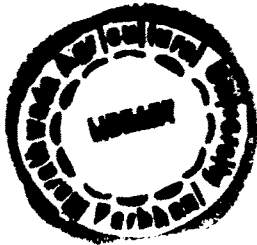


**PHYSIOLOGICAL ANALYSIS OF SAFFLOWER  
(*Carthamus tinctorius* L.) GENOTYPES**

BY

**PHAPAL AMAR PANDITRAO**  
B.Sc.(Agri.)

T4340



DISSERTATION

Submitted to

the Marathwada Agricultural University

in partial fulfilment of the

requirement for the Degree of

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IN

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DEPARTMENT OF AGRICULTURAL BOTANY  
MARATHWADA AGRICULTURAL UNIVERSITY  
PARBHANI (Maharashtra) INDIA

2002

**AFFECTIONATELY  
DEDICATED TO  
THE ARCHITECTS  
OF MY LIFE  
MY BELOVED PARENTS**

## CANDIDATE'S DECLARATION

*I hereby declare that this dissertation  
or part thereof, has not been  
previously submitted by  
me for a degree of  
any University*

Place : PARBHANI

Date : 27/12/2002

  
( A. P. PHAPAL )

**Dr. A.N. Gitte**

M.Sc. (Agri.), Ph.D.

Associate Professor,

Department of Agricultural Botany,

(Plant Physiology)

Marathwada Agricultural University,

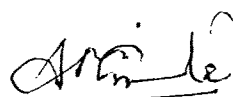
Parbhani - 431 402 (M.S.).

## **CERTIFICATE-I**

This is to certify that the dissertation entitled "PHYSIOLOGICAL ANALYSIS OF SAFFLOWER (*Carthamus tinctorius* L.) GENOTYPES" submitted by Shri. **PHAPAL AMAR BANDITRAO** to the Marathwada Agricultural University, Parbhani in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE** in the subject of **AGRICULTURAL BOTANY (Plant Physiology)** is record of original and bonafide research work carried out by him under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree. I also certify that the dissertation or part thereof has not been previously submitted for a degree of any university.

PARBHANI

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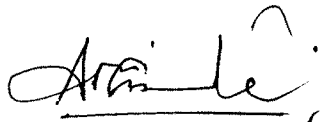
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Research Guide

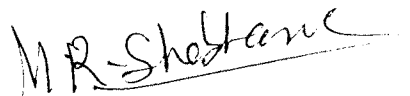
## CERTIFICATE-II

This is to certify that the dissertation entitled "PHYSIOLOGICAL ANALYSIS OF SAFFLOWER (*Carthamus tinctorius* L.) GENOTYPES" submitted by Shri. **PHAPAL AMAR PANDITRAO** to the Marathwada Agricultural University, Parbhani in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE** in the subject of **AGRICULTURAL BOTANY (Plant Physiology)** has been approved by the student's advisory committee after viva-voce examination in collaboration with the external examiner.

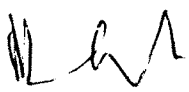
  
(Prof. M. H. Chavhan)  
External Examiner

  
( Dr. A.N. Gitte )  
Research Guide ✓

Advisory committee:

  
( Dr. M.R. Shobhane )

  
( Dr. R.K. Bhalerao )

  
**Associate Dean (P.G.)**  
College of Agriculture  
MAU, Parbhani.

  
( Dr. M.B. Misal )

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*"Winners don't do different things; but they do the things differently."*

*Emotions are not be adequately expressed in words because then emotions are transformed into mere formalities My acknowledgement are many more what I am expressing here .*

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**PARBHANI**

**Date : 27 / 12 / 2002**

*Phapal.*  
**( A. P. PHAPAL )**

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# INTRODUCTION

## Chapter-I

### INTRODUCTION

The oilseeds have been the back bone of agricultural economy of India from time immemorial. The role of oilseed crops in Indian economy and the importance of oil in Indian diet hardly need to emphasise. The edible oil industry is one of the most vibrant sectors of the Indian agricultural economy with annual turn over of Rs. 6000 crore.

Among oilseed crops, safflower is an important *rabi* oilseed crop in India. It is locally known as 'Karadi' and belongs to the family Compositae. Of the several species, *Carthamus tinctorius* L. is presently known to exist under cultivation. It is believed to be native to India, Afghanistan and Ethiopia.

The safflower plant is highly branched, herbaceous, thistle like annual, varying in height from 30 to 150 cm and each branch terminates in a flower. The inflorescence is broad flat or slightly curved and densely bristled owing to the presence of numerous floral bracts. The flowers are yellow to red, containing 20 to 100 individual florets each of which produces a seed.

The oilseed crops are chief sources of oils and fats in India which form valuable ingredients in human diet and industry. The per capita basic requirement of fats and oils per day as recommended by Indian Council of Medical Research is 30 g. The crop is now cultivated primarily for its seeds which yield oil, though at one time it used to be grown for the

extraction of a dye also. The oil content varies from 24 to 36 % depending on the variety, soil, climate and other conditions. The cold pressed oil is golden yellow and is used for culinary purposes or for making soap. The oil is very good for heart patient as it is rich in polyunsaturated fatty acids (about 75%) which are supposed to play an important role in reducing blood cholesterol level. The oil obtained by dry hot distillation is black and sticky and is used only for greasing well ropes and leather goods exposed to water. Safflower oil has good dyeing properties and is therefore, used in the manufacture of paints, varnishes and linoleum. The safflower tea is very good for diabetic patient.

The safflower seeds are edible and are eaten after roasting. Young seedlings of safflower are commonly used as green vegetable. Recently many products are prepared from its petals. The cake, particularly from decorticated seed is used as a concentrated cattle feed and that from undecorticated seed is used as a manure. The dried flowers are ground and used as a colouring agent in food (Chavan, 1961).

India holds a premier position in the global oilseeds scenario. India has 14 percent of world area under oilseed crops which accounts 8 per cent world's oilseed production (1999) (Hegde, 2002).

In India, area under oilseed crops was 14 per cent of the country's gross cropped area accounting for nearly 5 per cent of gross national product and 10 per cent of the value of all agricultural products (Hegde, 2000). India ranks first in the world in the production of safflower (2000). However, the productivity of safflower in country was very low i.e.

500 kg/ha during 1999-2000 (Anonymous, 2000). In India during 2000-2001, area under safflower was 4.74 lakh hectares with total output of 2.94 lakh tonnes (Anonymous 20002b).

During 1999-2000 total production from oilseeds was 20.872 million tonnes (Anonymous, 2002a). The oilseed production during 2000-2001 decreased to 17.395 million tonnes. Since 1994 there has been continuous increase in imports to meet consumer demand during 1999-2000, the import of refined and crude edible oil reached to 44.94 lakh tonnes (Anonymous, 2002b).

Most of the varieties of safflower have thick seed coat, low oil content and are late in maturity. In order to bridge the gap between demand and supply of present days, it is essential to increase production by bringing more area under oilseed crops as well as to raise their production potential. In India productivity of oilseeds is low because oilseed crops are grown on marginal and submarginal land as rainfed crop with no adoption of improved package of agronomical practices. Although safflower is a drought resistant crop, the average productivity per unit area is low and hence improvement is desirable.

The yield of safflower depends upon the number of capitula per plant, number of seeds per capitulum and seed size (Ashti et al, 1978)

It is therefore, essential to study physiological differences for various characters in the genotypes evolved at Marathwada Agricultural University, Parbhani (PBNS) and find out the yield limiting as well as desirable yield components in these genotypes.

The experiment, therefore, was taken with following objectives.

1. To study variability in growth and development of the safflower genotypes.
2. To study variability in seed yield and yield attributes of the safflower genotypes and pin point plant characteristics useful in productivity.

# REVIEW OF LITERATURE

## Chapter-II

### REVIEW OF LITERATURE

The work done on physiological analysis of safflower genotypes in past is reviewed in the following pages of this chapter under following heads.

1. Varietal growth differences
2. Variation in yield and yield components
3. Chemical analysis
4. Correlation studies

#### **2.1 Varietal growth differences**

##### **2.1.1 Plant height**

The variation in plant height between lines of safflower from same countries is well known but divergence between regions is still apparent.

Ashri *et al.* (1975) reported that average plant height of lines of safflower from Indian subcontinent was lowered as compared to Iran, Afghanistan and Turkey. However, Obeso (1975) found new safflower lines which were dwarf with 35 cm height but Deokar and Patil (1978) noted plant height of 16 cultivars of safflower ranging from 69 to 95.7 cm.

Jadhav (1975) reported that maximum increase in height of all varieties viz., 116-4-2, Tara, N-62-8 and No. 25 was during 54-85 days of crop growth. He further observed that the growth was almost stopped after 94 days. In the case of variety 116-4-2 it was observed that the

growth rate was slow at initial stage, subsequently it attained the maximum height during the later part of the growth as compared to the other varieties. However, variety Tara showed comparatively more height at initial stages but subsequently the difference became narrow.

Kamel *et al.* (1982) observed that by increasing spacing and nitrogen levels the plant height increased in safflower. Plant height varied according to region, environmental factors, genotypes and also the fertility status of soil.

### **2.1.2 Primary and secondary branches**

Primary and secondary branches are important yield contributing characters as they contribute towards the yield through the number of capitula per plant. Veeranna (1977) found that in safflower cv. A300 that secondary branches contributed 10.77 g and primary branches 10.04 g to seed yield per plant.

Mehta *et al.* (1979) similarly reported that in safflower contribution of primary branches over secondary branches was 4.74-21.5 per cent in 100-seed weight, 3.1 - 103.5 per cent in seed oil content and 0.59 - 20 per cent in seed protein.

Deokar and Patil (1978) found that number of primary branches per plant ranged from 10.6 to 15.1 (averaging to 13.2). The range for secondary branches was 7.5 - 35.1 (averaging to 21.2). The spread ranged from 44.6 to 51 cm (averaging to 48.1 cm). However, Rahman *et al.* (1978) found that fertilizer application of 40 lb N-30 lb P<sub>2</sub>O<sub>5</sub> - 30 lb K<sub>2</sub>O per hectare gave maximum branches per plant in safflower. Literature

reviewed in the preceding pages would indicate that in safflower there is a strange divergence in number of branches per plant.

### **2.1.3 Dry matter**

Difference in yield between varieties can partly be attributed to efficiency of conversion of biological yield into economical yield which in turn is related to sink capacity. Patil and Bangal (1977) attributed low sink capacity of some safflower strains to less number of seeds per capitulum and smaller seed size resulting into less utilization of dry matter for production of economic yield which was expressed by stored dry matter in leaves and stems.

### **2.1.4 Days to 50% flowering**

Ashri *et al.* (1975) reported extensive divergence for the length of duration from sowing to flowering between lines of safflower within same countries. Generally lines from Indian subcontinent were earlier. Able (1975) found that the sowing of safflower seeds between 15 November to 15 December at 2 higher altitudes lengthened the rosette stage.

### **2.1.6 Growth parameters**

Ramachandram and Rao (1980) observed that in safflower nitrogen application influenced AGR, RGR, LAD and dry matter accumulation in positive and highly significant manner. They found safflower cv. A-1 exceeded all other cvs. in dry matter accumulation, related growth components and yield by application of 60 kg N/ha. The initial increase was accompanied by progressive decrease after cessation of

flowering in AGR, LAI, LAD and after flower bud emergence in NAR. Further, Kamel *et al.* (1982) found somewhat parallel results showing increase in leaf area, plant height, dry weight, LAI of safflower with increasing nitrogen levels.

Pande and Nath (1990) studied safflower cultivars in Bihar. They found that total biomass increased until 150 DAS and then decreased. Net primary productivity was highest at 105 DAS in HOS 305 and 120 DAS in HOS 1788-1-3 and T-65. Leaf area ratio was highest at 75 DAS while NAR and RGR decreased steadily from 30 DAS.

Lakshamma (1996) studied five promising safflower hybrids (DSH 107, DSH 110, DSH 113, DSH 114 and DSH 116) developed at the Directorate of Oilseed Research, Hyderabad. He found that hybrids were superior to controls in terms of various growth parameters such as total dry matter, crop growth rate, relative growth rate, net assimilation rate and leaf area ratio. The hybrid DSH 113 was significantly superior to all other hybrids in yield and physiological parameters tested.

## **2.2 Variation in yield and yield components**

Mundel (1969) studied the performance of indigenous and exotic varieties of safflower both under rainfed and irrigated conditions. It was revealed that they performed well both under rainfed and irrigated conditions and the yields were in the range of 18.9 to 21.8 and 28.4 to 33.4 q/ha respectively. Variety Gilla-9 (from USA) gave higher yield than N 62-8.

Ramnath *et al.* (1974) reported that at Bellary under rainfed conditions safflower variety A300 gave the highest yield of 402 kg per hectare.

Patil and Jadhav (1977) studied the contribution from different capitula towards seed yield in safflower and they reported that secondary capitula had contributed maximum towards the seed yield because of their greater number. The varietal differences in yield were partly due to efficiency of variety to convert biological yield into economic yield and the probable reason they stated was the sink capacity of variety. They had further stated that capitulum number was not the only cause for yield, but seed size and seed number per capitulum also accounted for yield. The peculiar characters of the varieties were bigger seed size in N-62-8 while No. 25 had more seed number per capitulum as compared to 116-4-2 and Tara. The seed yield of T-13-3 was more because of its greater number of capitula per plant.

Jackson (1978) tested yield results of top 7 varieties of safflower for dryland and irrigated conditions and reported that cv. Rio gave the highest mean yield of 892 kg/ha for dryland and 1418 kg/ha for irrigated. In dryland trials, no variety consistently outyielded the commercial varieties Gill and Saffola G-27.

From the coordinated varietal trial conducted at Latur on 7 different safflower strains, it was found that H-4 gave maximum seed yield of 845 kg/ha followed G-1254 (Anonymous, 1983a).

Bajaj *et al.* (1991) recorded data on 8 yield components for 4 safflower genotypes grown during *rabi* 1996. Annegiri-1 gave the highest seed yield (7.25 g/plant).

Ghorpade *et al.* (1993) studied variability for 8 yield components in 98 germplasm accessions and 5 control varieties. Variability was high for seed yield, number of primary and secondary branches/plant and number of effective capitula. Seed yield was highest in GMU 398.

Hotbauer and Pehkan (1996) reviewed briefly recent production of safflower in the Czech Republic. In trials in 1994-96, 12 cultivars were compared (Spanish cultivars in 1996 only). The newly bred Czech cultivar TB-10 gave seed yields 30.2 - 72.9 per cent higher than all the foreign cultivars. The highest oil content was found in the Spanish cultivar SM 8 (44.1 %) and mother foreign cultivars. But these were low yielding because of susceptibility to *Botrytis Cinerea* and were not recommended for use in the Czech Republic.

Under rainfed conditions, considering the performance of different entries across five locations in respect of seed yield, none of the entries could surpass the national check A-1 (1149 kg/ha) although LASF 29 (1114 kg/ha) and JLSF 327 (1144 kg/ha) yielded almost equal to A-1. However, at Bhavanipatna, Bhilwara and Annegiri-1, some entries yielded significantly higher seed yield than A-1 (Anonymous, 1997-98).

Varietal trial with 21 genotypes conducted at Solapur during 1998-99 revealed that, on medium deep soil in normal plant density two

genotypes viz., GMU 1530 (280 g) and GMU 1572 (250 g) recorded higher seed yield than the local check Bhima (193 g) and national check A-1(200 g). Other genotypes viz., GMU 1517, GMU 1571 and IGW 6812 produced slightly higher yield than checks, whereas GMU 499, 285, 1514, 1632, 1654 recorded yields similar to that of national check A-1. Under higher plant density (P2) genotypes viz., GMU 3523 (150 g), GMU 6812 (175 g), GMU 1592 (160 g) recorded higher yields than checks (Anonymous, 1998-99).

Devani *et al.* (1999) carried out field studies at 2 sites in Argentina to compare crop yield and growth of 5 safflower hybrids (D1, D2, D3, D4 and D5) and 5 cultivars (S-137, Sironasia, S-296, CW-74 and S 541). Crop yields of all hybrids were higher (by 56-140 %) than that of CW-74 (the most common cv.) and D2 obtained the highest yield (2390 kg/ha).

Under medium soil and normal plant density conditions, significant differences were observed in respect of seed yield and biological yield, while other characters were non-significant. The genotype A-1 (1542 kg/ha) gave significantly higher yield over check Bhima (1234 kg/ha). In high density situation (P2), three genotypes viz., A-1 (728 kg/ha), JSI-106 (697 kg/ha) and DSH-129 (758 kg/ha) recorded higher seed yield, although they were at par with local check Bhima (672 kg/ha). These genotypes have better drought tolerance efficiency of 61.2, 62.7 and 57.2 per cent, respectively (Anonymous, 2000-01).

### 2.3 Chemical analysis

Bhardwaj and Singh (1988) observed in cotton, lower chlorophyll a/b ratio due to increase in chlorophyll 'b'. Relatively higher level of chlorophyll 'b' is indicative of higher PS-II activity. They also observed that the thick leaf possessed higher chlorophyll content and was relatively more thermostable. This trait (thick leaf) is desirable under tropical conditions.

According to Chopra and Mukhopaddhy (1991) the high values of relative water content and osmotic potential were reported to be of great significance for drought tolerance. On the contrary, low values of CSI and transpiration rate were considered useful for stress conditions.

Nagaraj (1994) studied 24 safflower genotypes grown during *rabi* 1991-92 at Solapur which were analysed for oil, protein and fatty acid composition. He found that, in general, safflower genotypes had low oil stability values (0.14 - 0.25) and high nutritional quality indices (7.7 - 10.3). BLY 652, HOS 305, 86-93-20 A, NIRA, JSF 1, CTV 196, CTV 102 and CTV 107 had high oil (more than 30 %) and linoleic acid levels (more than 75%).

Bharad *et al.* (1995) evaluated 14 safflower genotypes for their yield performance and physiological parameters in dryland situation. The genotype AKS-146 had recorded significantly highest yield (22.88 q/ha). This was attributed to high RWC (66.90 %), moderate stomatal conductance (0.40 cm/s), moderate leaf area (19.11 dm<sup>2</sup>) and high

chlorophyll content (1.78 mg/g). This genotype, therefore seems to be more suitable for rainfed conditions.

Rajarajeshwari (1995) observed that earliness, high relative water content and low CSI were associated with drought tolerance in cotton.

Regarding oil yield, under rainfed condition, average data of three locations indicated that only LASF 29 (396 kg/ha) could yield as much oil as national check A-1 (393 kg/ha). Under irrigated condition, averaged over three locations, NARI-12 (390 kg/ha), NARI-9 (388 kg/ha), AKS-152 (316 kg/ha), JLSF-327 (312 kg/ha), PBNS-10 (306 kg/ha) and NARI-10 (303 kg/ha) recorded higher oil yield than A-1 (297 kg/ha). At national level, averaged over six locations, only NARI 12 (377 kg/ha) could give higher oil yield than A-1 (345 kg/ha) mainly due to higher oil content (Anonymous, 1997-98).

Mirza *et al.* (1998) studied 19 different genotypes of safflower which showed large variation in oil and protein content of seeds. Turk 4 and Iran 7 seeds contained the highest content of oil and protein.

#### **2.4 Correlation studies**

Correlation coefficients have been worked out to find out the association of different growth and yield attributing characters in safflower.

Khidir (1974) showed highly significant and positive correlation amongst number of seeds per head, head width and seed oil content. The low seed weight was negatively correlated with the number of seeds per head and plant height at maturity in safflower.

Ashri *et al.* (1974) observed highly significant and positive correlation between number of seeds per plant and the seed yield per plant in safflower, but number of seeds had negative but nonsignificant correlation with oil content. Yield per plant did not show correlation with season length or oil content.

Ashri *et al.* (1975) did not find significant correlation between length of growth period in safflower from sowing to flowering and yield and yield attributes. Similarly, the oil content and plant height were not correlated with each other.

Ashri (1975) correlated seed yield per plant positively with number of heads per plant, but not with days to flowering in safflower.

Abel (1976) studied different cultivars of safflower viz., Dart, Frio, Rio, 12289, US 10, 14154-30 and PI 209, PI 285 (short Russian) and observed that the differences in days to flower and duration of flowering of these varieties were significantly correlated with seed yield, but correlation were low. Neither flowering time nor duration affected the oil content of seeds.

Mathur *et al.* (1976) found positive association of seed yield per plant with plant height, head diameter and seeds per head and negative correlation with number of primary branches of safflower.

Rao and Ramachandram (1977) found that capsule number per plant and capsule weight per plant had positive correlation with yield per plant. Seed size had little effect on yield while seed number exerted a positive influence. The proportion of hull expressed in per cent of whole

seed revealed a highly significant and inverse relationship with oil content and was mainly responsible for observed variability in oil content in the material. Although negative association indicated between seed size and oil content, it might be due to the indirect effect of hull content and due to direct effect of seed size. Correlation between yield per plant and its major components, viz., number of capsules and capsules weight was negligible or low.

Solanki *et al.* (1979) observed positive correlation of the seed yield per plant with number of seed per head, number of heads per plant and 100-seed weight in safflower.

Thombre and Joshi (1981) stated that in safflower, branches per plant, number of days to first flower opening and seeds per capitulum, showed positive and highly significant correlation with the yield per plant. Path coefficient analysis indicated that number of seeds per capitulum was major yield attributing character, whereas the number of branches per plant increased the seed yield through the number of seeds per capitulum.

Dhopte and Lall (1981) correlated the seed yield positively with chlorophyll content of bracts and their dry matter per capitulum in safflower.

Kamel *et al.* (1982) found significant positive correlation between the growth attributes and both seed yield and oil content due to treatment of nitrogen application in safflower.

Lakha *et al.* (1992) after studying correlation in safflower supported the recommendation that the number of secondary branches,

number of capitula, number of seeds per capitulum and test weight are suitable selection criteria for improvement of seed yield in safflower.

Reddy *et al.* (1992) gave information on yield correlations from data on 8 yield components in 50 genotypes during 1990-91. The number of capitula per plant, seeds per capitulum and 100-seed weight were major contributors to yield.

Hoque *et al.* (1997) studied correlations and path coefficients in twenty genotypes of safflower at the Oilseed Research Centre, Bangladesh Agricultural Research Institute, Gazipur during *rabi* (winter) 1993-94. Harvest index, branches per plant, seeds per capitulum and seed weight showed highly significant positive correlations with seed yield per plant. Path coefficient analysis revealed that seed weight, seeds per capitulum and days to maturity were directly related to seed yield.

# **MATERIALS AND METHODS**

## Chapter-III

### MATERIALS AND METHODS

The details of materials used and methods adopted for conducting present investigation are described in this chapter.

#### 3.1 Experimental site and soil

The experiment for present investigation was conducted in the field of Department of Agricultural Botany, College of Agriculture, M.A.U., Parbhani, during *rabi* season 2001-02. The soil was medium black with moderate moisture retention capacity. The land having uniform topography was used to conduct the experiment.

#### 3.2 Climate and weather conditions

Parbhani falls in the subtropical region geographically on latitude 19° 16' North and longitude 76° 47' east at 409 meters above sea level. The mean annual rainfall is 918 mm. In order to get an idea about climate conditions during the period of investigation that is, from October, 2001 to march 2002, the data on weekly averages of weather conditions viz, maximum and minimum temperatures in centigrade, humidity in morning and evening hours in per cent, were obtained from meteorological observatory, M.A.U., Parbhani and are presented in Table 1.

The rainfall (mm), mean maximum and minimum temperature, (°C) and humidity in percentage per week during the period of investigation are given in Fig. 1.

Table 1. Meteorological data from June to December 2001 recorded at Meteorological Observatory, Marathwada Agricultural University, Parbhani.

MW	Rain-fall (mm)	Rainy days	Temp. °C		Humidity (%)		Evap-oration (mm/day)	BSS (hr/day)	Wind velocity (kmph)
			Max.	Min.	AM	PM			
<b>June</b>									
23	5.7	1	36.3	24.6	77	43	7.3	6.8	7.1
24	92.1	4	30.5	22.5	86	61	4.3	4.3	7.7
25	2.0	0	33.7	23.5	76	46	7.0	7.0	10.3
26	1.5	0	35.0	24.0	73	42	9.3	8.4	12.3
<b>July</b>									
27	1.0	0	33.1	23.4	72	50	7.0	5.5	9.2
28	14.4	2	32.0	23.2	76	56	5.3	2.9	8.2
29	16.2	1	30.6	22.6	75	57	4.5	1.6	8.4
30	63.2	3	31.6	22.6	80	59	4.3	5.5	4.7
31	93.7	3	29.8	22.6	84	69	3.3	2.3	4.6
<b>August</b>									
32	166.4	6	27.9	22.2	88	76	2.5	2.3	6.6
33	96.2	6	29.1	21.6	85	71	2.5	2.1	5.8
34	37.4	4	27.6	21.9	83	75	2.2	1.6	5.0
35	0.0	0	30.8	21.1	75	57	3.8	8.0	7.1
<b>Sept</b>									
36	20.6	1	21.9	22.0	81	56	4.2	6.8	4.3
37	0.0	0	33.1	22.6	77	54	5.0	8.3	3.6
38	22.5	1	33.1	21.7	78	63	4.0	7.2	3.6
39	15.2	1	34.4	21.7	80	51	5.4	8.6	4.2
<b>Oct</b>									
40	322.4	4	30.4	22.7	80	72	2.6	5.3	6.4
41	59.0	2	31.3	21.8	90	60	2.3	7.2	4.1
42	0.0	0	32.1	20.0	74	52	4.6	7.8	4.6
43	0.0	0	32.7	14.1	71	35	4.0	10.9	3.3
44	0.0	0	32.7	14.2	71	34	4.2	10.9	3.3
<b>Nov</b>									
45	0.0	0	32.3	15.5	68	35	4.0	10.6	4.5
46	0.0	0	31.8	14.3	66	37	4.0	10.5	3.7
47	0.0	0	31.5	13.2	68	45	3.6	10.4	2.6
48	0.0	0	29.4	11.0	66	28	3.5	10.4	3.3
<b>Dec</b>									
49	0.0	0	30.9	9.4	69	25	3.4	10.6	1.7
50	0.0	0	31.4	10.9	80	28	3.1	10.6	2.2
51	0.0	0	29.2	9.0	69	28	3.9	10.4	3.8
52	0.0	0	28.9	9.8	7.9	31	3.7	9.9	2.8

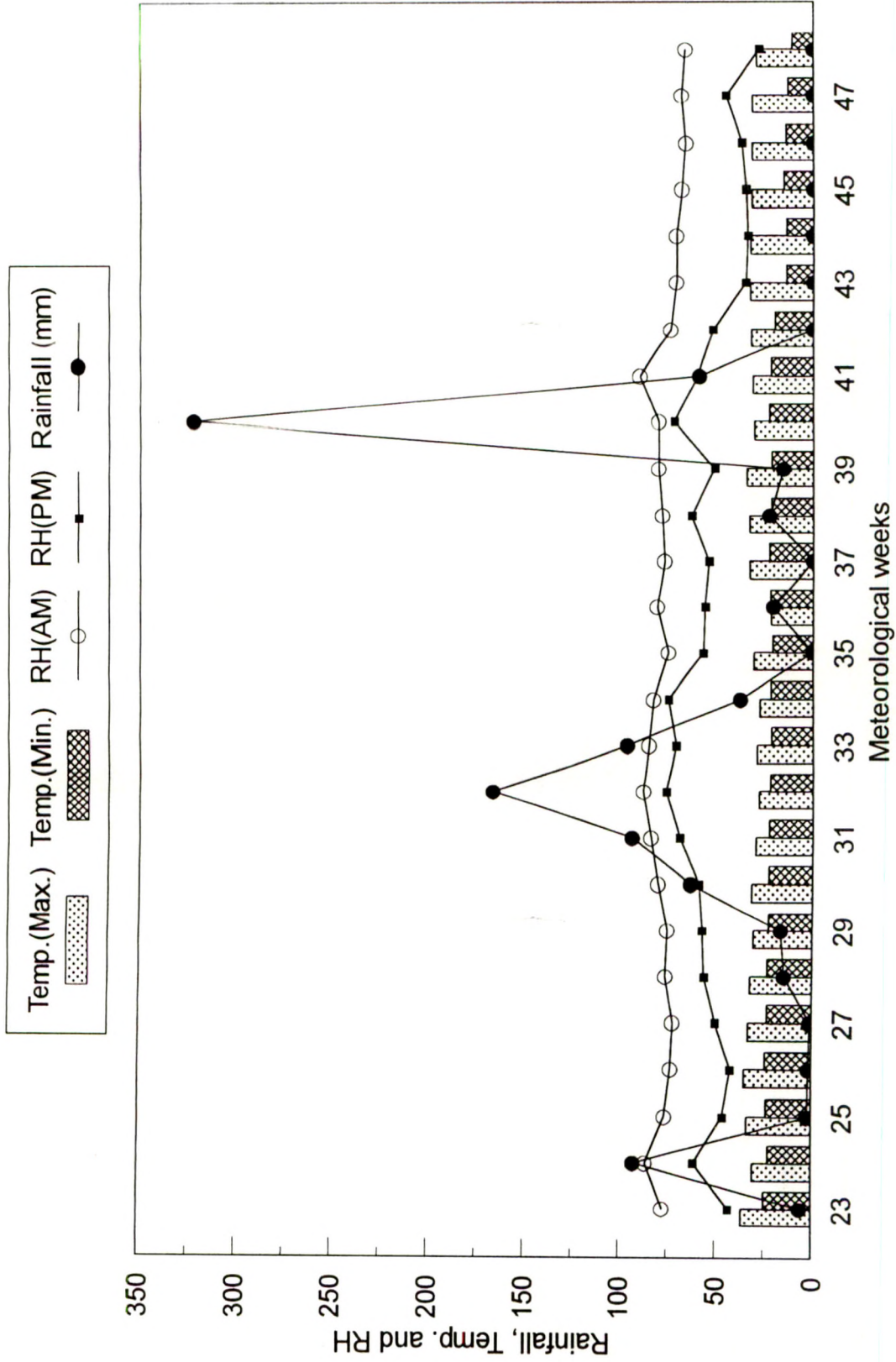


Fig. 1. Weekly weather data for the year 2001-2002 at Parbhani

### **3.3 Experimental details**

#### **3.3.1 Details of layout**

The experiment entitled “Physiological analysis of safflower (*Carthamus tinctorius* L.) genotypes” was undertaken during *rabi* season of 2001-02.

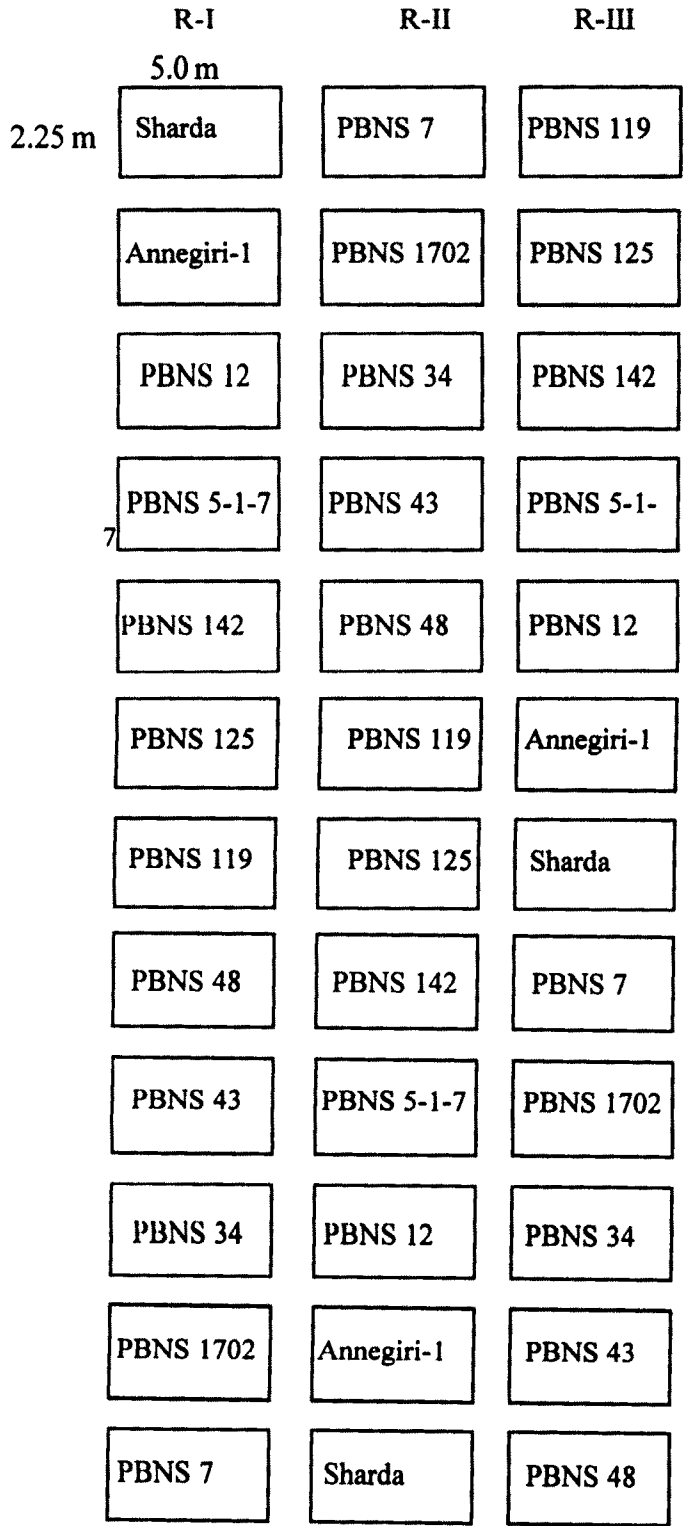
1. Experimental Design : Randomised Block Design
2. Number of Replications : Three
3. Treatments : Twelve (12)

PBNS 7, PBNS 1702, PBNS 34, PBNS 43, PBNS 48, PBNS 119, PBNS 125, PBNS 142, PBNS 5-1-7, PBNS 12, Annegiri-1, Sharda

4. Number of plot : Thirty six
5. Plot size : a) Gross plot size : 5.0 m x 2.25 m  
b) Net plot size : 4.60 m x 1.35 m
6. Spacing : Row to row – 45 cm  
Plant to plant – 20 cm
7. Fertilizer : 60:40:20 (NPK) kg/ha
8. Sowing method : Dibbling
9. Date of sowing : 19/10/2001

#### **3.3.2 Treatment details**

The twelve safflower cultivars viz. PBNS 7, PBNS 1702, PBNS 34, PBNS 43, PBNS 48, PBNS 119, PBNS 125, PBNS 142, PBNS 5-1-7, PBNS 12, Annegiri-1 and Sharda were included as treatments. The latter two were treated as checks.



Gross plot size : 5.0 m x 2.25 m  
 Net plot size : 4.60 m x 1.80 m

Fig. 1. PLAN OF LAYOUT

The layout of the experiment was laid out in the field as shown in Fig. 1. The fertilizer dose of 60:40:20 kg NPK per hectare was applied in the form of urea and single super phosphate following broadcasting method.

The allotment of treatments was done randomly in 36 plots.

### **3.3.3 Seeds and sowing**

The seeds of the twelve genotypes of safflower were obtained from All India Co-ordinated Research Project on Oilseeds (Safflower), Marathwada Agricultural University, Parbhani. Sowing was done on 19th October, 2001 by dibbling method.

### **3.3.4 Gap filling and thinning**

More than 90 per cent germination was observed during 5 to 7 days after sowing in almost all plots. Thinning and gap filling was done when seedlings achieved height of 5 to 7 cm to achieve uniform plant population.

### **3.3.5 Cultural operations**

Two hand weedings were carried out on 20th November, 2001 and 4th December, 2001. Hoeing was undertaken on 10th November 2001. Three protective irrigations were given.

### **3.3.6 Plant protection measures**

In order to protect crop against attack of aphids and jassids, Roger 0.1 per cent was sprayed twice while for controlling root rot drenching of copper oxychloride was carried out at the rate of 0.2 per cent.

### 3.3.7 Sampling

For the purpose of dry matter accumulation studies, three plants from each plot were selected randomly at each observation. The plants were uprooted and roots were removed. The above ground portion of the plant was divided into leaves, stem and fruiting part. These were separated and dried in oven and dry weights were recorded.

### 3.4 Biometric observations

Three plants from each plot were selected and labelled. These plants were used for taking all morphological observations at 15 days interval and first observation was taken 30 days after sowing. The list of characters studied is given in Table 2, 3, 4 and 5.

Table 2. List of biometric observations and relative water content

Sr. No.	Name of observation	Number of Observations	Days after sowing
1.	Plant height (cm)	5	30,45,60,75,90
2.	No. of primary branches per plant	5	30,45,60,75,90
3.	No. of secondary branches per plant	5	30,45,60,75,90
4.	Days to first flower opening	1	-
5.	Days to 50% flowering	1	-
6.	Number of leaves per plant	5	30,45,60,75,90
7.	Leaf area per plant (cm <sup>2</sup> )	5	30,45,60,75,90
8.	Leaf dry weight per plant (g)	5	30,45,60,75,90
9.	Stem dry weight per plant (g)	5	30,45,60,75,90
10.	Total dry weight per plant (g)	5	30,45,60,75,90
11.	Relative water content (%)	1	-

Table 3 : List of growth and yield attributing parameters

Sr. No.	Parameters studied	No. of stages at which parameters are studied	Days after sowing
1.	Absolute growth rate (mg/day/plant)	4	31-45,46-60,61-75, 76-90
2.	Relative growth rate (mg/g/day)	4	31-45,46-60,61-75,76-90
3.	Net assimilation rate (mg/cm <sup>2</sup> /day)	4	31-45,46-60,61-75,76-90
4.	Leaf area index (LAI)	5	30,45,60,75,90

Table 4 : List of post harvest observations recorded.

Sr. No.	Name of observation recorded	No. of observation
1.	Number of capitula per plant	1
2.	Number of seeds per capitulum	1
3.	100-seed weight (g)	1
4.	Seed yield per plant (g)	1
5.	Seed yield per ha (kg)	1
6.	Total biological yield (kg/ha)	1
7.	Harvest index (%)	1
8.	Volume weight (g/l)	1

Table 5 : List of observations recorded for chemical analysis

Sr. No.	Name of observation recorded	No. of observation
1.	Chlorophyll 'a' and 'b' (mg/g)	1
2.	Total chlorophyll (mg/g)	1
3.	Chlorophyll stability index (CSI)	1
4.	Seed oil content (%)	1

#### 3.4.1 Plant height (cm)

The observation on plant height in cm was recorded at 15 days interval from the base of the plant to top of the main stem.

#### 3.4.2 Number of branches

Number of primary and secondary branches were counted on the observation plants in the field and recorded at 15 days interval.

#### 3.4.3 Days to first flower opening

Days to first flower opening and days on which 50 per cent population of plot flowered were recorded from each plot.

#### 3.4.4 Number of leaves

The number of leaves produced per plant were recorded at 15 days interval.

#### 3.4.5 Leaf area per plant (cm<sup>2</sup>)

Leaf area was calculated on dry weight basis. Five leaf punches were taken from three selected plants from each plot. Diameter of punches was measured and area was calculated. Dry weight of punches and leaves was recorded. Total leaf area was calculated.

#### **3.4.6 Leaf dry weight per plant (g)**

All the leaves were kept for oven drying at 80°C for two days. The leaf dry weight was recorded as such.

#### **3.4.7 Stem dry weight per plant (g)**

The stem dry weight was recorded after complete drying in oven at 80°C for two days till the constant weight was reached.

#### **3.4.8 Total dry weight (g)**

The total dry weight of plant was obtained by addition of leaf dry weight and stem dry weight.

#### **3.4.9 Relative water content (%)**

The method of estimation of relative water content was given by Barss and Weatherley (1962) is explained below.

A leaf that is physiologically functional (third from top) is selected for RWC estimation. The fresh weight of leaf samples is immediately recorded. These leaf samples kept floating on water under diffused light to get turgid weight for 4-6 hrs depending upon the degree of imbibition. Finally, the same leaf samples were kept in an oven at 75°C for assessing dry weight and the values of RWC are calculated by using following formula.

$$\text{RWC (\%)} = \frac{\text{Fresh weight (W}_f\text{) - dry weight (W}_d\text{)}}{\text{Turgid weight (W}_t\text{) - Dry weight (W}_d\text{)}}$$

### 3.5 Growth analysis

#### 3.5.1 Absolute growth rate (AGR)

AGR was calculated as per the method of West et al. (1926) and expressed in mg/day.

$$\text{AGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

$W_2$  and  $W_1$  are total dry weights at time  $t_2$  and  $t_1$  respectively.

#### 3.5.2 Relative growth rate (RGR)

RGR was calculated as per formula of Blackman (1919) and expressed in mg/g/day

$$\text{RGR} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where,

$W_2$  and  $W_1$  are total dry weights at time  $t_2$  and  $t_1$  respectively.

#### 3.5.3 Net assimilation rate (NAR)

NAR was calculated by using formula of Gregory (1917) and expressed in mg/cm<sup>2</sup>/day

$$\text{NAR} = \frac{\text{Log}_e A_2 - \text{Log}_e A_1}{A_2 - A_1} \times \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

$A_1$  and  $A_2$  are the leaf areas at time  $t_1$  and  $t_2$  respectively and  $W_1$  and  $W_2$  are dry weights of plant at time  $t_1$  and  $t_2$  respectively.

### **3.5.4 Leaf area index (LAI)**

LAI was calculated by using formula developed by Watson (1947).

$$\text{LAI} = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Area occupied by plant (cm}^2\text{)}}$$

## **3.6 Post harvest observations**

### **3.6.1 Number of capitula per plant**

Number of capitula per plant were recorded at the time of harvesting.

### **3.6.2 Number of seeds per capsule**

Number of seeds per capsule were calculated at the time of harvesting.

### **3.6.3 Hundred seed weight (g)**

The hundred seeds were collected at random from each treatment and weights of seeds were recorded in grams.

### **3.6.4 Seed yield per plant (g)**

Seed yield per plant was worked out from the total yield harvested from selected five plants from each plot.

### **3.6.5 Seed yield per hectare (kg)**

Seed yield per hectare was worked out from the total yield harvested.

### **3.6.6 Total biological yield (kg/ha)**

The total dry weight of a plant was recorded at harvest and expressed in kg/ha.

### 3.6.7 Harvest index (%)

Harvest index indicated the yielding efficiency of a crop to produce grain yield per unit of total biological yield. Harvest index was worked out by the formula given by Donald and Hamblin (1976).

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

### 3.6.8 Volume weight of seeds (g/l)

Fill the seeds in a measuring cylinder or a beaker of one litre capacity and find out the weight of litre of seeds. If the quantity of seed is less, use 500 or 100 ml measuring cylinder or beaker and express the volume weight in grams per litre.

## 3.7 Chemical analysis

### 3.7.1 Chlorophyll content (mg/g)

Extraction of pigments was done in DMSO (Dimethyl sulphoxide) according to the method of Hiscox and Israelstam (1979). Two fresh leaf discs weighing 500 mg were placed in 10 ml of the extractant and were held for 2 hr at 60°C. The supernatant was used for estimation of pigments. Absorbance was recorded at 645 and 663 nm on spectronic 20. The amounts of chlorophyll were calculated using Arnon's (1949) formulae:

$$\text{Chlorophyll 'a'} = (12.7 \times A_{663}) - (2.69 \times A_{645}) \times \frac{V}{1000 \times W}$$

$$\text{Chlorophyll 'b'} = (22.9 \times A_{645}) - (4.68 \times A_{663}) \times \frac{V}{1000 \times W}$$

$$\text{Total chlorophyll} = (22.2 \times A_{645}) + (8.02 \times A_{663}) \times \frac{V}{1000 \times W}$$

Where,

V = Final volume

W = Fresh weight of sample taken (g)

The unit of chlorophyll content is mg/g of leaves.

### **3.7.2 Chlorophyll stability index (CSI)**

The chlorophyll stability index was computed by using the method given by Dhopte and Livera (1989). The difference in two readings on absorbance (reading without heating and reading after heating at 50°C control) is defined as chlorophyll stability index.

### **3.7.3 Oil content in seeds (%)**

Oil content in seeds was estimated in per cent by using soxhlet method. Three gram sample was taken for oil estimation.

### **3.8 Statistical analysis**

In order to evaluate the significance of differences occurring from treatment to treatment, the data were statistically analyzed to find out the levels of significance as per the method advocated by Panse and Sukhatme (1967). Critical differences were calculated at 5 per cent level of probability.

### **3.9 Correlation studies**

Correlation coefficient (r) values were compared between seed yield per plant (g) and various growth and yield contributing characters as per procedure illustrated by Snedecor and Cochran (1968).

The value of (r) was computed from the error lines of the corresponding co-variance table as follows.

$$r = \frac{\Sigma xy}{\sqrt{(\Sigma x^2) (\Sigma y^2)}}$$

Where,

r = Correlation coefficient

y = dependent variable (yield)

xy = correlation cross product of independent and dependent variables

All correlations were compared with table value at 5 per cent and 1 per cent.

# EXPERIMENTAL FINDINGS

## **Chapter-IV**

### **EXPERIMENTAL FINDINGS**

The results obtained in the present investigation are presented in this chapter.

#### **4.1 Biometric observations**

##### **4.1.1 Plant height (cm)**

The data on mean plant height of safflower genotypes at different stages of growth are presented in Table 6.

The data revealed that the plant height significantly differed at all the stages of growth.

The height in safflower genotypes increased rapidly up to 60 days and slowed down thereafter.

The genotype PBNS-125 was significantly superior to rest of the genotypes in height at all the stages of growth except genotype PBNS-119 at all the stages of growth, PBNS 5-1-7 at 45, 60, 90 and also PBNS 43 at 45 DAS.

##### **4.1.2 Number of primary branches per plant**

The data on mean number of primary branches per plant in safflower genotypes at different stages of growth are presented in Table 7.

The data showed that the number of primary branches per plant increased up to 90 DAS.

The genotype PBNS 125 recorded significantly more number of primary branches at all stages of growth than all other genotypes except PBNS 1702 at 30, 45 and 90 DAS and the genotypes PBNS 43 and PBNS 5-1-7 at 30 DAS.

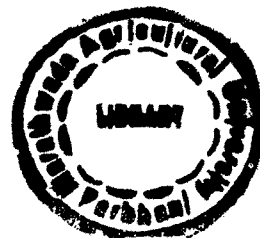
Table 6. Mean plant height (cm) at various growth stages

Sr. No.	Treatment	Days after sowing				
		30	45	60	75	90
1	PBNS 7	22.20	37.21	50.57	62.54	70.35
2	PBNS 1702	25.23	40.41	55.37	60.66	68.39
3	PBNS 34	20.66	35.67	48.13	65.35	73.61
4	PBNS 43	27.61	42.62	58.69	69.31	76.60
5	PBNS 48	26.30	41.38	56.31	67.62	75.36
6	PBNS 119	31.22	45.00	62.33	72.72	80.67
7	PBNS 125	32.69	47.80	65.22	75.14	83.37
8	PBNS 142	24.28	39.31	53.67	64.31	72.34
9	PBNS 5-1-7	29.31	43.32	60.97	71.10	79.38
10	PBNS 12	23.68	38.67	52.11	63.35	71.67
11	Annegiri-1	21.35	36.61	49.34	61.67	69.31
12	Sharda	20.51	35.10	47.58	60.35	68.33
	SE $\pm$	0.953	2.100	1.806	1.309	1.576
	CD at 5%	2.791	6.150	5.290	3.836	4.616

Table 7. Mean number of primary branches per plant at various growth stages

Sr. No.	Treatment	Days after sowing				
		30	45	60	75	90
1	PBNS 7	4.90	5.08	6.37	8.01	9.13
2	PBNS 1702	5.32	5.89	7.58	8.93	10.42
3	PBNS 34	5.20	5.53	7.01	8.26	9.68
4	PBNS 43	5.28	5.81	7.49	8.81	10.12
5	PBNS 48	5.10	5.41	6.92	8.91	9.67
6	PBNS 119	4.89	5.00	6.64	8.31	8.90
7	PBNS 125	5.42	5.98	8.00	9.51	10.52
8	PBNS 142	5.00	5.33	6.74	8.11	9.57
9	PBNS 5-1-7	5.26	5.60	7.34	8.34	9.92
10	PBNS 12	4.94	5.23	6.24	8.05	9.26
11	Annegiri-1	4.86	4.98	6.12	7.86	8.88
12	Sharda	4.48	4.86	6.00	7.35	8.72
	SE $\pm$	0.059	0.042	0.034	0.041	0.061
	CD at 5%	0.174	0.125	0.100	0.120	0.179

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#### **4.1.3 Number of secondary branches**

The data on mean number of secondary branches per plant in safflower genotypes at different stages are presented in Table 8.

The data indicated that the number of secondary branches increased up to 90 DAS.

The differences in the number of secondary branches per plant were significant except at 30 DAS. The genotype PBNS 125 was significantly superior in the number of secondary branches per plant to rest of the genotypes. However, it was at par with the genotype PBNS 1702 at 45, 60, 75 and 90 DAS, with PBNS 34, PBNS 43 and PBNS 5-1-7 at 45, 60 and 75 DAS, with PBNS 48 at 45 and 60 DAS, with PBNS 119 at 45 DAS, with PBNS 142 at 45, 75 DAS and with PBNS 12 at 75 DAS.

#### **4.1.4 Days to first flower opening and 50% flowering**

The data on mean number of days to first flower opening and 50% flowering in safflower genotypes are presented in Table 9.

The data exhibited significant differences. It was found that the genotype PBNS 34 was significantly earlier in respect of days to first flower and to 50% flowering than rest of the genotypes except PBNS 7. It was also at par with Sharda for days to first flower and with Annegiri-1 for days to 50% flowering.

#### **4.1.5 Number of leaves per plant**

The data on mean number of leaves per plant in safflower genotypes at different stages are presented in Table 10.

Table 8. Mean number of secondary branches per plant at various growth stages

Sr. No.	Treatment	Days after sowing				
		30	45	60	75	90
1	PBNS 7	3.55	6.09	10.16	13.21	14.97
2	PBNS 1702	3.61	6.70	10.75	14.34	17.37
3	PBNS 34	3.64	6.50	10.47	13.85	16.28
4	PBNS 43	3.69	6.64	10.60	14.18	17.02
5	PBNS 48	3.62	6.42	10.32	13.28	16.05
6	PBNS 119	3.54	6.28	10.08	12.99	14.05
7	PBNS 125	3.80	6.75	10.80	14.62	17.98
8	PBNS 142	3.60	6.30	10.27	14.06	15.91
9	PBNS 5-1-7	3.67	6.58	10.52	14.04	16.80
10	PBNS 12	3.57	6.14	10.21	14.20	15.48
11	Annegiri-1	3.53	5.98	10.02	12.42	13.96
12	Sharda	3.51	5.92	9.95	12.27	13.84
	SE $\pm$	0.130	0.172	0.166	0.352	0.218
	CD at 5%	NS	0.503	0.488	1.032	0.638

Table 9. Mean days to first flower opening and 50% flowering for various genotypes

Sr. No.	Treatment	Days to first flower	Days to 50% flowering
1	PBNS 7	81.33	88.33
2	PBNS 1702	83.33	90.33
3	PBNS 34	79.33	86.33
4	PBNS 43	83.00	91.00
5	PBNS 48	83.66	91.33
6	PBNS 119	84.33	91.66
7	PBNS 125	87.00	95.00
8	PBNS 142	85.00	92.66
9	PBNS 5-1-7	86.33	94.33
10	PBNS 12	85.33	93.00
11	Annegiri-1	85.66	93.33
12	Sharda	80.33	87.33
	SE $\pm$	0.856	0.779
	CD at 5%	2.509	2.278

Table 10. Mean number of leaves per plant at various growth stages

Sr. No.	Treatment	Days after sowing				
		30	45	60	75	90
1	PBNS 7	7.40	14.98	23.46	152.10	205.57
2	PBNS 1702	8.58	17.48	26.63	173.32	302.25
3	PBNS 34	7.95	16.10	25.23	165.64	275.77
4	PBNS 43	8.40	16.46	25.69	167.40	292.24
5	PBNS 48	7.90	15.75	25.07	159.62	261.22
6	PBNS 119	7.30	14.93	21.90	151.28	200.14
7	PBNS 125	8.85	18.61	32.18	179.34	310.48
8	PBNS 142	7.80	15.73	24.27	159.05	253.44
9	PBNS 5-1-7	8.10	16.23	25.36	171.55	283.32
10	PBNS 12	7.68	15.08	23.57	158.42	249.89
11	Annegiri-1	7.00	14.37	21.57	145.31	190.67
12	Sharda	6.90	13.00	21.34	144.53	182.38
	SE $\pm$	0.336	0.520	1.777	2.405	2.049
	CD at 5%	0.986	1.525	5.205	7.044	6.002

The data showed that, in general, the number of leaves per plant increased up to 90 DAS while the rate of increase was high from 60 to 75 DAS.

The genotype PBNS 125 was significantly superior in the number of leaves per plant over all other genotypes at all stages except PBNS 1702 at 30, 45 and 75 DAS and PBNS 48 and PBNS 5-1-7 at 30 DAS.

#### **4.1.6 Leaf area (cm<sup>2</sup>)**

The data on mean leaf area of safflower genotypes at different stages of growth are presented in Table 11.

The data showed that the mean leaf area per plant of safflower genotypes increased continuously from 30 to 90 DAS.

The genotypes differed significantly in leaf area per plant at all stages of growth. The genotype PBNS 125 was significantly superior in respect of mean leaf area over all other genotypes at all stages of growth except PBNS 1702 at all stages of growth, PBNS-43 at 45, 60, 75 and 90 DAS and with PBNS-34 and PBNS 5-1-7 at 45 DAS.

#### **4.1.7 Leaf dry weight (g)**

The data on mean leaf dry weight per plant of safflower genotypes at different stages of growth are presented in Table 12.

The data revealed that the dry weight of leaves per plant was increased progressively from 30 to 90 DAS.

The genotypes differed significantly in leaf dry weight at all stages of growth. The genotype PBNS 125 was significantly superior in

Table 11. Mean leaf area (cm<sup>2</sup>) per plant at various growth stages

Sr. No.	Treatment	Days after sowing				
		30	45	60	75	90
1	PBNS 7	102.23	287.92	500.65	825.67	1041.8
2	PBNS 1702	162.10	361.58	578.86	876.16	1116.2
3	PBNS 34	132.37	351.22	528.37	852.81	1078.9
4	PBNS 43	154.39	356.10	572.12	868.14	1110.5
5	PBNS 48	121.12	345.43	516.99	841.93	1070.0
6	PBNS 119	101.14	282.40	494.28	819.91	1029.9
7	PBNS 125	165.62	365.56	584.75	883.26	1121.9
8	PBNS 142	109.74	318.17	510.54	835.53	1058.8
9	PBNS 5-1-7	143.34	354.97	553.24	860.19	1090.1
10	PBNS 12	105.34	299.78	505.16	831.75	1049.9
11	Annegiri-1	100.01	277.12	488.32	814.34	1018.3
12	Sharda	99.62	273.69	481.92	808.44	1007.7
	SE ±	2.677	5.158	6.054	6.372	7.605
	CD at 5%	7.841	15.107	17.731	18.661	22.273

Table 12. Mean leaf dry weight (g) per plant at various growth stages

Sr. No.	Treatment	Days after sowing				
		30	45	60	75	90
1	PBNS 7	0.71	1.92	4.96	9.08	11.68
2	PBNS 1702	1.01	2.49	5.84	10.01	12.80
3	PBNS 34	0.87	2.27	5.54	9.60	12.21
4	PBNS 43	0.98	2.42	5.76	9.89	12.69
5	PBNS 48	0.81	2.20	5.41	9.41	12.08
6	PBNS 119	0.69	1.86	4.78	8.92	11.52
7	PBNS 125	1.09	2.72	5.98	10.10	12.91
8	PBNS 142	0.77	2.02	5.29	9.29	11.98
9	PBNS 5-1-7	0.92	2.31	5.65	9.78	12.50
10	PBNS 12	0.73	1.97	5.07	9.15	11.80
11	Annegiri-1	0.66	1.83	4.70	8.85	11.43
12	Sharda	0.65	1.80	4.60	8.78	11.32
	SE $\pm$	0.040	0.041	0.067	0.108	0.302
	CD at 5%	0.119	0.120	0.196	0.318	0.885

leaf dry weight over rest of the genotypes at all stages of growth except PBNS 1702 at 30, 60, 75 and 90 DAS, PBNS 43 at 30, 75 and 90 DAS and also PBNS 34, PBNS 48 and PBNS 5-1-7 at 90 DAS.

#### **4.1.8 Stem dry weight (g)**

The data on mean stem dry weight per plant of safflower genotypes at different stages of growth are presented in Table 13.

The data indicated that the dry weight of stem per plant was increased progressively from 30 to 90 DAS.

The genotypes differed significantly in stem dry weight at all stages of growth except at 30 DAS. The genotype PBNS 125 was significantly superior in stem dry weight over rest of the genotypes at all stages of growth except PBNS 1702 and PBNS 43 at all stages, PBNS 5-1-7 at 45 and 90 DAS and PBNS 34 at 45 DAS.

#### **4.1.9 Total dry weight (g)**

The data on mean total dry weight per plant of safflower genotypes at different stages of growth are presented in Table 14.

The data revealed that the total dry weight per plant increased progressively from 30 to 90 DAS.

The genotypes differed significantly in total dry weight at all stages of growth. The genotype PBNS 125 was significantly superior in respect of total dry weight over rest of the genotypes at all stages of growth except genotypes PBNS 1702, PBNS 43 and PBNS 5-1-7 at 90 DAS.

Table 13. Mean stem dry weight (g) per plant at various growth stages

Sr. No.	Treatment	Days after sowing				
		30	45	60	75	90
1	PBNS 7	0.09	0.19	3.15	7.02	12.32
2	PBNS 1702	0.12	0.32	4.23	8.24	13.88
3	PBNS 34	0.11	0.24	3.76	7.81	13.21
4	PBNS 43	0.12	0.31	4.10	8.07	13.76
5	PBNS 48	0.15	0.23	3.52	7.62	13.07
6	PBNS 119	0.09	0.18	3.02	6.94	12.08
7	PBNS 125	0.13	0.34	4.46	8.40	14.10
8	PBNS 142	0.10	0.21	3.38	7.41	12.90
9	PBNS 5-1-7	0.11	0.26	3.87	7.92	13.54
10	PBNS 12	0.09	0.20	3.23	7.18	12.65
11	Annegiri-1	0.08	0.17	2.93	6.80	11.97
12	Sharda	0.07	0.17	2.89	6.73	11.77
	SE $\pm$	0.028	0.036	0.125	0.142	0.215
	CD at 5%	NS	0.106	0.366	0.418	0.631

Table 14. Mean total dry weight (g) per plant at various growth stages

Sr. No.	Treatment	Days after sowing				
		30	45	60	75	90
1	PBNS 7	0.80	2.11	8.11	16.10	24.00
2	PBNS 1702	1.13	2.81	10.07	18.25	26.68
3	PBNS 34	0.98	2.51	9.30	17.41	25.42
4	PBNS 43	1.10	2.73	9.86	17.96	26.45
5	PBNS 48	0.87	2.43	8.93	17.03	25.15
6	PBNS 119	0.78	2.04	7.80	15.86	23.60
7	PBNS 125	1.22	3.06	10.44	18.50	27.01
8	PBNS 142	0.87	2.23	8.67	16.70	24.88
9	PBNS 5-1-7	1.03	2.57	9.52	17.69	26.04
10	PBNS 12	0.82	2.17	8.30	16.33	24.45
11	Annegiri-1	0.74	2.00	7.63	15.65	23.40
12	Sharda	0.72	1.97	7.49	15.51	23.09
	SE ±	0.005	0.007	0.018	0.024	0.050
	CD at 5%	0.016	0.022	0.054	0.073	1.491

#### **4.1.10 Relative water content (RWC) (%)**

The data on mean relative leaf water content of safflower genotypes are presented in Table 15.

The data revealed that the genotype PBNS 43 was significantly superior in relative leaf water content over PBNS 7, PBNS 34, PBNS 12 and Annegiri-1 and it was at par with rest of the genotypes.

#### **4.2 Growth parameters**

The data on growth parameters are presented below and not analysed statistically except leaf area index (LAI)

##### **4.2.1 Absolute growth rate (AGR)**

The data presented in Table 16 indicated that the absolute growth rate increased continuously from 31-45 to 76-90 DAS. The genotype PBNS 125 recorded the highest AGR followed by PBNS 1702.

##### **4.2.2 Relative growth rate (RGR)**

The data on the relative growth rate recorded at various stages of growth of safflower genotypes are presented in Table 17.

The data indicated that the relative growth rate increased up to 46-60 DAS but decreased thereafter.

The highest AGR was found in the genotype Sharda followed by Annegiri-1.

##### **4.2.3 Net assimilation rate (NAR)**

The data on the net assimilation rate recorded at various stages of growth of safflower genotypes are presented in Table 18.

Table 15. Mean relative water content (%) of various genotypes

Sr. No.	Treatment	Relative water content (%)
1	PBNS 7	88.07
2	PBNS 1702	91.52
3	PBNS 34	89.37
4	PBNS 43	92.87
5	PBNS 48	89.75
6	PBNS 119	92.23
7	PBNS 125	90.19
8	PBNS 142	92.74
9	PBNS 5-1-7	91.16
10	PBNS 12	85.48
11	Annegiri-1	83.58
12	Sharda	92.77
	SE $\pm$	1.194
	CD at 5%	3.499

Table 16. Mean absolute growth rate (AGR) (mg/day) at various growth stages

Sr. No.	Treatment	Days after sowing				
		31-45	46-60	61-75	76-90	Mean
1	PBNS 7	87.33	399.99	532.66	526.66	386.66
2	PBNS 1702	112.21	483.77	545.32	561.99	425.82
3	PBNS 34	101.99	452.66	540.66	533.99	407.32
4	PBNS 43	112.44	475.33	540.00	565.99	423.44
5	PBNS 48	103.55	433.33	539.99	541.33	404.55
6	PBNS 119	83.99	384.00	537.33	516.00	380.33
7	PBNS 125	122.66	491.99	537.33	567.33	429.83
8	PBNS 142	90.66	429.33	535.32	545.33	400.16
9	PBNS 5-1-7	102.66	463.33	544.66	556.66	416.83
10	PBNS 12	89.99	408.66	535.33	541.33	393.83
11	Annegiri-1	84.00	375.33	534.66	528.66	380.66
12	Sharda	83.33	369.99	504.66	505.32	365.83
	G.M.	97.90	430.64	535.66	540.88	

Table 17. Mean relative growth rate (RGR) (mg/g/day) at various growth stages

Sr. No.	Treatment	Days after sowing				
		31-45	46-60	61-75	76-90	Mean
1	PBNS 7	28.14	38.99	19.85	11.77	24.68
2	PBNS 1702	26.38	36.93	17.21	11.25	22.94
3	PBNS 34	27.27	38.59	18.17	10.95	23.74
4	PBNS 43	26.19	37.19	17.36	11.20	22.98
5	PBNS 48	29.49	37.70	18.68	11.29	24.29
6	PBNS 119	27.86	38.86	20.54	11.50	24.69
7	PBNS 125	26.79	35.55	16.56	10.95	22.46
8	PBNS 142	27.25	39.33	18.99	11.54	24.27
9	PBNS 5-1-7	26.56	37.91	17.94	11.18	23.39
10	PBNS 12	28.21	38.84	19.60	11.67	24.58
11	Annegiri-1	28.92	38.76	20.81	11.64	25.03
12	Sharda	29.14	38.69	21.08	11.52	25.10
	G.M.	27.68	38.11	18.89	11.37	

Table 18. Mean net assimilation rate (NAR) (mg/cm<sup>2</sup>/day) at various growth stages

Sr. No.	Treatment	Days after sowing				
		31-45	46-60	61-75	76-90	Mean
1	PBNS 7	0.5114	0.4495	0.3562	0.2475	0.3911
2	PBNS 1702	0.4964	0.4550	0.3302	0.2463	0.3819
3	PBNS 34	0.3976	0.4532	0.3465	0.2354	0.3831
4	PBNS 43	0.5022	0.4531	0.3302	0.2505	0.3840
5	PBNS 48	0.5100	0.4422	0.3519	0.2409	0.3862
6	PBNS 119	0.5065	0.4596	0.3638	0.2427	0.3931
7	PBNS 125	0.5108	0.4596	0.3228	0.2412	0.3836
8	PBNS 142	0.5009	0.4583	0.3524	0.2450	0.3891
9	PBNS 5-1-7	0.4911	0.4504	0.3403	0.2530	0.3837
10	PBNS 12	0.5103	0.4508	0.3549	0.2540	0.3925
11	Annegiri-1	0.5101	0.4371	0.3643	0.2548	0.3915
12	Sharda	0.5101	0.4342	0.3677	0.2448	0.3892
	G.M.	0.4964	0.4502	0.3484	0.2463	

The data showed that the NAR was maximum at 31-45 DAS and decreased thereafter.

The highest NAR was found in the genotype PBNS 119.

#### **4.2.4 Leaf area index (LAI)**

The data on mean leaf area index of safflower genotypes at different stages of growth are presented in Table 19.

The data revealed that the LAI was increased progressively from 30 to 90 DAS. The genotypes differed significantly in LAI at all stages of growth except at 75 DAS. the genotype PBNS 125 was significantly superior in LAI over rest of genotypes at all stages of growth except PBNS 1702 at 30 and 90 DAS and PBNS 34, PBNS 43 and PBNS 5-1-7 at 90 DAS.

### **4.3 Post harvest observations**

#### **4.3.1 Yield contributing characters**

The data presented in Table 20 indicated that the yield contributing characters in safflower genotypes differed significantly in number of capitula per plant, number of seeds per capsule and 100-seed weight (g).

##### **4.3.1.1 Number of capitula per plant**

The data in Table 20 and Fig. 3 revealed that the genotype PBNS 125 produced significantly more number of capitula per plant than the rest of the genotypes.

Table 19. Mean leaf area index (LAI) per plant at various growth stages

Sr. No.	Treatment	Days after sowing				
		30	45	60	75	90
1	PBNS 7	0.1135	0.3198	0.5562	0.9173	1.1561
2	PBNS 1702	0.1800	0.4017	0.6431	0.9735	1.2032
3	PBNS 34	0.1470	0.3902	0.5870	0.9475	1.1987
4	PBNS 43	0.1715	0.3956	0.6356	0.9645	1.2338
5	PBNS 48	0.1348	0.3837	0.5744	0.9354	1.1888
6	PBNS 119	0.1123	0.3137	0.5491	0.9109	1.1443
7	PBNS 125	0.1839	0.4061	0.6496	0.9813	1.2465
8	PBNS 142	0.1219	0.3534	0.5672	0.9283	1.1765
9	PBNS 5-1-7	0.1592	0.3943	0.6146	0.9557	1.2111
10	PBNS 12	0.1170	0.3330	0.5612	0.9241	1.1665
11	Annegiri-1	0.1100	0.3078	0.5425	0.9048	1.1314
12	Sharda	0.1106	0.3040	0.5354	0.8982	1.1196
	SE $\pm$	0.0020	0.0050	0.0060	0.0520	0.0180
	CD at 5%	0.0080	0.0010	0.0010	NS	0.0540

Table 20. Yield contributing characters in various genotypes of safflower.

Sr. No.	Treatment	Number of capitula per plant	Number of seeds per capsule	100-seed weight (g)
1	PBNS 7	20.33	22.66	5.53
2	PBNS 1702	22.66	23.33	5.50
3	PBNS 34	17.66	26.00	5.01
4	PBNS 43	20.00	25.66	4.56
5	PBNS 48	16.33	21.33	5.16
6	PBNS 119	18.33	17.33	5.73
7	PBNS 125	28.00	29.66	5.93
8	PBNS 142	17.33	25.00	5.96
9	PBNS 5-1-7	24.33	26.33	5.56
10	PBNS 12	22.66	18.00	5.91
11	Annegiri-1	20.00	17.66	5.45
12	Sharda	19.66	17.33	5.26
	SE $\pm$	1.060	1.135	0.181
	CD at 5%	3.106	3.325	0.532

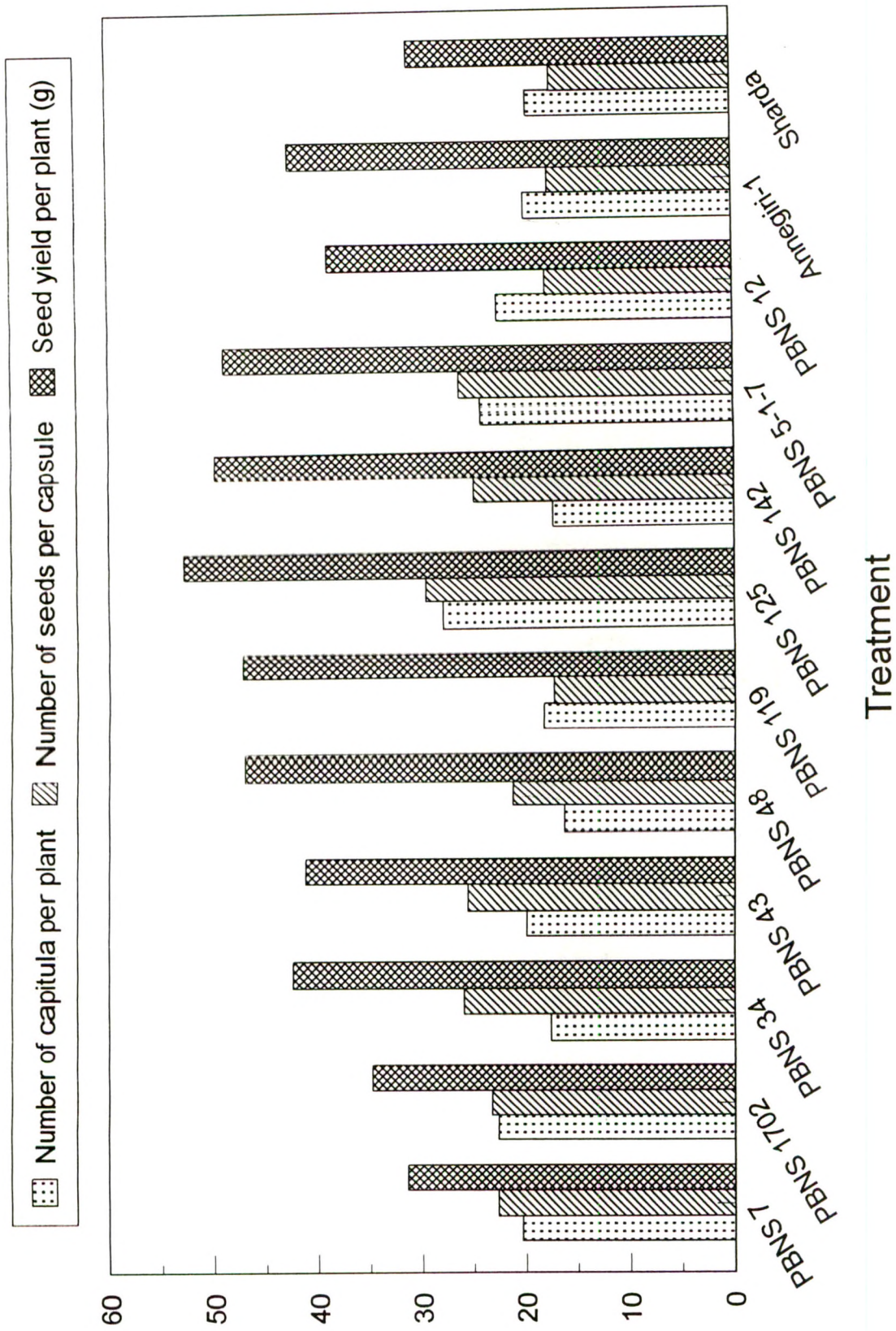


Fig. 3. Mean number of capitula per plant, number of seeds per capsule and seed yield per plant (g) of various safflower genotypes

#### **4.3.1.2 Number of seeds per capsule**

The data in Table 20 and Fig. 3 showed that the genotype PBNS 125 produced significantly more number of seeds per capsule than the rest of the genotypes except PBNS 5-1-7.

#### **4.3.1.3 100-seed weight**

The data in Table 20 revealed that the genotype PBNS 142 recorded significantly more 100-seed weight than PBNS 34, PBNS 43, PBNS 48 and Sharda while it was at par with the rest of the genotypes.

#### **4.3.2 Yield studies**

The data presented in Table 21 indicated that the yield studies in safflower genotypes showed significant differences in seed yield per plant (g), seed yield per hectare (kg), total biological yield (kg/ha) and harvest index (%).

##### **4.3.2.1 Seed yield per plant (g)**

The data on seed yield per plant presented in Table 21 and Fig. 3. revealed that PBNS 125 produced significantly more yield than all other genotypes except PBNS 48, PBNS 119, PBNS 142 and PBNS 5-1-7.

##### **4.3.2.2 Seed yield per hectare (kg)**

The data in Table 21 indicated that mean seed yield per hectare of genotype PBNS 125 was significantly superior over all other genotypes except PBNS 1702, PBNS 43 and PBNS 5-1-7.

##### **4.3.2.3 Total biological yield (kg/ha)**

The data on total biological yield presented in Table 21 revealed that the genotype PBNS 125 produced significantly more total

Table 21. Yield studies of various genotypes of safflower

Sr. No.	Treatment	Seed yield per plant (g)	Seed yield per ha (kg)	Total biological yield (kg/ha)	Harvest index (%)
1	PBNS 7	31.40	1889.5	7246.6	26.18
2	PBNS 1702	34.80	2238.4	7246.6	30.95
3	PBNS 34	42.40	2012.9	6441.4	31.21
4	PBNS 43	41.20	2229.3	6709.8	34.53
5	PBNS 48	47.06	1987.8	7246.6	27.50
6	PBNS 119	47.26	1878.8	7783.4	24.53
7	PBNS 125	52.86	2442.4	9125.4	27.00
8	PBNS 142	49.86	1960.9	7783.4	26.08
9	PBNS 5-1-7	49.00	2202.5	7783.4	28.42
10	PBNS 12	38.93	1894.9	5904.6	32.74
11	Annegiri-1	42.60	1873.4	6709.8	28.01
12	Sharda	31.06	1771.4	6978.2	24.45
	SE $\pm$	2.209	102.33	477.04	1.550
	CD at 5%	6.470	299.66	1397.0	4.540

biological yield per hectare than rest of the genotypes except PBNS 119, PBNS 142 and PBNS 5-1-7.

#### **4.3.2.4 Harvest index (%)**

The data on harvest index presented in Table 21 showed that the genotype PBNS 43 recorded significantly higher harvest index than rest of the genotypes except PBNS 1702, PBNS 34 and PBNS 12.

#### **4.3.2.5 Volume weight (g/l)**

The data on volume weight presented in Table 22 revealed that Sharda recorded significantly higher volume weight than the rest of the genotypes except PBNS 142.

### **4.4 Chemical analysis**

#### **4.4.1 Chlorophyll 'a' (mg/g)**

The data on chlorophyll 'a' in Table 23 showed that the genotypes differed significantly in chlorophyll 'a' content in fresh leaf.

The genotype PBNS 5-1-7 was significantly superior to PBNS 48, PBNS 119, PBNS 125 and PBNS 142 while it was at par with the rest of the genotypes.

#### **4.4.2 Chlorophyll 'b' (mg/g)**

The data on chlorophyll 'b' presented in Table 23 revealed that the genotypes differed significantly in chlorophyll 'b' content in fresh leaf.

The genotype PBNS 5-1-7 was significantly superior to PBNS 48 and PBNS 119 while it was at par with the rest of the genotypes.

Table 22. Volume weight (g/l) of various safflower genotypes.

Sr. No.	Treatment	Volume weight (g/l)
1	PBNS 7	524.20
2	PBNS 1702	517.71
3	PBNS 34	506.28
4	PBNS 43	519.32
5	PBNS 48	523.43
6	PBNS 119	485.34
7	PBNS 125	516.61
8	PBNS 142	530.83
9	PBNS 5-1-7	508.43
10	PBNS 12	494.49
11	Annegiri-1	507.51
12	Sharda	553.74
	SE $\pm$	7.9381
	CD at 5%	23.247

Table 23. Mean chlorophyll 'a', chlorophyll 'b', total chlorophyll content (mg/g) and chlorophyll stability index (CSI) of safflower genotypes.

Sr. No.	Treatment	Chlorophyll 'a'	Chlorophyll 'b'	Total chlorophyll	Chlorophyll stability index
1	PBNS 7	0.8280	0.7192	1.6348	0.5458
2	PBNS 1702	0.7862	0.6615	1.5287	0.5759
3	PBNS 34	0.8160	0.7070	1.6146	0.7048
4	PBNS 43	0.7622	0.6831	1.5328	0.5037
5	PBNS 48	0.6366	0.5102	1.2146	0.4475
6	PBNS 119	0.6718	0.5557	1.3005	0.5579
7	PBNS 125	0.7421	0.6486	1.4724	0.6926
8	PBNS 142	0.7203	0.6254	1.4401	0.6036
9	PBNS 5-1-7	0.8414	0.7556	1.6952	0.5635
10	PBNS 12	0.7634	0.7430	1.5974	0.3566
11	Annegiri-1	0.7724	0.6647	1.5367	0.6172
12	Sharda	0.7657	0.6525	1.5032	0.6059
	SE $\pm$	0.033	0.047	0.008	0.0033
	CD at 5%	0.098	0.137	0.026	0.0098

#### **4.4.3 Total chlorophyll (mg/g)**

A glance at Table 23 indicated that the genotypes differed significantly in total chlorophyll content of leaves.

The genotype PBNS 5-1-7 was significantly superior over all other genotypes.

#### **4.4.4 Chlorophyll stability index (CSI)**

The data presented in Table 23 revealed that the genotypes differed significantly in respect of chlorophyll stability index (CSI).

The genotype PBNS 12 recorded significantly lower chlorophyll stability index (CSI) than all other genotypes.

#### **4.4.5 Oil content (%)**

The data presented in Table 24 indicated significant differences in oil content among the safflower genotypes. The genotype PBNS 12 produced significantly higher oil content than all other genotypes.

#### **4.5 Correlation studies**

The data on correlation coefficients presented in Table 25 revealed that there were positively significant correlations between plant height and seed yield, leaf area and total dry weight, number of seeds per capitulum and harvest index, total dry weight and number of seeds per capitulum.

There were negative correlations between plant height and harvest index, leaf area and 100-seed weight, total dry weight and 100-seed weight, number of seeds per capitulum and 100-seed weight. Harvest index is negatively correlated with 100-seed weight and seed yield per plant.

Table 24. Mean seed oil content (%) of various safflower genotypes

Sr. No.	Treatment	Oil content (%)
1	PBNS 7	24.30
2	PBNS 1702	25.13
3	PBNS 34	24.26
4	PBNS 43	25.10
5	PBNS 48	24.53
6	PBNS 119	24.76
7	PBNS 125	24.53
8	PBNS 142	24.40
9	PBNS 5-1-7	23.73
10	PBNS 12	28.53
11	Annegiri-1	25.20
12	Sharda	24.00
	SE $\pm$	0.447
	CD at 5%	1.309

Table 25. Correlation of yield with other yield components in safflower.

Characters	Plant height (cm)	Leaf area (cm <sup>2</sup> )	Total dry weight (g)	Number of capitula per plant	Number of seeds per capitulum	Harvest index (%)	100-seed weight (g)	Seed yield per plant (g)
Plant height (cm)	1.000	0.442	0.445	0.361	0.482	-0.076	0.130	0.780**
Leaf area (cm <sup>2</sup> )		1.000	0.996**	0.489	0.837**	0.546*	-0.151	0.351
Total dry weight (g)			1.000	0.509	0.850**	0.528	-0.127	0.382
Number of capitula per plant				1.000	0.416	0.142	0.390	0.144
Number of seeds per capitulum					1.000	0.262	-0.071	0.449
Harvest index (%)						1.000	-0.452	-0.107
100-seed weight (g)							1.000	0.300

\* Significant at 5 % level

\*\* Significant at 1 % level

# DISCUSSION

## Chapter-V

### DISCUSSION

The findings of present investigation entitled "Physiological analysis of safflower (*Carthamus tinctorius* L.) genotypes" are discussed in the following pages.

The genotype PBNS 125 proved to be the tallest of all throughout the growth period. Its more height may be because of more number of internodes or more internodal length or both. The genotypic differences in plant height were also observed by Jadhav (1975) and Deokar and Patil (1978).

The genotype PBNS 125 was significantly superior in number of primary branches at all the stages and secondary branches per plant at most of the stages of growth. Primary and secondary branches are important yield contributing characters as they contribute towards the yield through the number of capitula per plant. Mehta *et al.* (1979) and Veerana (1977) reported contribution of primary and secondary branches to yield.

The genotype PBNS 34 came significantly earlier to first flower opening and 50 % flowering. Genotypic differences in days to 50% flowering were observed by Patil *et al.* (1990) and Ashri *et al.* (1975) in safflower.

The genotype PBNS 125 produced significantly more number of leaves over other genotypes at all stages of growth. Its more number of

leaves may be because of more number of primary and secondary branches per plant.

The genotype PBNS 125 maintained more leaf area than all other genotypes throughout the growth period. Its more leaf area per plant might be attributed to more number or larger size or both of leaves. Similar results were reported by Bharad *et al.* (1995).

The genotype PBNS 125 was significantly superior in leaf dry weight over all other genotypes throughout the growth period. Its more leaf dry weight might be due to its more number of leaves and larger leaf area.

The genotype PBNS 125 maintained its superiority in stem dry weight over others at most of the stages. Its more stem dry matter accumulation might be due to more number of primary and secondary branches and larger leaf area which in turn might have provided more photosynthate for accumulation in stem.

The genotype PBNS 125 produced more total dry matter per plant at all stages of growth which was due to the highest leaf and stem dry weight.

The genotype PBNS 43 was significantly superior in respect of relative water content over all other genotypes.

The genotype PBNS 125 recorded the highest mean AGR throughout the growth period. Its highest AGR might be due to more interception of radiation by its larger leaf area.

The genotype Sharda recorded the highest mean RGR.

NAR values were maximum during initial stage.

The genotype PBNS 125 maintained highest LAI at most of the growth stages which might be attributed to its larger leaf area. Similar findings were reported by Ramchandram and Rao (1977) in safflower.

The genotype PBNS 125 was significantly superior to the rest of the genotypes in respect of number of capitula per plant which might be due to more number of primary and secondary branches per plant.

The genotype PBNS 125 recorded more number of seeds per capitulum which might be due to bigger size of capsule.

The genotype PBNS 142 gave significantly highest 100-seed weight.

The genotype PBNS 125 was significantly superior to the rest of the genotypes in respect of seed yield per plant.

The genotype PBNS 125 gave significantly highest total biological yield which might be attributed to its high stem and leaf dry weight and high seed yield.

The genotype PBNS 43 recorded significantly highest harvest index which might be due to strong reproductive sink.

The volume weight of Sharda was significantly superior over all other genotypes which might be due to its thin seed coat.

The genotype PBNS 125 gave significantly highest yield of all genotypes. The higher seed yield could be attributed to more number of primary and secondary branches, more biological yield with moderate harvest index, more number of capitula per plant, more number of seeds per capitulum and moderate test weight.

It can be concluded that the genotype PBNS 125 was better in yield and yield contributing characters than other genotypes.

The genotype PBNS 5-1-7 was significantly superior over all other genotypes in respect of chlorophyll 'a', chlorophyll 'b' and total chlorophyll. Genotypic differences in chlorophyll content were also observed by Bharad *et al.* (1995).

The genotype PBNS 12 gave significantly lowest CSI than rest of the genotypes which pointed to its capacity to tolerate moisture stress.

The genotype PBNS 12 recorded significantly superior oil content over the rest of the genotypes. Genotypic differences in oil content were also observed by Mirza *et al.* (1998) and Nagraj (1994).

It would be seen in simple correlation studies that there were positively significant correlations between plant height and seed yield, leaf area and total dry weight, number of seeds per capitulum and harvest index, total dry weight and number of seeds per capitulum.

There were negative correlations between plant height and harvest index, leaf area and 100-seed weight, total dry weight and 100-seed weight, number of seeds per capitulum and 100-seed weight. Harvest index is negatively correlated with 100-seed weight and seed yield per plant. The results are in confirmation with findings reported by Khidir (1974), Ashri (1975), Mathur (1976), Rao and Ramchandram (1977), Solanki *et al.* (1979) and Reddy *et al.* (1992) in safflower.

# **SUMMARY AND CONCLUSION**

## **Chapter-VI**

### **SUMMARY AND CONCLUSION**

The experiment was conducted on "Physiological analysis of safflower (*Carthamus tinctorius* L.) genotypes" at the Agricultural College Farm, Parbhani during *rabi* season, 2001-2002.

The genotype PBNS 125 exhibited maximum plant height at all observation stages.

The genotype PBNS 125 produced highest number of primary and secondary branches at all the observation stages.

Earliest flowering was observed in PBNS 34.

The genotype PBNS 125 gave the highest number of leaves.

The genotype PBNS 125 produced highest leaf area at all the observation stages.

The genotype PBNS 125 showed overall superiority in leaf, stem and total dry weight during growth period.

The genotype PBNS 43 exhibited maximum relative water content.

AGR values showed definite trend, that is, the values increased up to a certain point and decreased thereafter. The same trend was followed in RGR, while NAR values decreased continuously.

The genotype PBNS 125 recorded the highest leaf area index.

The genotype PBNS 125 recorded the highest number of capitula and number of seeds per capsule.

The genotype PBNS 142 showed high 100-seed weight.

The genotype PBNS 125 is having good yield contributing characters, high seed yield per plant and high total biological yield and resulted in giving high yield.

The genotype PBNS 142 exhibited high harvest index.

Sharda recorded the highest volume weight.

The genotype PBNS 5-1-7 recorded the highest chlorophyll 'a', chlorophyll 'b' and total chlorophyll.

Chlorophyll stability index was recorded lowest in PBNS 34.

The genotype PBNS 12 recorded the highest oil content.

It would be seen in simple correlation studies that, the seed yield was positively correlated with plant height, leaf area, total dry weight, number of capitula per plant, number of seeds per capitulum and 100-seed weight.

The genotype PBNS 125 has recorded high number of primary and secondary branches, high number of leaves, high dry matter, high number of capitula, number of seeds per capsule, seed yield per plant, total biological yield and 100-seed weight. These are the characters which might have helped PBNS 125 in producing high yield.

In light of above findings, it can be concluded that, in given conditions, the genotype PBNS 125 is high yielder having good number of yield contributing characters amongst the genotypes studied.

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# PHYSIOLOGICAL ANALYSIS OF SAFFLOWER (*Carthamus tinctorius* L.) GENOTYPES

## THESIS ABSTRACT

Name of student : **Phapal A.P.** Reg. No. : **34 M /2000A**  
Guide : **Dr. A.N. Gitte**

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An experiment on twelve genotypes of safflower was conducted during rabi season of 2001-2002 to study physiological variability in growth and seed yield, and also to pin point plant characteristics useful in productivity. The genotype PBNS 125 had maximum plant height, the highest number of primary and secondary branches, number of leaves, leaf area, leaf area index, total dry matter, number of capitula per plant, number of seeds per capsule and moderate harvest index and test weight, which might have to attributed its highest yield. PBNS 142 recorded the highest harvest index and test weight. PBNS 34 exhibited earliest flowering, PBNS 5-1-7 recorded the highest chlorophyll content whereas the highest oil content was found in PBNS 12.

From the correlation studies, it was seen that seed yield in safflower was positively associated with plant height, leaf area, total dry weight, number of capitula per plant, number of seeds per capitulum and test weight.