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Seed Physiological Characterization of Safflower (*Carthamus tinctorius* L.) Genotypes

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ABSTRACT

Sixty one genotypes including four checks were grown in augmented block design; all the recommended practices and plant protection measures were adopted for raising healthy crop. Analysis of seed physiological traits was carried out at Department of Seed Science and Technology, College of Agriculture, Rajendranagar, Hyderabad. Range and mean of seed physiological traits were as follows: germination (90-100%; 95.81), speed of germination (13.15-43.5; 28.59), shoot length (6.29-11.59 mm; 9.18), root length (7.78-15.96 mm; 11.99 mm), seedling length (15.52-25.96 mm; 21.17 mm), seedling dry weight (0.12-0.27 g; 0.18 g), seedling vigour index-I (1417-2405; 2029.03), seedling vigour index-II (11.65-24.71; 17.12) and field emergence (81-100%; 92.71%).

Key words: *Safflower, Foods, Crop, Seed, Oil*

INTRODUCTION

Safflower (*Carthamus tinctorius*) is commercially cultivated for vegetable oil extracted from the seeds. Safflower is native to arid environments having seasonal rain. Taproot system of safflower helps to withstand in arid environments. Traditionally, the crop was grown for its seeds, and used for coloring and flavoring foods, in medicines, and making red (carthamin) and yellow dyes, safflower has been cultivated mainly for the purpose of vegetable oil extracted from its seeds. Safflower seed oil is nutritionally similar to sunflower oil which is good for diabetic patients and also used in cosmetics. There are two types of safflower that produce two different kinds of oil, one consist higher monounsaturated fatty acid (oleic acid) which is predominant in edible oil market and the other high in polyunsaturated fatty acid (linoleic acid) which is used in painting. Oils rich in polyunsaturated fatty acids, notably linoleic acid, are considered to have some health benefits. Safflower flowers are occasionally used in cooking as a cheaper substitute for saffron.

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The dried safflower petals are also used as a herbal tea variety. In coloring textiles, dried safflower flowers are used as a natural dye source for the orange-red pigment Carthamin. Seed physiological characterization for the important traits is the basis for the safflower improvement. However, the physiological traits are highly influenced by the environments, which is a major limitation of using these correlated traits in plant selections.

MATERIAL AND METHODS

The pure seeds of sixty one germplasm lines including four check varieties grown in ICRISAT farm of IIOR, Hyderabad were used for the study. The laboratory work was carried out at seed quality testing laboratory of Department of Seed Science and Technology, College of Agriculture, Rajendranagar, Hyderabad.

Observations recorded

Standard germination (%)

A total of 400 seeds were randomly selected from each genotype and grouped into four replicates 100 seeds each. The germination test was conducted in the laboratory using 'between paper' method (bp) as described by ISTA rules[2]. One hundred seeds of four replicates were placed equidistantly on moist germination paper. The rolled towels were incubated in germination chamber maintained at 25±1°c and 95 per cent relative humidity (RH). The first and final germination counts were recorded on 4th and 14thday of germination test respectively for normal seedlings, abnormal seedlings, fresh ungerminated and dead seeds. The germination was expressed in percentage based on normal seedlings.

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds planted}} \times 100$$

Root length (cm)

Ten normal seedlings were selected randomly per replication in each treatment on 14thday of germination test. The root length was measured from the tip of the primary root to base of the hypocotyl with the help of a scale and the mean root length was expressed in centimeters.

Shoot length (cm)

Ten normal seedlings used for root length measurement, were also used for the measurement of shoot length. The shoot length was measured from the tip of the primary leaf to the base of the hypocotyl and mean shoot length was expressed in centimeters.

Seedling dry weight (mg)

Ten normal seedlings used for root and shoot length measurements in germination test were put in butter bags and dried in hot air oven at 80 ± 2^0C for 24 hours. Later, they were removed and allowed to cool in a desiccator for 5 minutes before weighing on electronic weigh balance. The mean seedling dry weight was recorded and expressed in milligrams.

Seedling vigour indices

The seedling vigour indices were calculated by using the following formula as suggested by Abdul Baki and Anderson[1]. and expressed in whole number.

Seedling vigour index I = Germination (%) x seedling length (cm)

Seedling vigour index II = Germination (%) x seedling dry weight (g)

Speed of germination

Germination test was conducted in four replications of 100 seeds each by adopting between paper methods. Daily germination counts were taken until no further germination was observed for 14 days. An index of the speed of germination was calculated by adding the quotients of the daily counts divided by the number of days of germination[9].

Speed of germination = Σ (n_1/d_1+ n_2-n_1/d_2 + ...n_n-n_n-$1/d_n$)

Where n= number of seeds germinated on day (d), d= serial number of days

Field emergence (%)

Randomly 100 seeds were selected per replication from each treatment and sown on a well prepared seed bed at adequate moisture conditions. Seeds were sown uniformly to 4 cm depth with a spacing of 45cm between rows and 15cm between the plants. The number of seedlings emerged at least 4 cm high above the soil surface on 14th day after sowing were counted and expressed as percentage.

$$\text{Field emergence (\%)} = \frac{\text{Number of seedling emergence at } 14^{th} \text{ day}}{\text{Total number of seeds sown}} \times 100$$

RESULTS AND DISCUSSION

Seed physiological traits

Mean and range of physiological traits namely germination, speed of germination, shoot length, root length, seedling dry weight, seedling vigour index-I, seedling vigour index-II and field emergence are presented in Table 1.

Germination (%)

Genotypes differed for germination per cent which ranged from 90 per cent (EC-29 and EC-31) to 100 per cent (EC-24, GMU-3 and GMU-5) with mean of 96 per cent. However, non-Significant differences were observed in germination percentage among all genotypes (Table 1). Highest seed germination was recorded in Nari-57, GMU-3, GMU-4 (100 %) and the lowest in EC-29 (90%). The check varieties recorded more than 94% of germination in this study. Thus, the germination percentage was recorded above Minimum Seed Certification Standards (*i.e.*, > 80%) in all safflower genotypes. The seed germination percentage varied among the genotypes might be due to the quality parameters like initial seed quality, viability and vigour could be attributed to better development of seeds. The variation germination among genotypes may be mainly due to oxygen uptake and dehydrogenase activity which may influence the germinative capacity in two ways: (i) respiratory activity provides energy to the germinating embryo and (ii) respiratory activity reflects both the integrity and overall capacity of the metabolic machinery, which was in support of finding of Woodstock[14]. The same findings was obtained by Pacheco *et al*[11]. who reported that sunflower genotype seeds greatly influenced by environmental factors during seed development stages. Similar observations was made by Suhasini[13]. among 22 sesame genotypes selected, highest seed germination was observed in ORM-17 and the lowest was observed in RT 54.

Seedling length (cm)

The seedling length varied among the genotypes (Table 1)**.** The trait ranged from 15.52 cm to 25.96 cm with 21 cm as general mean. The variety EC-28 recorded highest seedling length (25.96 cm) and GMU-9 recorded lowest seedling length (15.52 cm). Among the check varieties, the variety NARI-57 recorded highest seedling length (23.77 cm). On the basis of standard deviation (2.08) and mean (21 cm). values of seedling length of 57 genotypes were categorized into two groups as 34 genotypes recorded high seedling length (23.77), 23 genotypes recorded low seedling length (20.71 cm). Variation in seedling length was due to its better quality of seeds of the genotypes (Fehr, 1973) in rice.

Shoot length (cm)

The shoot length varied among the genotypes (Table 1). The trait ranged from 6.29 cm to 11.59 cm with 9.18 cm as a general mean. The variety EC-15 recorded highest shoot length (11.59 cm) and lowest by GMU-15 (6.29 cm) among genotypes. Among the check varieties NARI-57 showed the maximum shoot length (11.03 cm). The significant increase in shoot length might be due to bold seed size and might have supplied adequate food reserves to resume embryo growth, consequently leading

to more seedling length, seedling dry weight and higher vigour index[6].

Root length (cm)

Significant variance was found among genotypes for root length (Table 1). The general mean value of 11.99 cm with a range of 7.78 cm (GMU-9) to 15.96 cm (EC-26) was recorded. Among all genotypes, EC-26 genotype exhibited highest root length (15.96 cm) and GMU-9 genotype had low root length (7.78 cm). Among the check varieties centennial recorded highest root length (12.85 cm). The significant increase in shoot and root length might be due to higher seed index as it is reflected in the test weight of the seed, which might have supplied adequate food reserves to resume embryo growth. Thus, root system perform the crucial task for providing water, nutrient and physical support to plant especially during seed development phase. The length of the main root and density of the lateral roots determine the architecture of the root system in crop plants and varied from genotype to genotype.

Seedling dry weight (g)

Significant variation among safflower genotypes was observed for dry weight (Table 1). The range from 0.12 g to 0.27 g with the mean of 0.18 g in the safflower genotypes. Seedling dry weight was highest in the genotype GMU-12 (0.27 g) whereas the lowest in the genotype EC-2 (0.12 g). The variety Bhima had the highest seedling dry weight (0.23 g) followed by A1 (0.2 g) and NARI-57 (0.18g). Higher seedling dry weight might be due to higher seed size which could be attributed to more food reserves in the seed ultimately resulting into good seedlings. Decrease in seedling dry weight was due to restricted supply of nutrients from mother plant to seed due to disruption of vascular connection and utilization in various physiological and metabolic process[7].

Vigour Indices

The seedling vigour index varied significantly among the genotypes (Table 1). Seedling vigour index-1 ranged from 1417 to 2405 with the mean of 2029 among genotypes studied. Among the check varieties, NARI-57 (2369) had highest seedling vigour index-I followed by Bhima (2116), Centennial and A1. Highest seedling vigour index-I was noticed in EC-28 (2405) and the lowest in GMU-9 (1417) among germplasm accessions. Seedling vigour index-II ranged from 11.65 to 24.71 with the mean of 17.12 in the genotypes. Among check varieties, Bhima had the highest SVI-2 (22.82) followed by A1 (20.33) and NARI-57 (18.49). The variety Centennial recorded the lowest seedling vigour index-II (15.87). Highest seedling vigour index-II was noticed in GMU-12 (24.71) and the lowest in EC-2 (11.65) in genotypes. The variation in seed vigour may be due to varied germination and seedling length and seedling dry weight recorded with the genotypes. It is capability of the genotype to produce the quality seeds based on the utilisation of the resources such as a light, moisture and nutrients. The translocation of food reserves from plant to seed, leading to better development of seed is the genotypic character, thus, resulting into low and high vigour types. The variation in seed germination and vigour comes from the environmental conditions that the crop experiences during the seed development and maturation[3]. Thus, the seedlings ability for shoot penetration through the impeding soil of the seed bed is an essential attribute of seed vigour.

Speed of germination

Significant variance was found among safflower genotypes for speed of germination. (Table 1). The general mean value of 28.59 in the genotypes with a range of 13.15 to 43.5. The check variety NARI-57 recorded the highest speed of germination (31.52) and the lowest was recorded by variety A1 (25.34). Where as in germplasm lines EC-10, EC-22 and EC-25 recorded higher speed of germination (more than 40). The lowest speed of germination was recorded for GMU-12 (13) followed by CO1 (18), EC-26 (18), GMU-7 (18). This might be due to different environmental conditions during seed development, initial seed quality and seed size resulting into higher or lower seed vigour. These findings are supported by

Mirshekarnezhad *et al*.[10], who reported that the Esfahan recorded highest speed of germination (20) and the lowest speed of germination was recorded in Sina (14) among safflower genotypes studied.

Field emergence (%)

Modern crop production systems require a high degree of precision in crop establishment. The need for high plant population densities and uniform plant stand requires seeds of high quality that constantly produce rapid and uniform seedlings from each seed sown. The results of field emergence were presented in Table 1. The check varieties recorded 95 per cent of field emergence. In germplasm the field emergence ranged from 81 per cent (EC-4) to 100 per cent (EC-30 and GMU-17) with the mean of 93 per cent. The variety EC-30 and GMU-17 recorded highest field emergence (100 %) and EC-4 had recorded lowest field emergence (81 %). This might be due to differences in seed size, hull type and hull content. The higher field emergence was observed in bold seeds when compared to small seeds is due to large food reserves present in bold seeds. These findings are supported by Indrakumar *et al*.[5] who reported that the seed size and test weight positively correlate with field emergence. Kolasinka *et al*.[8] and Rahman *et al*.[12], who reported that there was a strong positive correlation of field emergence with either laboratory germination or vigour index.

Thus the evaluation of traits of economic importance, information on nature and magnitude of genetic variation in the seed quality characters is an essential prerequisite for systemic crop improvement programme. The genotypes with heavier seeds, bigger seed size, higher germination, seedling length, speed of emergence and field emergence are considered as superior genotypes. The initial crop emergence and establishments such as seed physical, physiological and seedling traits are considered important both agriculturally and commercially in terms of the quality of seeds.

Frequency distribution

The results of physiological responses of freshly harvested safflower seeds suggest that genotypic differences existed among the genotypes studied which exhibited quantitative variation. No much information is available in the safflower literature regarding the variation for seed physiological traits, which were used in this study. A frequency distribution provides a summarized grouping of data divided into mutually exclusive classes and the number of concurrences in a class. It is applied to indicate the nature of genetic variation (qualitative or quantitative) for traits in a population. In this study, most of the seed physiological traits which may be controlled by many genes, seed quality parameters like initial seed quality, vigour and influence of environment during the development of seeds.

Table 1: Mean performance of seed physiological traits in a set of 57 safflower genotypes compared with four check varieties

Genotype	Germination	Speed of Germination	Shoot length	Root length	Seedling length	Seedling dry weight	Seedling vigour index-I	Seedling vigour index-II	Field emergence
Checks									
A1	97	25.34	9.46	11.25	20.71	0.20	2016	20.33	95
Bhima	96	29.00	9.19	12.85	22.04	0.23	2116	22.82	95
Centennial	94	27.85	9.34	12.46	21.80	0.16	2060	15.87	95
NARI-57	99	31.52	11.03	12.74	23.77	0.18	2369	18.49	96
Genotypes									
HUS-305	98	20.93	7.19	12.96	20.35	0.20	2001	20.46	89
CO1	94	17.51	8.50	13.81	22.52	0.22	2109	21.04	86
EC-1	94	26.52	10.49	11.32	22.02	0.21	2070	19.86	84
EC-2	97	28.14	9.21	11.15	20.57	0.12	1988	11.73	92
EC-3	95	31.77	9.37	10.72	20.29	0.17	1935	16.65	94
EC-4	98	31.49	9.36	10.60	20.18	0.18	1984	18.17	81
EC-5	95	23.61	9.65	11.12	20.98	0.15	2000	14.75	87
EC-6	96	25.26	9.50	12.17	21.89	0.15	2094	15.12	97

EC-7	95	29.56	9.55	12.28	22.04	0.16	2101	15.38	96
EC-8	98	37.47	6.29	14.55	21.05	0.18	2070	18.49	97
EC-9	94	31.20	8.97	12.67	21.85	0.19	2061	18.68	89
EC-10	91	40.12	9.65	13.32	23.18	0.19	2101	17.64	97
EC-11	97	35.40	6.70	10.45	17.35	0.14	1683	14.36	96
EC-12	96	32.89	8.71	13.96	22.88	0.13	2189	12.88	96
EC-13	95	29.56	9.16	14.53	23.90	0.13	2270	12.48	97
EC-14	95	32.12	9.67	12.03	21.91	0.14	2082	13.74	83
EC-15	92	29.79	9.35	12.19	21.75	0.13	2009	12.12	97
EC-16	95	35.37	11.16	11.46	22.83	0.14	2169	13.43	94
EC-17	93	35.39	9.92	12.06	22.19	0.17	2064	16.24	89
EC-18	95	35.02	10.93	12.43	22.72	0.17	2158	16.85	95
EC-19	98	25.83	11.16	10.18	20.70	0.24	2022	24.47	82
EC-20	96	22.60	8.73	12.98	21.07	0.23	2022	22.46	85
EC-21	93	30.58	9.54	12.99	21.89	0.16	2043	15.32	89
EC-22	91	43.50	10.11	11.78	21.25	0.14	1941	13.79	99
EC-23	95	30.66	9.26	10.63	19.25	0.19	1823	18.69	93
EC-24	100	23.74	11.00	13.45	23.81	0.20	2381	20.37	87
EC-25	98	42.14	11.42	12.51	23.29	0.12	2290	12.83	95
EC-26	99	17.57	7.76	15.96	23.08	0.18	2285	18.52	84
EC-27	95	36.33	9.65	10.87	19.88	0.17	1882	16.48	89
EC-28	93	29.61	11.59	15.00	25.96	0.19	2405	18.31	93
EC-29	90	35.87	9.01	11.84	20.21	0.18	1826	16.66	98
EC-30	95	27.87	8.03	13.25	20.64	0.20	1968	19.45	100
EC-31	90	25.89	11.55	12.24	23.16	0.10	2077	15.35	92
EC-32	99	31.57	10.40	13.00	22.76	0.15	2253	15.88	98
EC-33	96	32.93	8.18	12.15	19.69	0.19	1896	19.32	94
EC-34	99	33.24	9.78	13.47	22.61	0.18	2239	18.85	94
EC-35	95	24.21	10.14	11.52	21.03	0.15	1998	14.95	95
EC-36	96	30.63	10.12	11.89	21.36	0.15	2044	14.73	93
GMU-1	98	26.40	9.00	11.28	20.73	0.17	2032	16.78	95
GMU-2	98	20.57	7.84	11.52	19.81	0.14	1948	13.56	99
GMU-3	100	28.74	8.35	12.11	20.91	0.17	2091	16.80	94
GMU-4	95	20.69	9.08	11.26	20.79	0.16	1975	14.99	98
GMU-5	100	31.78	8.32	13.97	22.74	0.19	2266	19.07	97
GMU-6	93	25.70	6.94	8.21	15.60	0.19	1456	17.51	92
GMU-7	91	17.64	7.37	13.80	21.61	0.19	1960	17.00	87
GMU-8	97	26.90	8.63	9.77	18.85	0.19	1835	18.94	88
GMU-9	91	20.19	7.29	7.78	15.52	0.13	1417	11.65	87
GMU-10	99	19.87	7.91	9.83	18.19	0.24	1801	23.89	92
GMU-11	97	35.67	10.03	12.90	23.38	0.17	2275	16.67	96
GMU-12	92	13.15	8.34	8.81	17.60	0.27	1625	24.71	83
GMU-13	99	32.59	8.60	10.06	19.11	0.14	1892	13.66	99
GMU-14	96	22.81	8.93	12.08	21.46	0.15	2053	14.78	87
GMU-15	97	18.59	6.06	9.23	15.74	0.16	1532	15.37	93
GMU-16	95	34.61	9.99	12.77	23.21	0.18	2205	16.89	93
GMU-17	98	33.56	7.04	12.84	20.33	0.13	1992	12.54	100
GMU-18	99	27.34	7.82	10.23	18.50	0.14	1832	13.99	90
GMU-19	92	20.55	7.83	9.14	17.42	0.14	1597	13.22	84
Mean	96	28.59	9.18	11.99	21.17	0.18	2029	17.12	92
Range	90-100	13.15-43.5	6.29-11.59	7.78-15.96	15.52-25.96	0.12-0.27	1417-2405	11.65-24.71	81-100
SD	2.64	6.17	1.17	1.60	2.08	0.03	210.64	3.31	4.93

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