GENETIC ANALYSIS OF SEED YIELD RELATED TRAITS UNDER OPTIMUM AND LIMITED IRRIGATION IN SUNFLOWER

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ABSTRACT

In order to estimation of genetic components of variance for agronomic traits of sunflower, 16 single cross hybrids obtained by crossing between four restorer line and four CMS line as tester were evaluated as Randomized Block Design with three replications in two separate optimum and water limited conditions. The resulted data were analyzed as Line × Tester mating design fashion. According to the results under optimum irrigation condition days to maturity, seed weight and oil content were under control of additive effects while plant height was under control of none-additive effects. Flowering time, head diameter and seed and oil yield were under control of both additive and none-additive effects. Under water limited condition days to maturity was under control of additive while plant height, and seed and oil yield were under control of none-additive effects. Flowering time was under control of both additive and none-additive effects. There was a high (82%) general heritability for flowering time and an intermediate for plant height and oil yield (61-62%) under optimum irrigation. Under water limited condition the highest general heritability was obtained for flowering time, seed weight and oil yield. The values for heritability were lower under limited irrigation compared to the optimum condition which it could be resulted because of more environment effect under drought stress. The results of this study implies that selection under stressed condition is complicated and may bring illusory results, so controlling of the environmental condition is very critical in proper estimating of genetic components of variance and it is dependent to homogeneity of genetic materials and environmental condition. With environmental control, selection based methods may be efficient for production of early mature sunflower hybrids under drought condition while there is a necessity of hybridization for improvement of plant height and seed and oil yield.

Key words: Additive effect, Dominance, Heritability, Line × tester

INTRODUCTION

Sunflower whit an annual production of about 41M tones (fao.org) is the third major supplier of edible oil in the world following soybean and rapeseed. Development of hybrids with high genetic potential for seed yield and optimum plant architecture capable of adapting to the specific area of cultivation is the main objective of sunflower breeding programs (Hladni *et a*l., 2011). Breeding for desirable plant characteristics requires information about the nature of gene action and the mode of inheritance of quantitative traits as well as general and specific combining abilities of parental inbred lines. Generally different traits of any plant are under control of additive or none-additive gene action. The relative importance of these components has been reported by many authors in sunflower.

El-Hity (1992) indicated the importance of both additive and non-additive effects in controlling of 1000 seed weight and oil content. Putt (1996) reported that non-additive component was more important than the additive component in governing seed yield in sunflower. Bajaj *et al.* (1997) reported the significance of additive genetic effects in the inheritance of days to maturity, plant height, and 100 achene weight and oil contents. Kandalkar (1997) reported that seed yield was governed by both additive and non-additive genetic effects. Over dominance gene action is reported for plant height, head diameter, oil content, 100 seed weight and seed and oil yield (Gangappa *et al*, 1997). Singh *et al.* (1999) reported the predominance of non-additive genetic effects for achene yield, oil content. Ashok *et al.* (2000) found additive gene effects for seed yield. Sharma *et al.* (2003) reported the importance of additive genetic effects in the inheritance of head diameter, achene yield per plant and oil contents. Farrokhi (2003) reported that plant height, growth duration, head diameter, 1000 achene weight, achene yield and oil contents were under control of both additive and non additive effects. Parameshwari *et al.* (2004) reported the dominance of non-additve genetic effects for days flowering, plant height, head diameter, 100 achene weight and oil contents. Devi *et al*. (2005) reported that achene yield and its components were predominantly governed by non additive genetic effects. Jan *et al*. (2005) showed dominance of non additive genetic effects for achene yield. Mijic *et al*. (2006) reported that both additive and dominant variances were involved in inheritance of 1000 achene weight.

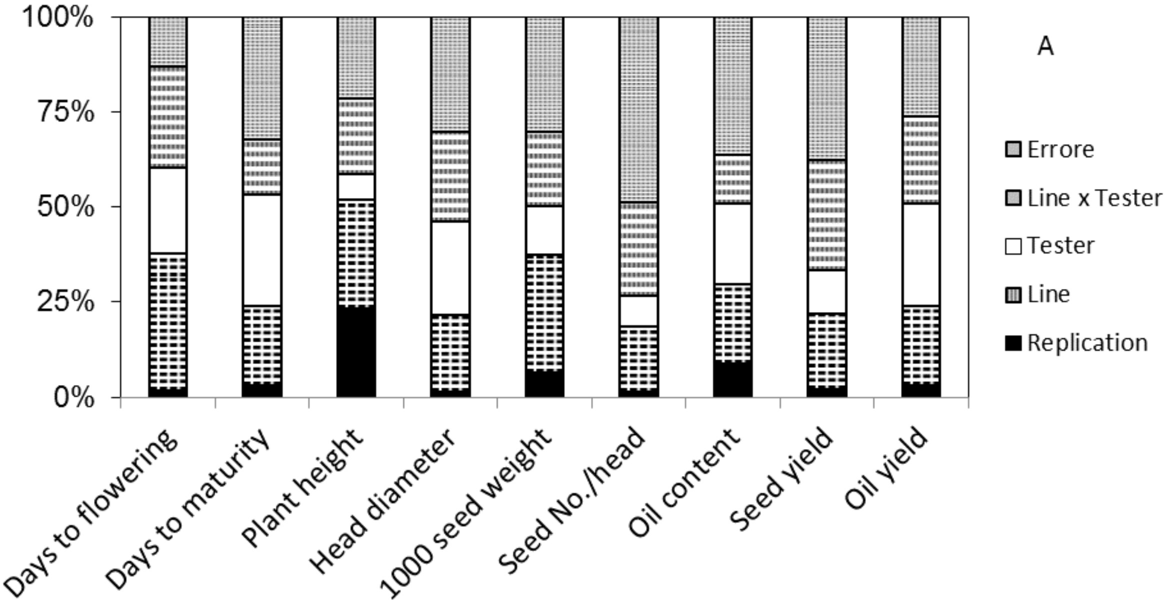
Skoric *et al.* (2007) stressed the non-additive gene effects on oil percentage. Karasu *et al.* (2010) reported significant general combining ability for plant height, 1000 seed weight and seed number per head. They found that the non-additive effects were the most effective than other type of polygenetic effects. The gene action was changed across the years, for example additive gene action was significant for number of achenes per head and 1000-achene weight in one year but not in the second. Ghaffari *et al.* (2011) reported that days to maturity, 100 achene weight, number of achenes per head and achene yield were under the control of both additive and dominant effects, however plant height and oil contents were controlled predominantly by additive effects and life cycle duration and achene yield were controlled by dominant effects. Nooryazdan *et al*. (2011) reported additive genetic effects for days to 50 percent flowering, branching and plant height. Machikowa *et al*. (2011) reported that the additive genetic effect for these traits was more important than non additive effect for 1000 achene weight and plant height, achene yield, head diameter and oil content. According to the results of Tabrizi et al. (2012) plant height, head diameter, empty seeds per head, days to beginning of flowering, days to maturity, stem diameter and 1000 seed weight were found to be controlled mainly by additive gene effects and over-dominance effect was important for days to end of flowering. Oil yield, oil percent, head dry weight, seed weight per head, seed yield and hulled seed yield were under the control of both additive and non-additive effects.

MATERIALS AND METHODS

The experiment was carried out in Khoy Agricultural and Natural Resources Research Station in Iran. The station located in 38° 32' north latitude and 44° 58' east altitudes. The 16 single cross hybrids obtained by crossing between four restorer lines by four CMS lines as tester were evaluated as Randomized Block Design with three replications under optimum and water limited conditions. Each experimental plot consisted of 3 rows of 4 m length with 60 x 25 cm spacing between and within rows. Fertilizers were applied at the rate of 100:70:90 kg/ha for N: P: K. Drought stress was imposed by water withholding in R4-R6 growth stage. During the growth season agronomic traits as days to flowering and maturity, plant height, head diameter and seed and oil yield and the related components were measured. The resulted data subjected to line x tester analysis (Kemptorne, 1957) to estimate respective genetic variance components.

RESULTS AND DISCUSSIONS

According to the results the restorer lines explained the most part of genetic variance for flowering time, plant height and seed weight, while testers (CMS lines) had the main role in explaining of the genetic variance of days to maturity, head diameter, oil content and oil yield under optimum irrigation condition. Line × tester interaction effects were important for seed number per head and seed yield (Fig. 1A). The lines had also explained the most of variability for days to flowering, plant height and 1000 seed weight under water limited condition, however except days to maturity the variability of other traits were explained by line × tester interaction effect (Fig. 1B). This indicate that different line tester combinations can provide more variability under drought condition which itself could be aroused from activation of drought responsive genes (Oncel et al. 2000; Shao et al. 2008; Skoric, 2009). These changes may act as a protective and adaptability factor against drought condition; however the response of genotypes could be different under drought condition which affects the line × tester interaction component.



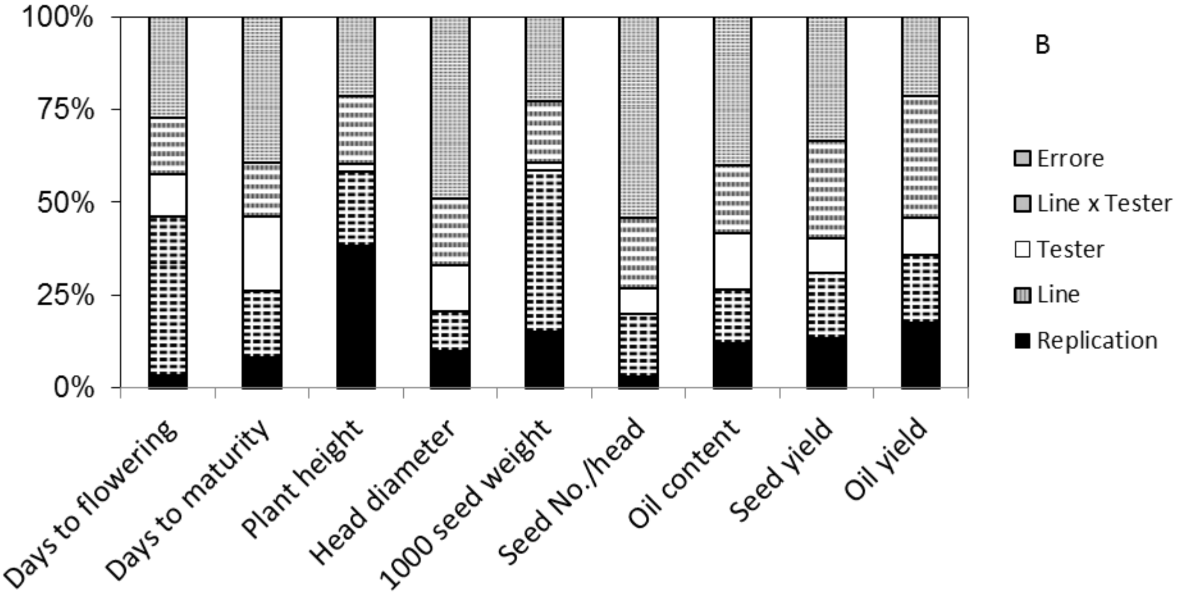


Fig.1. Relative contribution of different components on genetic variance components of agronomic traits under A) Optimum irrigation and B) water limited conditions.

The results indicated that under optimum irrigation condition growth period, seed weight and oil content were under control of additive effects, while plant height was under control of none-additive effects (Fig.2). Flowering time, head diameter and seed and oil yield were under control of both additive and none-additive gene effect. It is concluded from literature that generally the qualitative traits are predominantly under additive gene action (Singh *et al*. 1999; Sharma *et al.* 2003; Ghaffari *et al.* 2011; Nooryazdan *et al*. 2011), while quantitative characteristics as seed/oil yield are under control of both additive and non-additive gene actions (Putt, 1996; Gangappa *et al*, 1997; Devi *et al*. 2005; Jan *et al*. 2005a; Ghaffari *et al.* 2011; Tabrizi et al. 2012). Because of controversy reports it is impossible to determine absolute effect of gene action for a given trait.

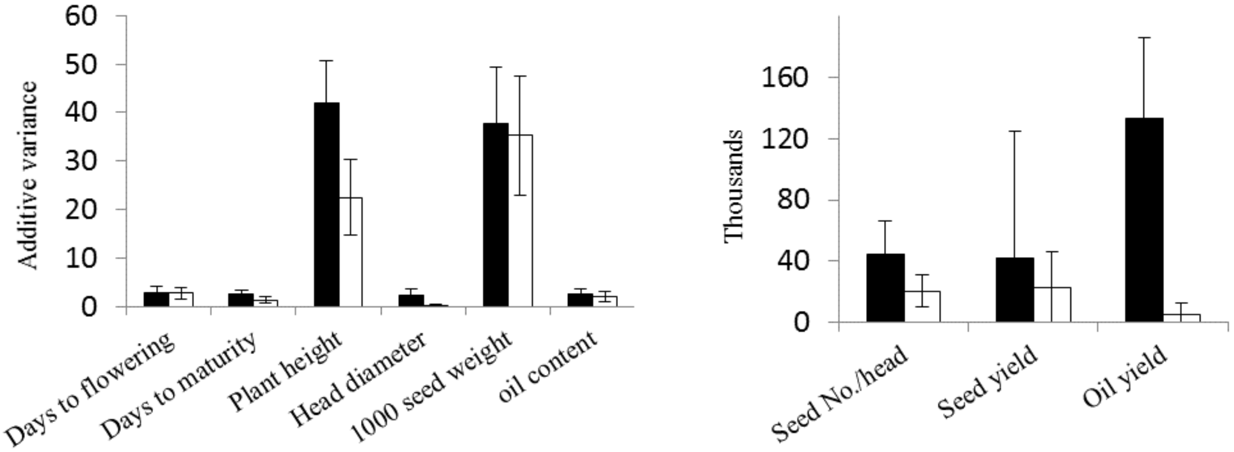


Fig. 2. Additive variance for agronomic traits under well watered (dark bars) and drought stressed condition (white bars)

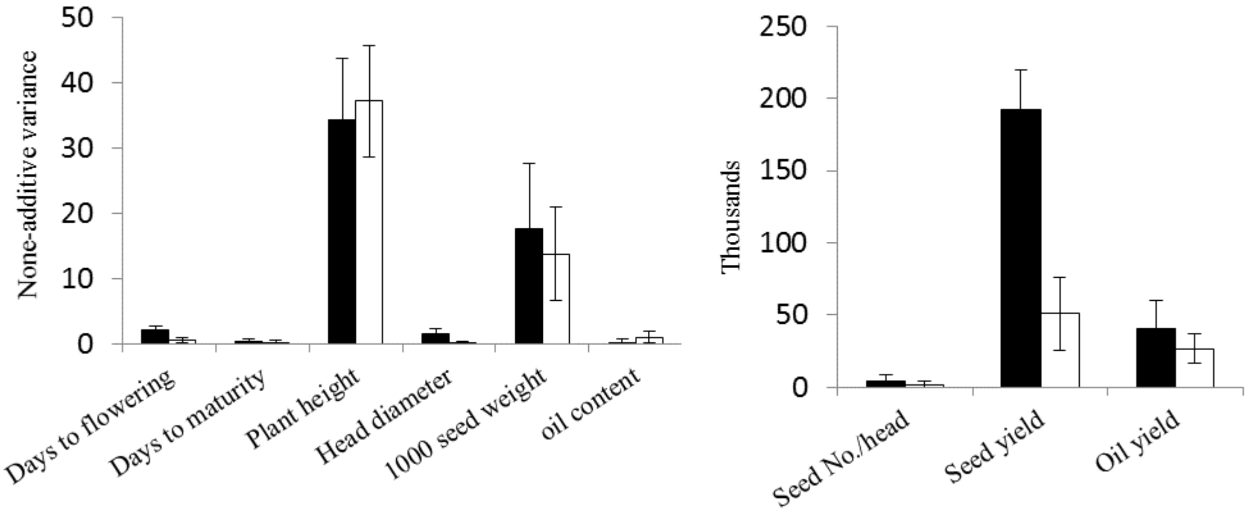


Fig.3. None- additive variance for agronomic traits under well watered (dark bars) and drought stressed condition (white bars)

Under water limited condition days to maturity was under control of additive while plant height, and seed and oil yield were under control of none-additive effects (Fig.3). Flowering time was under control of both additive and none-additive effects. These results is in accordance with other reports under non-stressed condition (putt, 1996; Bajaj et al. 1997; Gangappa et al. 1997; Devi et al. 2005; Parameshwari *et al.* 2004 and Nooryazdan *et al*. (2011). Comparison of genetic components showed that additive effects for plant height, head diameter and oil yield are significantly higher in optimum condition compared with stressed condition. There were also significant differences for days to flowering, head diameter and seed and oil yield. To the best of author's knowledge there is no information about genetic control of sunflower traits under drought condition. The results of this study indicated that additive gene action is restricted under drought condition which it could be resulted because of higher environmental effects on estimated variances. Karasu *et al*. (2010) indicated that the gene action was changed across the years, for example additive gene action was significant for number of achenes per head and 1000-achene weight in one year but not in the second.

There was high (82%) broad sense heritability for flowering time and intermediate for plant height and oil yield (61-62%) under optimum irrigation (Table 1). There was an intermediate heritability for days to flowering and maturity and oil content. Narrow sense heritability Estimates were low for all traits except seed number per head. Under water limited condition the highest broad sense heritability was obtained for flowering time, seed weight and oil yield (Table 2). The values for heritability were lower under limited irrigation compared to the optimum condition which it could be resulted because of more environment effect under drought stress. These results indicate that the effect of environment is higher than genotype under stressed condition which could reduce the efficiency of selection under drought condition. Alza and Fernandez (1997) reported higher narrow sense heritability estimates for various sunflower traits as seed yield, number of seeds per head, seed weight, head diameter; oil content and days to bloom. On the contrary, Sayed *et al*. (2013) reported low narrow sense heritability estimates for seed and oil yields. The lower narrow sense heritability estimates in this study indicated the importance of non-additive gene effects for the agronomic traits in the sunflower genetic materials which were used in this experiment.

Table 2. Heritability estimates for agronomic traits under well watered condition

	Days to flowering	Days to maturity	Plant height	Head diameter	Seed weight
h^2_B	0.82	0.55	0.61	0.57	0.51
h^2_N	0.47	0.47	0.33	0.34	0.32
	Seed number	Oil content	Seed yield	Oil yield	
h^2_B	0.70	0.45	0.39	0.73	
h^2_N	0.64	0.42	0.07	0.56	

Table 2. Heritability estimates for agronomic traits under drought stressed condition

	Days to flowering	Days to maturity	Plant height	Head diameter	Seed weight
h^2_B	0.62	0.40	0.50	0.21	0.64
h^2_N	0.51	0.35	0.19	0.15	0.46
	Seed number	Oil content	Seed yield	Oil yield	
h^2_B	0.49	0.35	0.12	0.31	
h^2_N	0.46	0.24	0.09	0.07	

CONCLUSIONS

The results of this study implies that selection under stressed condition is complicated and may bring illusory results, so controlling of the environmental condition is very critical in proper estimating of genetic components of variance and it is dependent to homogeneity of genetic materials and environmental condition. With environmental control, selection based methods may be efficient for production of early mature sunflower hybrids under drought condition while there is a necessity of hybridization for improvement of plant height and seed and oil yield.

LITERATURE

Alza JO, Fernandez-Martinez, JM. 1997. Genetic analysis of yield and related traits in sunflower (*Helianthus annuus* L.) in dry-land and irrigated environments. *Euphytica*, *95*(2), 243-251.

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