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# Competitive relationship between safflower and intercrops as affected by safflower (*Carthamus tinctorius* L.) based intercropping systems under protective irrigation

**CB Patil, AS Karle and MP Jagtap**

**Abstract**
An experiment was conducted at the Research Farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *rabi* seasons of 2016-17 and 2017-18. Sixteen intercropping treatments including sole crops were tested in randomized block design. Safflower crop and intercrops *viz.*, sorghum, wheat, chickpea, lentil and linseed were tested in 1:3 and 2:4 row proportions in replacement series. Safflower variety PBNS-12, sorghum variety Parbhani Moti, wheat variety Trimbak, chickpea variety Akash, lentil variety JL-3 and linseed variety PKVNL-260 were used. Safflower + chickpea (2:4) and safflower + lentil (2:4) intercropping system recorded similar land equivalent ratio during both years which was higher than other treatments. Safflower + sorghum (1:3) intercropping system recorded lowest values for land equivalent ratio. Safflower was more competitive in safflower + wheat (1:3) intercropping system followed by safflower + wheat (2:4) intercropping system. Higher values for area time equivalent ratio were observed in safflower + chickpea (2:4) and safflower + lentil (2:4) intercropping systems. Safflower in all intercropping systems was found to be aggressive except in safflower + sorghum intercropping systems during both the years.

**Keywords:** Safflower, land equivalent ratio, competitive ratio, aggressivity, area-time equivalent ratio

## Introduction
Safflower (*Carthamus tinctorius* L.) is an important *rabi* oilseed crop of Maharashtra. India ranks first in area (51 %) and production (37 %) in the world. The safflower area in the country during 2017-18 was 0.81 lakh ha area as compared to the year 2016-17 (1.05 lakh ha). The safflower was grown on 0.54 and 0.34 lakh ha area in Maharashtra during 2016-17 and 2017-18, respectively (Anonymous, 2018) [1].

The production of safflower in India was 0.94 and 0.54 million tonnes during 2016-17 and 2017-18 according to final and third advance estimates, respectively (Anonymous, 2018a)[2]. In India, Maharashtra and Karnataka are the two most important safflower growing states. The results of frontline demonstrations indicated that cultivation of safflower recorded the highest B: C ratio (4.60), net returns (Rs. 19675 $ha^{-1}$) as compared to lower net returns (Rs. 13592 $ha^{-1}$) and B: C ratio (3:1) by Bengal gram. (Kumar *et al.* 2009)[8]. Safflower + sorghum, safflower + chickpea, safflower + linseed and safflower + wheat are the most practiced safflower based intercropping systems on the vertisols of central India. Intercropping is defined as any cropping system where there is a significant amount of inter-crop competition (Willey and Rao, 1980) [14].

## Methodology
The present study was conducted on experimental farm of Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during the *rabi* seasons of 2016-17 and 2017-18. The soil of the experimental site was grouped as clayey in texture (54.30 % clay), alkaline in nature (pH 7.84), low in available nitrogen (209.16 kg $ha^{-1}$), medium in available phosphorus (15.26 kg $ha^{-1}$) fairly rich in available potassium (501.60 kg $ha^{-1}$) and medium in organic carbon (0.56 %). Sixteen intercropping treatments including sole crops were tested in randomized block design. Safflower crop and intercrops *viz.*, sorghum, wheat, chickpea, lentil and linseed were tested in 1:3 and 2:4 row proportions. Safflower variety PBNS-12, sorghum variety Parbhani Moti, wheat variety Trimbak, chickpea variety Akash, lentil variety JL-3 and linseed variety PKVNL-260 were used.

**Land equivalent ratio (LER)**

LER is defined as the relative area of the sole crop required to produce the yield or yield obtained in intercropping (Willey, 1981) [15]. LER values for replacement treatments were calculated by the following formula.

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where,
Yab = Yield of 'a' component intercropped with 'b'
Yaa = Yield of 'a' component in sole planting
Yba = Yield of 'b' component intercropped with 'a'
Ybb = Yield of 'b' component in sole planting.

**Competitive ratio (CR)**

Competitive ratio is measure of intercrop competition, to indicate number of times by which the component crop is more competitive with than the other (Willey and Rao, 1980) [14]. The CR values for different replacement treatments were calculated by the equation.

$$CRa = \frac{Yab}{Yaa \times Zab} \div \frac{Yba}{Ybb \times Zba}$$

CRa = Competitive ratio for component 'a'
Zab = Row proportion / proportionate area of 'a' component intercropped in 'b'
Zba = Row proportion/ proportionate area of 'b' component intercropped in 'a'
Other symbols are as defined in section 3.7.2

**Area time equivalent ratio (ATER)**

Area time equivalent ratio was calculated by using following formula suggested by Mendhe *et al.* (2007) [9].

$$ATER = \frac{1}{ti} = \sum_{1}^{n} \left( \frac{d - Yi}{Ym} \right)$$

Where,
D = Growth period of crops in days
t = Time in days for which the field remained occupied (i.e. the growth period of the longest duration crop)
Yi = Yields of component crops in the inter cropping system
Ym = Yield of component crops in monoculture cropping system
N = Number of crops involved

**Aggressivity**

Aggressivity is the mixture of how much the relative yield increase in component 'a' is greater than that for component 'b' (Mc Gilchrist, 1965) [4].

$$A_{ab} = \frac{Yab}{Yaa \times Zab} - \frac{Yba}{Ybb \times Zba}$$

Yab = Yield of 'a' component intercropped with 'b'
Yaa = Yield of 'a' component in sole planting
Yba = Yield of 'b' component intercropped with 'a'
Zab = Row proportion/ proportionate area of 'a' component intercropped in 'b'
Zba = Row proportion of 'b' component intercropped in 'a'
Ybb = Yield of 'b' component in sole planting
$A_{ab}$ = negative means get dominated
$A_{ab}$ = bigger value either positive or negative means bigger difference in competitive abilities

**Results and Discussion**

Data presented in Tables 1 and 2 revealed that mean values of land equivalent ratio (LER), competitive ratio (CR), area time equivalent ratio and aggressivity (A) of safflower based intercropping systems were recorded which indicated treatment effect of row ratio in the terms of economic, space and time dimensions simultaneously for the better assessment of yield advantage in intercropping system for justification of acceptance intercropping system.

Safflower + chickpea (2:4) and safflower + lentil (2:4) intercropping system recorded similar land equivalent ratio during both years which was higher than other treatments. Safflower + sorghum (1:3) intercropping system recorded lowest values for land equivalent ratio. Itnal *et al.* (1980)[6] observed that, Bengal gram + safflower recorded higher LER as compared to pure crop of Bengal gram and safflower. Land equivalent ratios in all the intercropping systems were more than 1.0 when chickpea was grown with safflower in a 3:1 or 5:1 (100 %:25 %) proportion additive series and 3:1 (75 %:25%) proportion replacement series (Nikam *et al.* 1987) [10]. These results are in agreement with those obtained by Bhatnagar *et al*. (1991) [3], Hiremath *et al.* (1991) [5], Sarkar *et al.* (2000) [11], Kumar *et al.* (2009) [8] and Zafaranieh (2014) [16].

During both years, safflower in all intercropping systems was found to be more competitive except in safflower + sorghum intercropping systems. Safflower was more competitive in safflower + wheat (1:3) intercropping system followed by safflower + wheat (2:4) intercropping system. Safflower+ sorghum (1:3 or 2:4) intercropping system recorded lower values for competitive ratio. The values of competition ratio were more than one for safflower intercropped with either lentil or chickpea (2:4 or 1:3 row proportions) during both the years. Wasu (2011) [12] reported that among all intercrops safflower within chickpea + safflower intercropping system was more competitive. Sarkar *et al.* (2000) [11] and Jalilian *et al.* (2017) [7] also mentioned that safflower is a dominant competitor as intercrop.

Higher values for area time equivalent ratio (ATER) were observed in safflower + chickpea (2:4) and safflower + lentil (2:4) intercropping systems during 2016-17 and 2017-18 indicating feasibility of these intercropping systems over other ones. The lowest ATER values were observed in safflower + wheat (1:3) intercropping system during both the years of study indicating negative relationship of the intercropping system.

Safflower in all intercropping systems was found to be aggressive except in safflower + sorghum intercropping systems during both the years. Safflower was more aggressive in safflower + wheat (1:3 or 2:4) intercropping system. Safflower + sorghum (1:3 and 2:4) intercropping system recorded lower values for aggressivity. Wasu *et al.* (2013) [13] also reported that when chickpea intercropped with safflower, the aggressivity of chickpea was least while safflower was more aggressive over chickpea due to more competition offered by safflower for nutrients, soil moisture and light. Similar trend was found during second year regarding aggressivity of safflower based intercropping systems**.**

## Conclusion

Safflower intercropped in chickpea/ lentil at 2:4 or 1:3 row ratios were shown positive relationship in respect of land equivalent ratio, competitive ratio, area time equivalent ratio and aggressivity.

**Table 1:** Land equivalent ratio (LER) and Competitive ratio (CR) of safflower based intercropping systems as influenced by different treatments (2016-17 and 2017-18)

| Treatments | Land equivalent ratio (LER) | | | | | | Competitive ratio (CR) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2016-17 | | | 2017-18 | | | 2016-17 | | 2017-18 | |
| | Safflower | Intercrop | Total | Safflower | Intercrop | Total | Safflower | Intercrop | Safflower | Intercrop |
| Safflower + Sorghum (1:3) | 0.216 | 0.698 | 0.914 | 0.218 | 0.705 | 0.923 | 0.930 | 1.075 | 0.926 | 1.080 |
| Safflower + Sorghum (2:4) | 0.300 | 0.640 | 0.940 | 0.302 | 0.647 | 0.949 | 0.939 | 1.065 | 0.934 | 1.071 |
| Safflower + Wheat (1:3) | 0.360 | 0.403 | 0.763 | 0.357 | 0.401 | 0.757 | 1.787 | 0.559 | 1.780 | 0.562 |
| Safflower + Wheat (2:4) | 0.560 | 0.388 | 0.948 | 0.555 | 0.386 | 0.941 | 1.443 | 0.693 | 1.438 | 0.695 |
| Safflower + Chickpea (1:3) | 0.298 | 0.683 | 0.980 | 0.295 | 0.694 | 0.989 | 1.308 | 0.765 | 1.276 | 0.784 |
| Safflower + Chickpea (2:4) | 0.409 | 0.627 | 1.036 | 0.406 | 0.639 | 1.045 | 1.306 | 0.766 | 1.270 | 0.787 |
| Safflower + Lentil(1:3) | 0.300 | 0.691 | 0.990 | 0.298 | 0.701 | 0.999 | 1.301 | 0.769 | 1.273 | 0.786 |
| Safflower + Lentil (2:4) | 0.411 | 0.635 | 1.045 | 0.413 | 0.644 | 1.056 | 1.295 | 0.772 | 1.281 | 0.781 |
| Safflower + Linseed (1:3) | 0.280 | 0.698 | 0.978 | 0.281 | 0.699 | 0.980 | 1.204 | 0.830 | 1.207 | 0.828 |
| Safflower + Linseed (2:4) | 0.380 | 0.640 | 1.019 | 0.381 | 0.642 | 1.023 | 1.186 | 0.843 | 1.188 | 0.842 |
| G. mean | 0.351 | 0.610 | 0.961 | 0.349 | 0.616 | 0.966 | 1.270 | 0.814 | 1.257 | 0.822 |

**Table 2:** Area time equivalent ratio (ATER) and Aggressivity (A) of safflower based intercropping systems as influenced by different treatments (2016-17 and 2017-18)

| Treatments | Area time equivalent ratio (ATER) | | | | | | Aggressivity (A) | |
|---|---|---|---|---|---|---|---|---|
| | 2016-17 | | | 2017-18 | | | 2016-17 | 2017-18 |
| | Safflower | Intercrop | Total | Safflower | Intercrop | Total | | |
| Safflower + Sorghum(1:3) | 0.216 | 0.615 | 0.832 | 0.218 | 0.652 | 0.870 | -0.0163 | -0.018 |
| Safflower + Sorghum (2:4) | 0.300 | 0.565 | 0.865 | 0.302 | 0.598 | 0.900 | -0.0098 | -0.011 |
| Safflower + Wheat (1:3) | 0.360 | 0.349 | 0.709 | 0.357 | 0.356 | 0.712 | 0.1586 | 0.156 |
| Safflower + Wheat (2:4) | 0.560 | 0.337 | 0.897 | 0.555 | 0.343 | 0.898 | 0.1720 | 0.169 |
| Safflower + Chickpea (1:3) | 0.298 | 0.562 | 0.860 | 0.295 | 0.575 | 0.870 | 0.0700 | 0.064 |
| Safflower + Chickpea (2:4) | 0.409 | 0.516 | 0.925 | 0.406 | 0.530 | 0.935 | 0.0479 | 0.043 |
| Safflower + Lentil(1:3) | 0.300 | 0.574 | 0.873 | 0.298 | 0.602 | 0.899 | 0.0693 | 0.064 |
| Safflower + Lentil (2:4) | 0.411 | 0.527 | 0.938 | 0.413 | 0.553 | 0.965 | 0.0468 | 0.045 |
| Safflower + Linseed (1:3) | 0.280 | 0.528 | 0.808 | 0.281 | 0.527 | 0.808 | 0.0475 | 0.048 |
| Safflower + Linseed (2:4) | 0.380 | 0.485 | 0.864 | 0.381 | 0.484 | 0.865 | 0.0298 | 0.030 |
| G. mean | 0.351 | 0.506 | 0.857 | 0.350 | 0.522 | 0.872 | 0.0616 | 0.060 |

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