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Some Technological and Morphological Characteristics of Safflower (*Carthamus tinctorius* L.) from Iran

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Abstract: In this study, ten breeding lines of safflower (*Carthamus tinctorius* L.) from Iran were evaluated in respect to technological and morphological traits for their utilization aspects in both food industry and agricultural applications. A considerable variation was found among the genotypes for hull, protein and oil content, iodine value, plant height, seed yield per plant, number of heads per plant and 100-seed weight. Oil content of seeds had a positive and considerable correlation with Iodine value and plant height and also, a negative correlation with seed yield per plant. Also, protein content recorded the highest positive association with oil content followed by plant height. Seed yield per plant showed positive and considerable correlation with hull content and number of days to flowering and a considerable negative correlation with protein content of seeds. Our results suggest that evaluated breeding lines of safflower could be valuable materials for breeding programs in which the main goals are improving oil yield and oil quality. The low correlation between oil content and seed yield in this study implied that it is possible to improve the seed yield and oil content simultaneously in safflower. Also, the results of this study indicated that improvement of seed yield could be achieved by selection for number of days to flowering.

Key words: Safflower, variation, seed yield, oil, protein

INTRODUCTION

Safflower, an annual crop adapted to somewhat arid and saline regions, is a potentially novel food source, which has not been fully explored in last country[1]. Traditionally it was first grown for the pigment in flowers that was used for coloring foods and dyeing cloths. Safflower seeds are the harvestable part, being used either for feeding poultry or for extracting their oil content. According to Knowels[2] Iran is one of the centers of safflower culture in the old world. Diverse climatic and agricultural conditions of Iran had led to formation of many local populations of this crop in the country[3]. Many of these populations possess genotypes with favorable characteristics for agricultural and industrial purposes.

The success of safflower production as an economical crop and its competition with the other oilseed crops such as sunflower, rapeseed and soybean is dependent upon the development of high yielding and oil cultivars. Thus, most efforts in safflower breeding programs emphasize on improvement of seed yield and oil content. The effectiveness of a selection program for improving a quantitative trait such as seed yield and oil content is mostly dependent upon the genetic variation of the trait in the germplasm and its heritability[4]. Also, for a rational improvement of seed yield and oil content, knowledge of association among their related traits is important for the breeders.

The previous studies showed that number of heads per plant, seed weight and oil content were the principal components of oil yield of safflower. Therefore appropriate combination of these components would constitute the most desirable plant type, but the strong negative associations between these desirable traits was the major problem in the selection programs[5]. In safflower, it has been shown that plant height and head size were highly correlated to seed yield and number of seeds per head[6]. Khidir[7] also reported that seed yield in safflower was correlated with number of seeds per head, head size and oil content. Kotecha[8] also found that there was a positive and considerable correlation between days to maturity and plant height in safflower.

Correlation analysis in safflower showed that seed weight could not be used as good selection criterion for improvement of seed yield, because of its competition and association with the other yield components[9]. The attempts were made to change the magnitude and direction of such associations through mutagenesis in homozygous parental lines and/or production of heterozygous hybrids by diverse crosses involving high yielding and oil genotypes[10]. The objective of this study

was to reveal potential of seed yield and oil quality of a fraction of Iranian safflower gene pool and also, to investigate association among important traits such as oil and protein content, plant height, seed yield and seed weight in 10 breeding lines from Iran. Findings of such study could be helpful to selection of parent for genetic design and also release of superior varieties in future and will be the basis of further studies by other researchers.

MATERIALS AND METHODS

Ten breeding lines of safflower (IUTS211, IUTC129, IUTC232,IUTK115,IUTK114,IUTK23,IUTM12,IUTM21, IUTE1449 and IUTH13), which obtained by single plant selection from various Iranian local populations, were used for this study (Table 1). The experiments were carried out in summer of 2002 at the Research Farm of Isfahan University of Technology, which has an altitude of 1626 m above sea level, annual precipitation of 375 mm and a soil pH of 5.7. Each experimental unit consisted of six 5.5 m rows spaced 50 cm apart. Enough seeds were planted and then plants were thinned to have 10 plants per meter of each row.

In this study, number of days to flowering, plant height, number of heads per plant, 100-seed weight, seed yield per plant, protein and oil content, hull number and Iodine value of oil were recorded for each genotype. The oil and protein content of seeds were determined by Soxhlet and Kjeldahl methods, respectively. The samples for oil and protein content were analyzed in triplicate and their means was considered in statistical analysis. The oil, protein and Iodine value were determined according to standard methods of oil and fat analysis[11]. The correlation coefficients among the traits were calculated using Statistical Analysis System Program[12].

RESULTS

Mean of characteristics for the 10 breeding lines of safflower are summarized in Table 1. The lines IUTC232 with 31.2 and IUTK115 with 21.0% ranked the highest and lowest in terms of oil content, respectively. Present lines exhibited differences in their iodine value as well. The lines IUTS211 and IUTM12 indicated the highest and lowest iodine value (135.5 and 112.3 gI/100 g, respectively). Protein content of seeds differed from 20.9 to 24.2% for the present lines. The lines IUTK23 and IUTC232 had the lowest and highest protein content, respectively (Table 1). IUTE1449 and IUTS211 had the highest and lowest number of days to flowering, respectively (Table 1). The minimum and maximum plant height in evaluated genotypes were belonged to IUTS211 and IUTC129, respectively. Number of heads per plant ranged from 8 to 24 with lines IUTK115 and IUTM12 ranking the highest and lowest, respectively. Means of seed yield per plant for the breeding lines varied between 24.1 (IUTS211) to 38.1 g (IUTE1449). In this manner, IUTK114 and IUTK115 had the highest (3.09 g) and the

Table 1: Mean of some technological and morphological traits and local origin of 10 safflower breeding lines from Iran

Breeding line	Reigin of collection	Hull content (%)	Protein (%)	Oil (%)	Iodine value	Days to flowering	Plant height (cm)	Head per plant	100-seed weight (gr)	Seed yield (g)
IUTS211	Khorasan	39.2	23.1	29.3	135.5+	86	56	17	2.85	24.1
IUTC129	Isfahan	42.2	22.6	26.3	126.4	91	114	22	2.45	24.9
IUTC232	Isfahan	37.7	24.2	31.2	126.4	94	103	15	2.12	25.1
IUTK115	Kurdistan	50.8	22.0	21.0	121.4	92	67	24	1.88	31.6
IUTK114	Kurdistan	54.3	22.0	21.9	131.6	90	82	11	3.09	30.7
IUTK23	Kurdistan	41.5	20.9	22.8	129.3	93	69	17	2.21	29.4
IUTM12	Markazi	46.5	23.1	22.0	112.3	93	74	8	2.06	29.0
IUTM21	Markazi	40.3	23.1	28.3	125.4	94	73	12	2.23	30.1
IUTE1449	Isfahan	42.9	22.0	27.1	120.6	96	87	13	2.58	38.1
IUTH13	Hamadan	46.6	22.0	21.1	123.5	92	73	23	2.21	27.1

+: The weight (g) of Iodine absorbed by 100 g of oil

Table 2: Coefficients of correlation among 10 traits in safflower breeding lines from Iran

Characters	Hull content (%)	Protein (%)	Oil (%)	Iodine value	Days to flowering	Plant height (cm)	Head per plant	100-seed weight (g)	Seed yield (g)
Hull content (%)	1								
Protein (%)	-0.45	1							
Oil (%)	-0.82**	0.68*	1						
Iodine value	-0.20	-0.07	0.34	1					
Days to flowering	-0.11	-0.04	0.01	-0.63*	1				
Plant height (cm)	-0.17	0.30	0.32	-0.10	0.34	1			
Head per plant	0.00	-0.28	-0.17	0.21	-0.24	0.06	1		
100 seed weight (g)	0.15	-0.09	0.17	0.63*	-0.52	0.00	-0.26	1	
Seed yield (g)	0.30	-0.49	-0.26	-0.41	0.63*	-0.13	-0.32	-0.02	1

* and **: significant at 0.05 and 0.01 of probability levels, respectively

lowest (1.88 g) 100-seed weight among all studied genotypes, respectively (Table 1).

Among the all traits that correlated with hull content, the lowest correlation was observed for number of heads per plant (Table 2). The hull content showed negative and considerable correlation with protein and oil content of the seeds (Table 2). Protein content recorded the highest positive association with oil content followed by plant height (r=0.68* and r=0.30, respectively). The protein content also showed a negative correlation with seed yield per plant (r=-0.49). Oil content of seeds had a positive and considerable correlation with Iodine value and plant height and also, a negative correlation with seed yield per plant (Table 2). The Iodine value was negatively correlated with number of days to flowering and seed yield per plant. The negative value with number of days to flowering was also significant (Table 2). The Iodine value also recoded a positive and significant association with 100-seed weight (r=0.63*).

The results indicated that among all traits that correlated with number of days to flowering, the highest correlation was observed for 100-seed weight (r=-0.52) and seed yield per plant (r=0.63*). Seed yield per plant showed positive and considerable correlation with hull content and number of days to flowering and a considerable negative correlation with protein content of seeds (Table 2).

DISCUSSION

Results of the present study showed a wide genetic variation for both technological and morphological traits of local populations of safflower from Iran. The hull contents of seeds found in this study were somewhat lower than average hull content reported in the literature[3]. Varieties with hull contents up to 62% have been reported[2]. Lower hull content improves the nutritional quality of the meal and decreases the production cost of the oil.

Protein content of the investigated lines was higher than those reported in the other studies, where it has been found to differ from 12 to 22% on a whole seed basis[3,13]. Results of this study also showed that this breeding lines could be produce oil content, comparably to those reported in the literature[3,13]. The oil and protein content that observed in the line IUTC232 could be related to its low hull content. The observed variant iodine value of these lines is thought to relate to their different fatty acid compositions. According to their iodine value, oil content of the lines namely IUTS211 and IUTK114 is classified as drying oil (Iodine value higher than 130)[3]. It could be concluded that some of the studied lines are acceptable for both nutritional (low hull and high oil and protein content) and industrial (variation in iodine value) purposes.

Between the evaluated breeding lines, only line IUTS211 was early (lower than 90 days) and the rest were late in terms of days to flowering. The number of heads per plant of these lines was in agreement with other reports[14,15]. Number of heads per plant along with 100-seed weight are the major seed yield components of safflower[3]. Argikar and solanki[14] reported that 100-seed weight varied from 3.5 to 7.6 g, which was not in agreement with the present findings.

The negative associations between hull content with oil and protein content means that lower hull content of seeds in safflower could be result in high amount of oil and protein content. Positive correlation between oil and protein content of seeds in this study implies that it is possible to improve both protein and oil content of safflower seeds simultaneously by an appropriate selection program. Also, the results indicated that improvement of seed yield in safflower could be decrease protein content due to negative association between theses traits. Strong correlation between oil content and Iodine value indicating that seeds of genotypes that had high oil content are suitable for food purposes. Also, it was concluded that low seed yielding or early flowering genotypes had seed oil with lower iodine value.

The results of this study showed that number of days to flowering can be used as selection criteria for improvement of seed yield of safflower and selection for improvement of seed yield may have no adverse effect on plant height and seed weight. It can be also concluded that selection for increasing seed yield in safflower may have considerable effect on oil and protein content.

In general, classification of these lines on the basis of morphological characteristics such as plant height, number of heads per plant and number days to flowering showed that Iranian germplasms could be economically beneficial. Also, the amounts of Iodine value of oil indicated that these lines have desirable potential for improvement of oil quality in safflower.

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