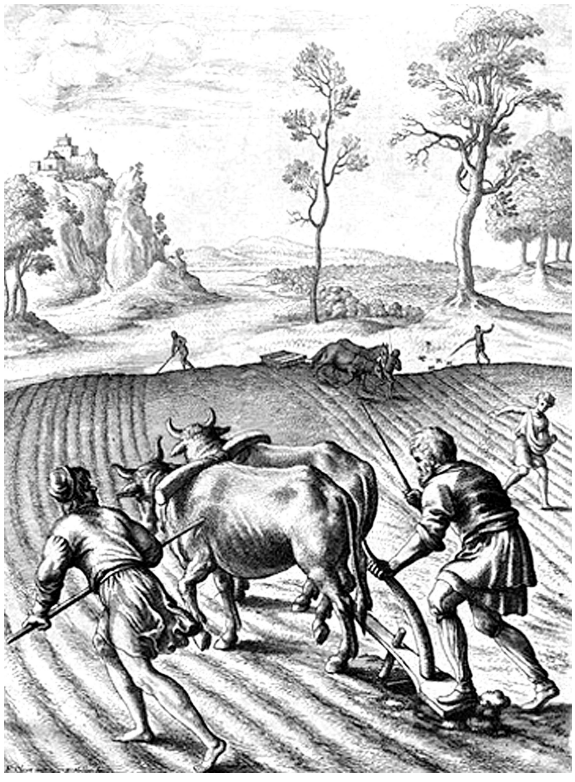
ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY



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Journal of Agronomy 5 (1): 50-52, 2006
ISSN 1812-5379

Genetic Variation in a Safflower Germplasm Grown in Rainfed Cold Drylands

[1]Khoshnoud Alizadeh and [2]Jirair Carapetian
[1]Department of Food and Feed Legumes,
Dryland Agricultural Research Institute, P.O. Box 119, Maragheh, Iran
[2]Department of Biology, College of Science, Urmia University, P.O. Box 165, Urmia, Iran

Abstract: The main breeding objective in growing field crops under rainfed condition is the selection for high performance lines. Traits that are correlated with grain yield may be useful for indirect selection. Genetic variation and correlations for eight agronomically important characters were studied across 45 selected exotic and indigenous safflower pure lines in the Dryland Agricultural Research Institute during two consecutive growing seasons. There was a considerable variation with regard to all characteristics under study in the spring planting. The observed range for plant height (cm), average number of heads per plant, days to flowering, average number of seeds per head, 100 seed weight (g), grain yield (kg ha^{-1}), oil percent and the ratio of kernel to hull were, 61-86, 5-16, 116-134, 10-66, 3.1-5.2, 211-1117, 21.4-31.7 and 0.74-1.44, respectively. Correlation studies indicated that only the average number of seeds per head has a significant positive relationship with grain yield. However, there was a negative significant correlation between grain yield and days to flowering. Genetic gains may be achieved in the future by augmenting number of seeds per head, while increasing earliness of safflower in cold drylands of Iran should also have a beneficial effect on grain yield.

Key words: *Carthamus tinctorius* L., morphological traits, oilseed, rainfed, safflower

INTRODUCTION

The chronic shortage of edible oil in Iran has persisted unabated for the last few decades and it continues to be a major national import. The local edible oil production meets less than 20% of the requirement. For this reason, edible oil production has gained a high priority in Iranian agriculture in recent years. This crisis requires a planned expansion of oil crop research and development to increase domestic production.

Although safflower (*Carthamus tinctorius* L.) can be considered as a suitable oil crop for Iran, its cultivation is risky under conditions of high humidity and rainfall, as excessive moisture causes many diseases. Therefore, tests are needed to identify its area of cultivation in the low rainfall regions of 280-380 mm during the growth period. Out of about 18 million hectares of arable land, cold drylands occupy over three million hectares across Iran. Cropping system is devoted to wheat/pasture in this region and oilseed crops in rotation have not been defined (Anonymous, 2002). Preliminary trials have indicated that no oilseed crop is better adapted than safflower to the low rainfall and stress conditions of cold drylands (Rashid *et al*., 2002). There is a significant variation in local landraces of safflower along with high adaptation to different conditions (Alizadeh, 2003; Pourdad and Beg, 2003). Evaluation of domestic and imported safflower lines is important to identify high oil, high yield and short duration lines for different areas.

The main breeding objective in drylands is drought resistance and the used crterion is grain yield under the stress conditions. Although direct selection for grain yield is the simplest method, but various yield components have their relative effects on this character. Furthermore, heritability of grain yield is low and in particular, it is diminished under stress condition that makes genetic gain very low (Blum, 1985). Traits that are correlated with grain yield may be useful for indirect selection. Trait variation and correlations between grain yield and agronomic traits have been repeatedly studied in safflower (Ashri, 1975; Ashri *et al*., 1975; Yazdi-Samadi 1979; Patel *et al*., 1989; Omidi, 2000). In many cases the reported relationships are highly dependent on the environment and on the material. The efficiency of using a trait as a selection criterion depends on its heritability and genetic correlation to plant performance (Falconer, 1989). Few reports are available for these trait's heritability and genetic correlations with grain yield under conditions of water stress and therefore of their suitability as indirect selection criteria in drylands. This breeding program was aimed to select the high performance safflower lines in rainfed condition. Hence, there is a need to evidence the extent of variation and the type of relationship between agronomic characters.

Corresponding Author: Dr. Jirair Carapetian, Department of Biology, College of Science, Urmia University, P.O. Box 165, Urmia, Iran Tel: 98 (441) 3441258 Fax: 98 (441) 2776707

MATERIALS AND METHODS

Forty five exotic and indigenous safflower pure lines which had been selected from the existing germplasm originating from India, Iran, Pakistan, Spain and USA were evaluated in Dryland Agricultural Research Institute (DARI) located in Northwest of Iran (Maragheh) with an elevation of 1720 m during 2002-2003 and 2003-2004 growing seasons. The total precipitation was 367 and 416 mm during the growing seasons in the consecutive years. Pure lines have been derived in previous years through self-pollination of individual plants from each entry. Spring planting as an alpha lattice design was used and in both planting seasons, trials were managed using standard agronomic practice for safflower cultivation (Alizadeh, 2003). Each plot consisted of six rows, 5 m in length and spaced 30 cm apart.

The characters recorded on plot basis were as follows: Grain Yield (GY) in kg ha^{-1}; Days to Flowering (DF) as number of days from planting time to 50% bloom; Plant Height (PH) in centimeters taken at the time of flowering; Hundred Seed Weight (HSW) in grams; Number of Heads per plant (NH) at maturity; Number of Seeds per head (NS) as average of five randomly selected heads; ratio of Kernel to Hull (K/H) as average ratio in five seeds after 24 h of wetting and Oil content of air dried seeds in Percent (OP). Statistical analyses was conformed using the Residual Maximum Likelihood (REML) procedure (Genstat 5 Committee, 1997).

RESULTS AND DISCUSSION

There was a considerable variation in all characteristics under study in both seasons (Table 1). The observation of significant genotypic variation for all studied characters is a valuable source for selection among accessions and for other breeding purposes. Each one of the studied traits has its specific value and merit in dryland condition. Some of the individual traits such as NH, NS and HSW are yield components and would increase grain yield. PH as a biomass index is a reflection of root growth that is essential in drought resistance. Early flowering is an advantage which provides an escape mechanism by avoiding hot and dry weather during the critical reproductive stage which prevails towards the end of the growing season. K/H and OP characters are direct criteria in oil production of genotypes and they are always positively correlated.

The significant genotypic variance (Table 1) indicates that significant differences exist between at least two genotypes with regard to all of the eight analyzed characters. As a result, superior genotypes were identified and selected for further investigation. However, traits that have significant correlation with seed yield in dryland condition is preferred.

Number of Seeds has a significant correlation with grain yield and there is a significant negative relationship between DF and GY, as well (Table 2). However, results are in contradiction with Omidi (Omidi, 2000). The observed differences are due to different plant materials used in the experiment and the existing differences in the environmental conditions, in particular, the lack of stress condition which provide different relationships. The observed negative correlations between NS and HSW is a common result in all environmental conditions (Omidi, 2000). A similar negative correlation between 100 seed weight and number of seeds per head (r = -0.56**) has been recorded in the evaluation of 23 accessions originating from six countries (Pascual-Villalobos and Alburquerque, 1996). They have also reported negative correlation between seed weight and earliness (r = -0.42*) which was also observed in our experiment. Although the number of heads per plant as a yield component is generally correlated with grain yield, but, we did not

Table 1: Variation among eight agronomic characteristics in 45 safflower genotypes for the combined (2002-2003 and 2003-2004) growing seasons

	Plant height (cm)	No. of heads/plant	Days to flowering	No. of seeds/head	100-seed weight (g)	Grain yield (kg ha^{-1})	Oil (%)	Ratio of kernel/hull
Range	61-86	5-16	116-134	10.00-66	3.1-5.2	211.00-1117	21.4-31.7	0.74-1.44
Mean	70.00	9.40	121.0	36.00	4.12	663.00	27.00	1.020
Genotypic variance	43.22**	6.92**	20.89**	191.29**	0.26*	41586.57**	5.46*	0.02**

* and **, significant at 0.05 and 0.01 level, respectively.

Table 2: Genotypic correlations between eight agronomic traits in 45 safflower genotypes grown in two consecutive years

	Plant height	No. of heads/plant	Days to flowering	No. of seeds/head	100-seed weight	Ratio of kernel/hull	Oil (%)
No. of heads/plant	0.281						
Days to flowering	0.418**	-0.029					
No. of seeds/head	0.104	0.178	-0.150				
Hundred seed weight	-0.381*	-0.040	-0.389**	-0.350*			
Ratio of kernel/hull	-0.130	0.107	-0.212	0.315*	-0.372*		
Oil percent	-0.093	0.302*	-0.370*	0.302*	-0.250	0.528**	
Grain yield	0.064	0.283	-0.390**	0.463**	0.068	0.267	0.231

* and ** Correlation is significant at the 0.05 and 0.01 level, respectively.

observe a significant correlation (r = 0.283) (Table 2). This result may be due to the prevailing stress condition which has imposed a narrow range for head number between 5 and 16, whereas using supplemental irrigation, Pascual-Villalobos and Alburquerque have observed a range of 4 to 116 heads per plant and they had recorded a positive and significant correlation of r = 0.76*** between number of heads per plant and seed yield (Pascual-Villalobos and Alburquerque, 1996).

There was variation for seed oil content among safflower lines in this experiment from 21.4 to 31.7% with an average of 27.0% (Table 1). The amount of kernel and hull in the 45 lines investigated were equal on the average, however, a noticeable variation of 0.74-1.44 existed for this ratio. The white-hulled commercial varieties of safflower under normal growing conditions with supplemental irrigation have an average of 40% hull and in contrast the thin-hulled varieties have been described as having about 25% hull (Applewhite, 1967) which amounts to a K/H ratio of 1.5 and 3.0, respectively. It is possible that in a rainfed condition and stress environment, the embryo development in the seed is hampered and in contrast, the development of the protective hull is enhanced.

The observed significant negative correlation between DF and GY is a reasonable relationship under dryland conditions because longer cycle genotypes suffer late season heat and drought sterss. It is concluded that genatic gains in grain yield may be achieved in future by augmenting number of seeds per head in conjunction with improving earliness of safflower in cold drylands of Iran.

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