.123 | 0.473** | -0.224 | 0.224 | -0.107 | -0.009 |
| Plant height | G | | | | | -0.093 | -0.243* | -0.148 | -0.009 | -0.057 |
| | P | | | | | -0.095 | -0.213 | -0.130 | 0.064 | -0.039 |
| Number of Capitulam/ plant | G | | | | | | -0.160 | -0.012 | 0.356** | -0.168 |
| | P | | | | | | -0.110 | -0.007 | 0.176 | -0.137 |
| Number of seeds/ capitulam | G | | | | | | | -0.630** | 0.135 | 0.584** |
| | P | | | | | | | -0.578** | 0.150 | 0.544** |
| 100 Seed weight | G | | | | | | | | 0.273* | -0.574** |
| | P | | | | | | | | 0.222 | -0.544** |
| Seed yield | G | | | | | | | | | 0.009 |
| | P | | | | | | | | | -0.045 |

*,** significant and 5 and 1 per cent level, respectively

The number of branches per plant (-2.670), the number of seeds per capitulum (-2.009) and plant height (-1.413) showed a negative direct effect on seed yield (**Table 2**). The characters *viz*., the number of seeds per capitulum, 100 seed weight and the number of capitulum per plant. As we know yield is a dependent trait and depends on the performance of other yield contributing traits. It is very difficult to have complete knowledge of all component traits of yield in plant breeding. The residual effect permits precise explanation about the pattern of interaction of other components of yield. In other words residual effect measures the role of possible independent variables which were not included in the study on the dependent variable. In this study, the residual effect at the genotypic level is -0.70109 indicating the characters included in the present investigation had contributed 100 per cent to the dependent variable ie. yield (**Table 2**).

Results revealed that an increased period of rosette helped plants to establish well with a good root system at an early stage of growth. Delayed days to 50% flowering and maturity greatly influenced the source and sink which converts into the number of capitulum per plant and 100 seed weight and resulted in increasing the seed yield per plant.

Days to maturity (4.190), days to 50% flowering (3.029) and 100 seed weight (1.090) showed the highest positive direct effect on oil content, whereas, negative direct effects were recorded with, the number of seeds per

**Table 2. Path analysis of yield contributing traits on seed yield in safflower**

| Traits | Rosette period | Days to 50% flowering | Days to maturity | Number of branches /plant | Plant height | Number of capitulam/ plant | Number of seeds/ capitulam | 100 seed weight | Oil content | Correlation with seed yield |
|---|---|---|---|---|---|---|---|---|---|---|
| Rosette period | **0.137** | -0.164 | -0.189 | 0.056 | 0.479 | -0.427 | -0.386 | -0.150 | 0.494 | -0.151 |
| Days to 50% flowering | -0.021 | **1.070** | 0.310 | 0.459 | -0.521 | -0.063 | -0.552 | -0.197 | -0.373 | 0.11 |
| Days to maturity | -0.057 | 0.736 | **0.451** | 0.397 | -0.732 | -0.197 | 0.593 | 0.454 | -1.536 | 0.10 |
| Number of branches/plant | -0.002 | -0.184 | -0.067 | **-2.670** | 0.423 | 0.716 | 0.692 | 0.548 | 0.043 | -0.499** |
| Plant height | -0.046 | 0.395 | 0.233 | 0.800 | **-1.413** | -0.119 | 0.489 | -0.202 | -0.145 | -0.009 |
| Number of capitulam/plant | -0.045 | -0.052 | -0.069 | -1.484 | 0.131 | **1.289** | 0.321 | -0.016 | -0.429 | 0.356** |
| Number of seeds/ capitulam | 0.026 | 0.294 | -0.133 | 0.919 | 0.344 | -0.206 | **2.009** | -0.862 | 1.491 | 0.135 |
| 100 seed weight | -0.015 | -0.154 | 0.149 | -1.069 | 0.209 | -0.015 | 1.266 | **1.369** | -1.466 | 0.273* |
| Oil content | 0.026 | -0.156 | -0.271 | -0.045 | 0.080 | -0.216 | -1.174 | -0.786 | **2.553** | 0.009 |

Residual effect: -0.70109

*,** significant and 5 and 1 per cent level, respectively

**Table 3. Path analysis of yield contributing traits on oil content in safflower**

| | Rosette period | Days to 50% flowering | Days to maturity | Number of branches /plant | Plant height | Number of capitulam /plant | Number of Seeds /capitulam | 100 seed weight | Seed yield | Correlation with oil content |
|---|---|---|---|---|---|---|---|---|---|---|
| Rosette Period | **-1.477** | -0.465 | 1.759 | 0.024 | 0.057 | 0.433 | -0.268 | -0.119 | 0.248 | 0.194 |
| Days to 50% flowering | 0.226 | **3.029** | -2.883 | 0.202 | -0.062 | 0.064 | -0.383 | -0.157 | -0.182 | -0.146 |
| Days to maturity | 0.620 | -2.084 | **4.190** | 0.174 | -0.087 | 0.200 | 0.411 | -0.361 | -0.176 | 0.602** |
| Number of branches/ plant | 0.031 | -0.521 | 0.623 | **-1.175** | 0.050 | -0.726 | 0.479 | 0.436 | 0.819 | 0.017 |
| Plant height | 0.500 | 1.118 | -2.173 | 0.352 | **-0.169** | 0.121 | 0.339 | -0.161 | 0.015 | -0.057 |
| Number of Capitulam/ plant | 0.489 | -0.148 | 0.641 | -0.653 | 0.015 | **-1.308** | 0.222 | -0.013 | 0.584 | -0.168 |
| Number of seeds/ capitulam | -0.284 | 0.833 | 1.237 | 0.404 | 0.041 | 0.209 | **-1.393** | -0.686 | 0.222 | 0.584** |
| 100 seed weight | 0.162 | -0.436 | -1.389 | -0.470 | 0.025 | 0.016 | 0.877 | **1.090** | -0.447 | -0.574** |
| Seed yield | 0.223 | 0.336 | -0.449 | 0.586 | 0.001 | 0.465 | 0.188 | 0.297 | **-1.641** | 0.009 |

Residual effect: 0.45070

** significant at 5 per cent level

capitulum (-1.393), seed yield (-1.641), the number of capitulum per plant (-1.308) and the number of branches per plant (-1.175). This indicated that prolonged period of days to 50% flowering would use more sources (sunlight) which would accumulate as a sink in form of 100 seed weight and would help to increase the oil content of plant (**Table 3**). The residual effect estimation (0.4507) when oil content was dependent variable indicated that the characters included in the present study had contributed 55 per cent to the dependent variable i.e. oil content and only 45 per cent is due to traits that were not considered in the present investigation (**Table 3**). Results of the present study confirmed the findings of Mathur *et al.* (1976), Patil *et al.* (1990), Chavan *et al.* (1999), Reddy *et al.* (2003), Mahasi *et al.* (2006), Hojghani *et al.* (2009), Sirisha *et al.* (2012) and Mojgan *et al.* (2014).

Characteristics such as days to maturity, plant height, the number of seeds per capitulum, 100 seed weight, and oil content were highly heritable. These traits were not greatly influenced by the environment and had the greatest genotypic influence on their inheritance.

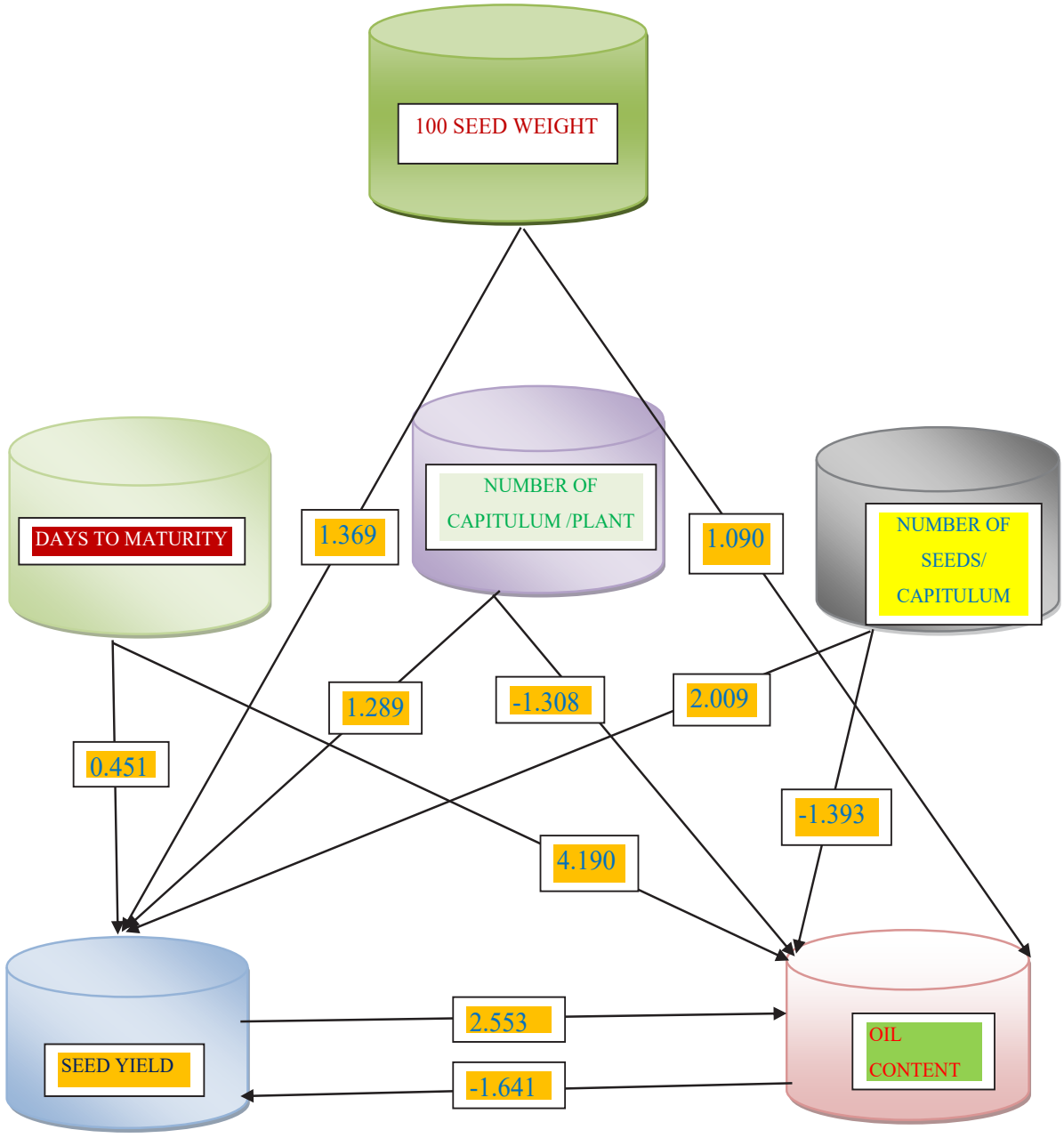


**Fig. 1. Direct effect of traits on seed yield and oil content in Safflower**

These characteristics also contributed as a source of photosynthesis in the production of energy and food material, which was then stored as a sink as the result of photosynthesis in form of the number of seeds per plant and 100 seed weight per plant (**Fig.1**).

These characters had a positive association as well as direct effects on seed yield and oil content. As a result, a plant with delayed maturity (130-135 days), medium plant height (110 cm), 30-35 seeds per capitulum, 100 seed weight (4.5-5 g), and oil content (32-33 %) would be regarded as the model plant type for late sown irrigated conditions in Chhattisgarh plain. This confirms the findings of Perveen *et al.* (2017).

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