# Identification of Plant Type of Safflower (Carthamus Tinctorius L.) for Late Sown Condition

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**Abstract—***Present experiment was carried out during rabi 2014-15 and 2015-16. 150 germplasm accessions and four check varieties were sown in augmented design, in five blocks. Correlation analysis indicated that seed yield per plant largely dependent on the characters mainly responsible for the conversion of light energy into chemical forms viz., biological yield, number of effective capitulum, plant and number of primary branches per plant up to a large extent. Correlation studies indicated that for seed yield a plant with more numbers of primary branches and biological yield with more numbers of effective capitulum will be an ideal plant type of safflower. Path analysis again expresses the architecture of the ideal plant type of safflower with more biological yield (Primary branches and number of effective capitulum per plant). As per present study an ideal safflower plant type for seed yield should have a rosette period of nearly 35 days with higher biological yield (more number of primary branches 8-10) and more numbers of effective capitulum per plant 30-35, with maturity 125-130 days. For a plant type of safflower for oil should have delayed 50% flowering, delayed maturity, more number of capitulum per plant, such type of safflower plant may be an ideal plant of safflower for better oil content.*

**Keywords***: Plant type, source, sink, correlation, path analysis.*

## 1. INTRODUCTION

Safflower (Carthamus tinctorius L.) is one of the oldest domesticated 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, 1969). Safflower is most commonly known as Kusum (India, Pakistan), derived from the Sanskrit word Kusumbha (Chavan, 1961), and as Honghua (red flower) in China. Its use as a less costly substitute for saffron is indicated by the names false saffron, bastard saffron, thistle saffron and dyers saffron (Weiss, 1983). Around the world, safflower is mainly grown for its edible oil for cooking, salad oil and margarine. In affluent countries, research linking health and diet has increased the demand for the oil, which has the highest polyunsaturated / saturated ratios of any oil available.

Chhattisgarh is rice growing state, where rice is a major crop during kharif. Most of the farmers grow late duration rice varieties like Swarna, which harvested in first fortnight of November. This delayed harvesting of rice and rains in month of October in Chhattisgarh delayed the sowing of rabi crops, and the sowing of all the rabi crops after rice crop delayed very much. Safflower is an oilseed crop, which is suitable for late sown condition, but not all varieties perform well. There is need to identify a plant type suitable for late sown condition better for yiled as well as oil content. Keeping in view a study has been carried out to find out a plant type of Safflower suitable under late sown condition.

## 2. MATERIALS AND METHODS

The present research work was carried out at the Research cum Instructional farm of Indira Gandhi Krishi Vishwadalaya, Raipur, Chhattisgarh during rabi, 2014-15 and rabi 2015-16. The experimental material included 150 germplasm accessions both indigenous collections (IC) and exotic collections (EC), obtained from Germplasm maintenance unit (GMU), Indian Institute of Oilseeds Research, Hyderabad and four check varieties viz., A-1, PBNS-12, Bhima and Manjira. The experiment was laid out in Augmented Design. The whole experimental material 150 germplasm accessions and four checks were divided in 5 blocks. Each block has 30 germplasm entries with 4 checks. Checks were replicated in each block whereas each germplasm accessions were grown in a single row. Each block was 5m × 67.8m in size and the spacing between rows was 45 cm and plant to plant was 20 cm, was maintained in each block.

## 3. RESULTS AND DISCUSSION

Under a general physiological framework, yield is the result of resource capture, conversion and partitioning to different organs and final grains. Partitioning between source and sink organs is often regarded in a static way by analyzing harvest index, however partitioning is a dynamic process and is a

result of the source-sink relationships in the different growth phases of the crop. All processes (resource acquisition, conversion and partition) are under genetic control and will interact with the environment determining the final plant type or ideotype (Donald, 1968).

Correlation analysis indicated that seed yield per plant largely dependent on the characters mainly responsible for the conversion of light energy into chemical forms viz., biological yield, number of effective capitulum, plant and number of primary branches per plant up to a large extent. These chemical energy were stored in economic sink i.e. number of effective capitulum, 100 seed weight. This type of plant will be able to produce maximum seed yield due to good source and sink relationship. Correlation studies indicated that for seed yield a plant with more numbers of primary branches and biological yield with more numbers of effective capitulum will be an ideal plant type of safflower.

Path analysis confirms the importance of biological yield, numbers of effective capitulum, number of primary branches as they had maximum direct effect on seed yield per plant. Its shows that number of primary branches and number of effective capitulum had maximum indirect effect via, biological yield. Path analysis again expresses the architecture of the ideal plant type of safflower with more biological yield (Primary branches and number of effective capitulum per plant) confirms the findings of Mathur et al. (1976), Thombre and Joshi (1981), Jadhav et al., (1992).

Association study shows that number of effective capitulum, final plant stand, 100 seed weight and seed yield had negative association with oil content. It clearly shows that flowering has important role in oil content. Path analysis further partitioned the correlation coefficient into direct and indirect effects and indicated that days to 50% flowering, 100 seed weight, final plant stand and number of effective capitulum had greater direct effect on oil content whereas seed yield and days to maturity had negative direct effect on oil content.

The association and path analysis indicated that for higher yield a plant type must have delayed flowering, more number of primary branches, more number of effective capitulum per plant and higher biological yield.

For oil content and yield both biological yield is a major attribute as it is responsible for photosynthesis and storage of sink. Time taken by a plant for flowering is directly related with storage of more sink. Oil content also showed positive association with 50% flowering, since safflower oil content more unsaturated fatty acids, its formation starts late in the plant which shows importance of delayed maturity for oil content.

As per present study an ideal safflower plant type for seed yield should have a rosette period of nearly 35 days with higher biological yield (more number of primary branches 8-10) and more numbers of effective capitulum per plant 30-35, with maturity 125-130 days. For a plant type of safflower for oil should have delayed 50% flowering, delayed maturity, more number of capitulum per plant, such type of safflower plant may be an ideal plant of safflower for better oil content.

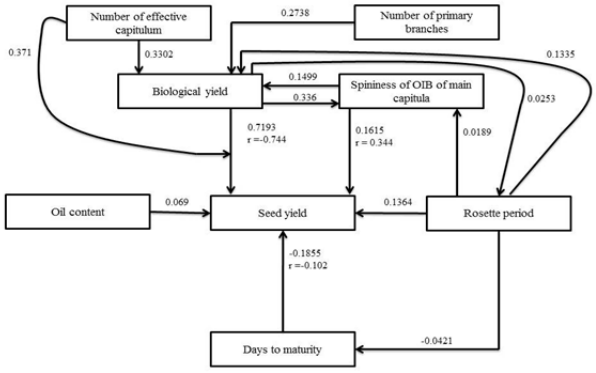


**Fig. I Summary of direct and indirect effects of major traits on seed yield.**

**Table 1: Correlation coefficient analysis for yield and its contributing traits**

| TRAITS UNDER STUDY | RP | DTF | DTM | SP | PH | LLP | APB | HPB. | NEC | 100 SW | OC | NPB | BY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DTF** | 0.219* | | | | | | | | | | | | |
| **DTM** | 0.227* | 0.726* | | | | | | | | | | | |
| **SP** | 0.117* | -0.085 | -0.102 | | | | | | | | | | |
| **PH** | -0.233* | 0.066 | 0.088 | -0.056 | | | | | | | | | |
| **LLP** | -0.230* | -0.132* | -0.169* | -0.010 | 0.145* | | | | | | | | |
| **APB** | 0.026 | -0.005 | 0.012 | 0.025 | -0.021 | -0.010 | | | | | | | |
| **HPB** | -0.191* | -0.117* | -0.111 | -0.044 | 0.265* | 0.040 | -0.110* | | | | | | |
| **NEC** | 0.008 | 0.051 | 0.050 | 0.025 | -0.189* | 0.290* | 0.011 | -0.167* | | | | | |
| **100 SW** | -0.131* | -0.240* | -0.132* | 0.061 | -0.049 | -0.011 | 0.099 | 0.102 | 0.098 | | | | |
| **OC** | 0.037 | 0.101 | -0.000 | -0.051 | 0.040 | 0.130 | -0.008 | 0.058 | -0.022 | -0.349* | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NPB** | 0.029 | -0.082 | -0.056 | -0.067 | -0.118* | 0.256* | -0.079 | -0.270* | 0.694* | -0.025 | -0.118* | | |
| **BY** | 0.186* | 0.037 | 0.117 | 0.208* | -0.108* | 0.145* | -0.076 | -0.168* | 0.459* | 0.002 | -0.055 | 0.381* | |
| **SY** | 0.257* | -0.106 | -0.102 | 0.344* | -0.167* | 0.103 | -0.079 | -0.146* | 0.309* | -0.004 | 0.022 | 0.274* | 0.744* |

* Significant at 5% level

RP-Rosette period, DTF- Days to 50% flowering, DTM- Days to maturity, SP- Spininess of OIB of main capitulum,

PH- Plant height (cm), LLP- Length of the longest primary branch(cm), APB- Angle of primary branch, HPB- Height of primary branch from the ground level(cm),NEC-Number of effective capitula, 100 SW- Seed weight (g), OC- Oil (%),

NPB- Number of primary branches, BY-Biological yield (Kg/pl) SY- Seed yield (Kg/pl)

**Table 2: Path coefficient analysis, with seed yield as dependent character.**

| Traits under study | RP | DTF | DTM | SP | PH | LLP | APB | HPB | NEC | 100 SW | OC | NPB | BY | Correlation with seed yield |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RP** | 0.136 | -0.003 | -0.042 | 0.018 | 0.009 | 0.0006 | -0.0008 | 0.0018 | -0.0002 | 0.0000 | 0.0025 | 0.0005 | 0.1335 | 0.2570* |
| **DTF** | 0.0298 | -0.0145 | -0.1347 | -0.0136 | -0.0025 | 0.0003 | 0.0001 | 0.0011 | -0.0019 | 0.0001 | 0.0070 | -0.0016 | 0.0262 | -0.0106 |
| **DTM** | 0.0310 | -0.0105 | -0.1855 | -0.0165 | -0.0034 | 0.0004 | -0.0004 | 0.0011 | -0.0018 | 0.0000 | -0.0000 | -0.0010 | 0.0844 | -0.1020 |
| **SP** | 0.0160 | 0.0012 | 0.0189 | 0.1615 | 0.0022 | 0.0000 | -0.0008 | 0.0004 | -0.0009 | -0.0000 | -0.0035 | -0.0013 | 0.1499 | 0.3440* |
| **PH** | -0.0317 | -0.0009 | -0.0162 | -0.0091 | -0.0389 | -0.0003 | 0.0006 | -0.0026 | 0.0070 | 0.0000 | 0.0027 | -0.0023 | -0.0774 | -0.1670 |
| **LLP** | -0.0314 | 0.0019 | 0.0313 | -0.0016 | -0.0056 | -0.0026 | 0.0003 | -0.0003 | -0.0107 | 0.0000 | 0.0089 | 0.0050 | 0.1041 | 0.1030 |
| **APB** | 0.0035 | 0.0000 | -0.0023 | 0.0040 | 0.0008 | 0.0000 | -0.0331 | 0.0010 | -0.0004 | -0.0000 | -0.0005 | -0.0015 | -0.0546 | -0.0709 |
| **HPB** | -0.0260 | 0.0017 | 0.0206 | -0.0070 | -0.0103 | -0.0001 | 0.0036 | -0.0099 | 0.0062 | -0.0000 | 0.0039 | -0.0052 | -0.1205 | -0.1460 |
| **NEC** | 0.0010 | -0.0007 | -0.0092 | 0.0039 | 0.0073 | -0.0007 | -0.0003 | 0.0016 | -0.0371 | -0.0000 | -0.0014 | 0.0136 | 0.3302 | 0.3090* |
| **100 SW** | -0.0179 | 0.0035 | 0.0244 | 0.0098 | 0.0019 | 0.0000 | -0.0032 | -0.0010 | -0.0036 | -0.0007 | -0.0241 | -0.0004 | 0.0013 | -0.0040* |
| **OC** | 0.0051 | -0.0014 | 0.0000 | -0.0082 | -0.0015 | -0.0003 | 0.0002 | -0.0005 | 0.0008 | 0.0002 | 0.0690 | -0.0023 | -0.0393 | 0.0020 |
| **NPB** | 0.0039 | 0.0011 | 0.0103 | -0.0108 | 0.0046 | -0.0006 | 0.0026 | 0.0026 | -0.0257 | 0.0000 | -0.0081 | 0.0196 | 0.2738 | 0.2740* |
| **BY** | 0.0253 | -0.0005 | -0.0217 | 0.0336 | 0.0042 | -0.0003 | 0.0025 | 0.0016 | -0.0170 | -0.0000 | -0.0037 | 0.0074 | 0.7193 | 0.744** |

*Significant at 5% level ** Significant at 1% level.

Residual effect (R) =0.3519 Diagonal bold values are direct effects

RP-Rosette period, DTF- Days to 50% flowering, DTM- Days to maturity,

SP- Spininess of OIB of main capitulum, PH- Plant height (cm) LLP- Length of the longest primary branch(cm), APB- Angle of primary branch, HPB- Height of primary branch from the ground level (cm),

NEC-Number of effective capitula, 100 SW- Seed weight (g), OC- Oil (%),

NPB- Number of primary branches, BY-Biological yield (Kg/pl).

**Table 3: Path coefficient analysis, with oil content as dependent character.**

| Traits under study | RP | DTF | DTM | SP | PH | LLP | APB | HGL | NEC | 100 SW | FPS | NPB | BY | SY | Correlation of oil content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RP** | 0.0662 | 0.0317 | -0.0345 | 0.0134 | 0.0063 | 0.0185 | -0.0036 | 0.0017 | 0.0021 | -0.0198 | 0.0028 | -0.0013 | -0.0442 | -0.0141 | 0.0370 |
| **DTF** | 0.0145 | 0.1451 | -0.1103 | -0.0097 | -0.0018 | 0.0106 | 0.0006 | 0.0010 | 0.0145 | -0.0362 | 0.0110 | 0.0038 | -0.0087 | 0.0058 | 0.1010 |
| **DTM** | 0.0150 | 0.1054 | -0.1519 | -0.0117 | -0.0024 | 0.0135 | -0.0017 | 0.0010 | 0.0140 | -0.0199 | -0.0013 | 0.0025 | -0.0279 | 0.0056 | 0.0000 |
| **SP** | 0.0077 | -0.0123 | 0.0155 | 0.1146 | 0.0015 | 0.0008 | -0.0034 | 0.0003 | 0.0070 | 0.0091 | -0.0033 | 0.0031 | -00497 | -0.0189 | -0.0510 |
| **PH** | -0.0154 | 0.0096 | -0.0133 | -0.0064 | -0.0274 | -0.0116 | 0.0028 | -0.0023 | -0.0538 | -0.0074 | -0.0148 | 0.0055 | 0.0256 | 0.0091 | 0.0400 |
| **LLP** | -0.0152 | -0.0192 | 0.0257 | -0.0011 | -0.0039 | -0.0802 | 0.0013 | -0.0003 | 0.0824 | -0.0016 | -0.0204 | -0.0119 | -0.0345 | -0.0056 | 0.1300* |
| **APB** | 0.0017 | -0.0006 | -0.0190 | 0.0028 | 0.0005 | 0.0008 | -0.1372 | 0.0009 | 0.0030 | 0.0148 | -0.0238 | 0.0036 | 0.0181 | 0.0043 | -0.0080 |
| **HGL** | -0.0126 | -0.0170 | 0.0168 | -0.0050 | -0.0072 | -0.0031 | 0.0151 | -0.0090 | -0.0474 | 0.0154 | 0.0162 | 0.0125 | 0.0399 | 0.0080 | 0.0058 |
| **NEC** | 0.0005 | 0.0074 | -0.0075 | 0.0028 | 0.0051 | -0.0233 | -0.0014 | 0.0015 | 0.2840 | 0.0148 | -0.0042 | -0.0323 | -0.1094 | -0.0169 | -0.0220 |
| **100 SW** | -0.0087 | -0.0348 | 0.0200 | 0.0069 | 0.0013 | 0.0008 | -0.0135 | -0.0009 | 0.0278 | 0.1509 | -0.0298 | 0.0011 | -0.0004 | 0.0002 | -0.3490* |
| **FPS** | 0.0012 | 0.0106 | 0.0013 | -0.0025 | 0.0026 | 0.0108 | 0.0216 | -0.00097 | -0.0078 | -0.0297 | 0.1512 | 0.001 | -0.0547 | -0.0079 | -0.0140 |
| **NPB** | 0.0019 | -0.0119 | 0.0084 | -0.0076 | 0.0032 | -0.0205 | 0.0108 | 0.0024 | 0.1970 | -0.0037 | -0.0040 | -0.0466 | -0.0908 | -0.0150 | --0.1180* |
| **BY** | 0.0123 | 0.0053 | -0.0178 | 0.0239 | 0.0029 | -0.0116 | 0.0104 | 0.0015 | 0.1303 | 0.0002 | 0.0347 | -0.0177 | -0.2384 | -0.0409 | -0.0550 |
| **SY** | 0.0170 | -0.0154 | 0.0155 | 0.0394 | 0.0045 | -0.0082 | 0.0107 | 0.0013 | 0.0877 | -0.0006 | 0.0218 | -0.0127 | -0.1774 | -0.0549 | 0.0220 |

* Significant at 5% level. ** Significant at 1% level. Residual effect(R) =0.8551 Diagonal bold values are direct effects

RP-Rosette period, DTF- Days to 50% flowering, DTM- Days to maturity, SP- Spininess of OIB of main capitulum, PH- Plant height, LLP- Length of the longest primary branch, APB- Angle of primary branch, HPB- Height of primary branch from the ground level, NEC-Number of effective capitula, 100 SW- Seed weight, OC-Oil content, FPS-Final plant stand, NPB- Number of primary branches, BY-Biological yield.

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