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Full Length Research Paper

Yield potential evaluation and path analysis of different sesame genotypes under various levels of iron

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In order to evaluate yield potential of different genotypes of sesame under different levels of iron micronutrient and determinate the most effective traits on the yield, the experiment was carried out as split plot based on randomized complete block design at Jiroft during 2008. Treatments consisted of three levels of Fe fertilizer (chalet 138) (0, 5 and 10 kg/ha) as the main factor and different genotypes of sesame (Markazi, Shahrbabak, Birjand, Dezfoul, Jiroft, Sirjan, Gorgan, Ardestan and Orzouyeh landraces) as the sub factor. Traits such as plant height, number of stem per plant, number of capsules per plant, number of capsules per main stem, capsule length, and number of seeds per capsule, weight of 1000-seed, seed yield, biological yield and harvest index were studied. Different statistical analysis such as ANOVA, correlation and path coefficient analyses were used. According to results ANOVA, genotypes were significantly different for all traits and Jiroft genotype was considered as the best one for cultivation at this region. Except 1000-seed weight, Fe micronutrient had no significant effect on understudied traits, also the interaction of fertilizer and genotype was not significant. It was concluded that the fertilizer did not have effective role on yield of studied genotypes. Seed yield showed highly positive and significant correlation with plant height, capsule length, number of seeds per capsule, 1000-seed weight, number of stem and biological yield ($p<0.01$) and positive significant correlation with number of capsules per plant ($p<0.05$). Based on path analysis, seeds number per capsule had the highest positive direct effect on seed yield and can be considered as a criterion for improving seed yield in breeding programs.

Key words: Sesame, Fe micronutrient, yields potential, path analysis.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest oil crops and is widely cultivated in Asia and Africa. It is an important source of edible oil and is widely used as a one of the ingredients in food products especially in bakery foods and animal feed. Sesame oil has medicinal and pharmaceutical value and is being used in many health cure products. Sesame seed contains 50 to 60% oil and 25% protein with antioxidants lignans such as sesamolin, sesamin and has been used as active ingredients in antiseptics, bactericides, vermicides, disinfectants, moth repellants, anti-tubercular agents (Bedigian et al., 1985) and considerable source of calcium, tryptophan, methionine and many minerals (Johnson et al., 1979).

Micronutrient deficiency can greatly disturb plant yield and quality and the health of domestic animals and human (Cakmak, 2002; Malakouti, 2007). Among the micronutrients reported as becoming deficient worldwide, zinc (Zn) and iron (Fe) are the most important elements (Lucca et al., 2001; Cakmak, 2002; Welch, 2002).

In an experiment on safflower, using 30 kg S per ha plus Fe and Zn foliar spraying caused the highest yield of

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the plants (Ravi et al., 2008). Moralidharudu (2006) reported that increasing of Zn and Fe levels causes the enhancement of sesame yield. Suresh et al., (1994) stated that Fe deficiency in sesame decreases a and b chlorophyll, photosynthesis rate and plant growth. The correlation between yield components has been extensively studied in sesame. For instance, Sharaan and Ghallab (1997) reported positive correlation of seed yield with branches per plant, capsule number per plant and plant height in sesame. Positive and significant association was established between morphological characters like plant height, branches per plant and capsule number with seed yield (Ganesh and Sakila, 1999). In another study, Yingzhong and Yishou (2002) found significant and positive correlation between seed yield per plant, capsule number and plant height while Sarwar et al. (2005) observed that the number of branches and capsule per plant had highly significant and positive phenotypic correlation with seed yield. In plant breeding, path analysis which is partitioning of the correlation coefficient into its components of direct and indirect effects has been widely used to identify traits that have significant effect on yield for potential uses in selection (Milligan et al., 1990; Williams et al., 1990 and Mohammadi et al., 2003). This technique is useful in determining the direct influence of a variable on another (Rodriguez et al., 2001; Yucel, 2004). By the path analysis of sesame, with some other genotypes showed that capsule number per plant and plant height had positive significant correlation and direct effect on sesame seed yield.

This research was carried out to evaluate seed yield potential of sesame different genotypes, as well as detecting the most effective traits on the yield and to determine the best advisable level of Iron for Sesame genotypes (Table 1).

MATERIALS AND METHODS

This experiment was carried out at Anbarabad Research Station of Horticultural Research Institute- Shahid Bahonar University of Kerman during summer season of 2008. In order to determine physical and chemical properties of experimental field soil, sampling was done from 30 cm of soil surface. Soil analysis is mentioned.

The experiment was arranged through split plot based on randomized complete block design with three replications. Treatments consisted of three levels of Iron fertilizer (chalet 138) (0, 5, 10 kg/ha^{-1}) as the main factor and sesame different genotypes (Markazi, Shahrbabak, Birjand, Dezfoul, Jiroft, Sirjan, Gorgan, Ardestan and Orzouyeh landraces) as the sub factor.

Fertilizers such as P (triple super phosphate, 100 Kg/ha) and K (potassium sulfate, 130 Kg/ha) were added to the soil before cultivation. Nitrogen fertilizer (urea, 250 Kg/ha) was used in three times: sowing time then when plants reached to 30 cm and the last was before flowering. Rows length and sowing depth were 3 m and 2 cm respectively. Iron treatment was applied to main plots 30 days after cultivation. Sampling was done during growing season and traits such as plant height, number of stem per plant, number of capsules per plant, number of capsules per main stem, capsule length, number of seeds per capsule, 1000-seed weight, seed yield, biological yield and harvest index were studied.

Each plot was containing of 4 rows by 4 meters length, yield components were measured based on 10 random samples from the 2 middle rows of 4 rows per plot seed yield and biological yield were assessed based on internal row with 2.5 m length at the middle of plot after removing marginal. Firstly simple phenotypic correlation coefficients among all observed traits were calculated using SPSS software then separated into direct and indirect effects through path coefficient analyses as suggested by Rodriguez et al. (2001) and Yucel (2004). By SAS software, for path analysis seed yield was considered as dependent variable while other characters were considered as independent variable.

RESULTS AND DISCUSSION

Phenotypic evaluation of Iranian sesame genotypes

According to analysis of variance, different genotypes were highly significant for all traits (Table 2). Based on means comparison, in the Table 3, Jiroft and Gorgan landraces had the highest (181.28 cm) and the lowest (97.33 cm), Plant height respectively. Birjand landrace showed the most number of capsules per plant (141.78) while it was the least for Gorgan (71) and Ardestan (73.44) landraces. Zainali (1998) also reported significant differences among sesame genotypes for this trait. Jiroft landrace had the highest seed number per capsule (75.66) and capsule length (3.31mm) while Shahrbabak landrace showed the lowest seed number per plant (44.55) and Markazi landrace had the lowest capsule length (2.47mm). The most stem number per plant was related to Orzouyeh landrace (4.85). Dezfoul landrace revealed the highest (3.5 gr) and Gorgan landrace revealed the lowest (2.5 gr) 1000-seed weight. Ardestan landrace had the most (73.44) and Markazi landrace the lowest (31.66) capsule number per main stem. The maximum of seed yield was shown by Jiroft (3.34 ton/ha) and Orzouyeh (3.05 ton/ha) landraces and it was minimal for Gorgan landrace (0.77 ton/ha) (Table 3). The most biological yield was seen in Jiroft (13.9 ton/ha) and the least in Gorgan (3.67 ton/ha) landraces. Orzouyeh and Dezfoul landrace showed the highest harvest index by amount of 43.51 and 40.70 respectively, while Shahrbabak showed the lowest harvest index (21.95) (Table 3).

Genetic variation of Iranian sesame landraces for all studied traits showed good potential of these landraces for using in breeding programs and it was confirmed Jiroft landrace is the best due to its adaptation at this region and it can be recommended to farmers.

Evaluation of Iron effects on sesame

Iron micronutrient affected 1000-seed weight significantly ($P<0.05$) and it was no significant for the traits such as stem number per plant, capsule number per plant, capsule length, seed number per capsule, seed yield, biological yield and harvest index. Based on using 10

Table 1. Physical and chemical properties of experimental field soil.

Soil texture	Absorbable iron (ppm)	Absorbable potassium (ppm)	Absorbable phosphate (ppm)	Absorbable nitrogen (ppm)	EC	pH	Sampling depth (cm)
Sandy- loam	2.5	174	3.4	0.002	1.87	7.5	0-30

Table 2. Variance analysis of sesame understudied traits.

S.O.V	DF	Plant height (cm)	Capsule number per plant	Seed number per capsule	Capsule length (mm)	Stem-number per plant	1000 seed weight (g)	Seed yield (ton/ha)	Biological yield(ton/ha)	capsule number per main stem	Harvest index (%)
Rep	2	2357.46	1035	34.1	0.06	0.025	0.037	144771.05	1695077.9	189.9	60.51
Iron	2	$0.25^{n.s}$	$171.89^{n.s}$	$175.89^{n.s}$	$0.04^{n.s}$	$2.82^{n.s}$	0.231^{*}	$55049.19^{n.s}$	$2487045.2^{n.s}$	$6.57^{n.s}$	$6.81^{n.s}$
Error A	4	158.95	2352.65	210.19	0.04	1.55	0.027	397320.96	2629936.9	166.37	15.28
Genotype	8	3570.3^{**}	4743.5^{**}	105.2^{**}	0.61^{**}	14.98^{**}	0.758^{**}	3845374.6^{**}	53752827.7^{**}	1771.7^{**}	363.51^{**}
Genotype* Iron	16	$173.05^{n.s}$	$445.41^{n.s}$	$46.98^{n.s}$	$0.021^{n.s}$	$0.17^{n.s}$	$0.079^{n.s}$	$103154.04^{n.s}$	$2100946.2^{n.s}$	$111.31^{n.s}$	$13.44^{n.s}$
Error B	48	177.38	880.03	72.72	0.042	0.82	0.045	247985.52	2079699.1	101.05	44.43
CV		10.40	28.80	14.35	7.2	31	6.71	26.88	22.68	22.71	22.55

*: Significant (P<0.05), **: Highly significant (P<0.01) and ns: non significant.

Table 3. Means comparison of different genotype for traits of sesame.

Harvest index (%)	Capsule no. per main stem	Biological yield (ton/ha)	Seed yield (ton/ha)	1000-seed weight (gr)	Stem no per plant	Capsule length (mm)	Seed no per capsule	Capsule no per plant	Plant height (cm)	Genotype
28.66^{d}	31.66^{d}	$4.47d^{e}$	1.26^{cd}	3d	2.75^{cd}	2.47^{f}	47.55^{ef}	80.33^{cd}	106.32^{ef}	Markazi
26.95^{b}	61.62^{b}	6.55^{b}	1.42^{c}	3.27a-c	3.14^{b-d}	2.52^{ef}	44.55^{f}	124.89^{ab}	131^{b-d}	Shahrbabak
26.67^{b}	42.77^{c}	4.87^{c-e}	1.35^{c}	3.35ab	3.25^{b-d}	2.85^{c-e}	55.22^{ce}	141.78^{a}	117.89^{de}	Birjand
40.70^{a}	43.11^{c}	5.82^{b-d}	2.36^{b}	3.5a	3.75^{bc}	3.17^{ab}	68.78^{ab}	107.44^{bc}	123.33^{cd}	Dezfoul
27.96^{b}	40.33^{cd}	13.90^{a}	3.34^{a}	3.33a-c	3.87^{b}	3.31^{a}	75.66^{a}	110.13^{bc}	181.28^{a}	Jiroft
24.91^{b}	40.88^{cd}	7.17^{b}	1.75^{c}	3.16b-d	2.88^{b-d}	2.71^{bc}	61.11^{bc}	112.56^{ab}	139.11^{b}	Sirjan
25.99^{b}	32.44^{cd}	3.67^{e}	0.77^{d}	2.5e	2.44^{d}	2.85^{df}	51.44^{df}	71^{d}	97.33^{f}	Gorgan
25.62^{b}	73.44^{a}	6.07^{bc}	1.46^{c}	3.27a-c	2.1^{e}	2.75^{cd}	59^{cd}	73.54^{d}	$132.^{bc}$	Ardestan
43.51^{a}	34^{cd}	6.66^{b}	3.05^{a}	2.11cd	4.85^{a}	3.05^{a}	72.11^{a}	100.11^{b-d}	133.55^{bc}	Orzouyeh

Columns means followed by the same letter are not significantly different at 0.05 or 0.01 significance level.

1000-seed weight (3.25 g), while the lowest 1000-wieght was obtained by no fertilizing (3.07 g) also a slight increase in seed yield by Fe increasing from 1.56 to 2. 02 (ton/ha) but it was non significant (Table 4). Genotype and Iron interaction was not significant for understudied

Table 4. Means comparison of Iron fertilizer for traits in sesame.

Fertilizer	Plant height (cm)	Capsule number per plant	Seed number per capsule	Capsule length (mm)	Stem number per plant	1000-seed weight (g)	Seed yield (ton/ha)	Biological yield (ton/ha)	Capsule number per main stem	Harvest index (%)
Level 1 (0 Kg/ha)	125.60^{a}	100.50^{a}	57.50^{a}	2.84^{a}	2.68^{a}	3.07^{a}	1.56^{a}	6.48^{a}	44.07^{a}	29.85^{a}
Level 2 (5 Kg/ha)	128.85^{a}	104.33^{a}	58.22^{a}	2.81^{a}	3.09^{a}	3.17^{ab}	1.95^{a}	6.01^{a}	44.18^{a}	30.01^{a}
Level 3 (10 Kg/ha)	128.74^{a}	104.4^{a}	62.37^{a}	2.88^{a}	3^{a}	3.25^{a}	2.02^{a}	6.60^{a}	44.51^{a}	28.73^{a}

Columns means followed by the same letter are not significantly different at 0.05 or 0.01 significance level.

Table 5. Correlation coefficients between the measured traits.

Trait	Plant height (cm)	Capsule number per plant	Seed number per capsule	Capsule length (mm)	Stem-number per plant	1000 seed weight (g)	Seed yield	Biological yield	Capsule number per main stem	Harvest index
Plant height (cm)	1									
Capsule number per plant	0.32^{**}	1								
Seed number per capsule	0.41^{**}	0.098	1							
Capsule length (mm)	0.43^{**}	0.18	0.7^{**}	1						
Stem-number-per plant	0.39^{**}	0.33^{**}	0.24^{*}	0.18	1					
1000 seed weight (g)	0.12	0.4^{**}	0.21	0.27^{*}	0.12	1				
Seed Yield	0.64^{**}	0.25^{*}	0.61^{**}	0.56^{**}	0.46^{**}	0.31**	1			
Biological yield	0.73^{**}	0.29^{**}	0.41^{**}	0.4^{**}	0.24^{*}	0.10	0.66^{**}	1		
Capsule number per main stem	0.21	0.16	-0.10	-0.21	0.24^{*}	-0.05^{**}	-0.08	0.14	1	
Harvest index	-0.04	-0.14	0.33^{**}	0.26^{*}	0.15	0.31	0.44^{**}	0.08	-0.03^{*}	1

*: Significant (P<0.05), **: Highly significant (P<0.01).

(kg/ha) of the micronutrient caused the highest traits; this revealed that different genotypes had the same response to Iron.

Correlation analysis

Correlation analysis (Table 5) showed highly positive significant correlation of plant height, capsule length, seed number per capsule, 1000-seed weight, stem number per plant and biological yield with seed yield (P<0.01). Positive significant correlation was also seen between seed yield and capsule number per plant (P<0.05) (Table 5).

This suggests that any increase in such traits will lead to seed yield improvement. Biswas and Akbar (1995) reported positive and significant correlation between seed yield and number of capsules per plant, 1000-seed weigh(g) which is in concordance with the present result.

Path analysis

According to path coefficient analysis, seed number per capsule caused the highest positive direct effect on seed yield and its indirect effect via other traits (capsule number per plant and1000-seed weight) was the least.

The next affecting trait that caused high direct effect on seed yield was capsule number per plant and its main indirect effect was through seed

Table 6. Path coefficient analysis of sesame seed yield to direct and indirect effects.

Indirect effect via			Direct effect	
1000-seed weight	**Seed number per capsule**	**Capsule number per plant**		**Traits**
0.042	0.56	---	0.152	Capsule number per plant
0.031	---	0.014	0.571	Seed number per capsule
---	0.14	0.05	0.128	1000-seed weight

number per capsule.

The direct effect of 1000-seed yield on yield was positive and its indirect effect via seed number per capsule was positive and higher than its direct effect (Table 6). Yingzhong and Yishou (2002) reported number of capsule per plant had the highest direct effect on seed yield per plant. Shim et al. (2001) indicated the culm length and number of capsules per plant had highest direct effects on grain yield in sesame. Lee et al. (1986) also reported that number of capsules per plant, 1000-seed weight and number seed per capsule had high direct effects on grain yield. The present result identified number of seeds per capsule, 1000-seed weight, and number capsules per plant as yield components to which priority should be given during selection for higher seed yield in sesame. In this study seed number per capsule had the most direct effect on seed yield and also the highest correlation of traits with seed yield and was related to seed number per capsule (Table 5). Therefore, this trait can be considered as a criterion for improving seed yield in breeding programs.

Conclusion

There is a high phenotypic variation in Iranian Sesame landraces. Utilization of Fe increased 1000- seed weight and slightly increased seed yield with non effects on the other traits, it could be due to the role of iron in chlorophyll. Also there were no interaction effects of genotypes* Iron, it means sesame genotypes had the same reaction to Iron. There was a positive correlation between yield and yield components. This suggests that any increase in such traits will lead to seed yield improvement. Seed number per capsule had the most direct effect on seed yield and also the highest correlation with seed and it can be considered as a criterion for improving seed yield in breeding programs finally in this study Jiroft landrace with application of 10 kg of iron which had the highest seed yield, is recommended for sesame production.

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