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# Yield and Yield Components in Terms of Moisture Stress and Non-Stress Conditions in the Spring Safflower Varieties

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## Abstract:

**Safflower (*Carthamus tinctorius* L) is a native of Iran oil seed. This crop is compatible with the environmental conditions in the country as well; this is especially true in areas exposed to non-biological stresses such as drought and salinity. In 2000, a research was conducted to investigate the relationship between two sets of variables. This research was in split- plot form with completely random block designs, twice the normal (7 irrigations) and two drought (6 and 5 irrigations, respectively) using 26 spring safflower varieties. In this study, several parameters were measured and studied: days to germination, days to stem growth, days to 50% budding, days to 50% flowering, days to 100% flowering, bush height, number of bolls per plant, seeds per boll, 1000 grain weight, plant performance, and oil content measuring. In this study, canonical analysis was performed between the two groups of phonological characteristics and traits related to yield and yield components. The results showed the impact of 1000 grain weight and yield per plant on W1 function and in terms of severe stress. But function V1 is influenced by some phonological traits especially the number of days to 100% flowering, the number of days to 50% flowering and the number of days to 50% budding. In terms of moderate stress (6 times irrigations), W1 function is greatly influenced by 1000-grain weight but some phonological traits like days to 100% flowering, days to 50% flowering and days to 50% budding impress function V1. In fact for the selection of cultivars for height yield under both stress conditions, these can be considered as an appropriate criterion: days to 100% flowering, days to 50% flowering and days to 50% budding. Based on the results of canonical correlation analysis and in terms of non-stress conditions, W1 function is influenced by 1000-grain weight but V1 function is influenced by some phonological traits such as the days to 100% flowering and days to 50% flowering. So for the selection of cultivars for height yield under normal conditions, we can consider the days to 100% flowering and the days to 50% flowering as appropriate phonological criterion.**

**Keywords**: canonical correlation analysis, phonological characteristics, safflower

## 1.0 Introduction:

Safflower (*Carthamus tinctorius* L) is one of the oil plants native to Iran. Safflower oil has a significant quality, as its linoleic acid is between 73 to 85 percent. Relative tolerance to drought and salinity of the soil profile is typical of this plant (Ahmadi et al. 1975). In breeding programs, not considering to the relationship between traits and selecting for one trait may not have good results. Therefore, in order to plan properly for the selection program, it is necessary to emphasize the correlations between traits. The simple correlation coefficient to determine the relationship between yield and its components and the relations between components are widely used (Bensalah et al.,2001)

In order to improve traits such as yield and oil yield that different ratios of the components are involved in their formation, the determination of important relationships and correlations between different traits can reveal the contribution of each variable in the expression of these complex traits. Ehdaei and Noormohammadi (1963)Solanaki and Paliwal mentioned the positive and significant correlation between yield and traits such as 1000-grain weight, number of seeds per boll, percent oil and plant height. Rao et al (1977) reported that traits like the number of boll per bush and seed performance in plant correlate to each other so much and between the yield components, the number of boll per bush impressed seed performance. Solanaki and Paliwal (1979)

mentioned the significant and positive correlation between grain yield and grain traits such as number of seeds per boll, boll number per plant and 1000-grain weight. Bratulean (1991) announced that there is a significant and positive relationship between grain yield and number of bolls per plant and also between 1000-grain weight and performance but non- significantly positive relationship between performance and the number of seeds per boll. Patil (1985) Solanaki and Paliwal was confirmed a significant positive correlation between 1000-grain yield and weight. Kumer et al (1982) reported that plant height, boll size and seed number per boll have significant and positive correlation with grain and oil yield, they announced this fact after checking safflower figures and the usage of causality analysis. Godrati (1976) with causality analysis revealed that traits such as the number of bolls per plant and seed weight per boll were most important factors affecting crop yield by a correlation coefficient of 0/96 %. Being aware of the occurrence of any of the development stages is a good guidance provided favorable conditions for vegetative growth and reproductive potential of the crop, because the duration of these two periods determines the biological and economical yield(Sarmadnia and Koochaki, 1968). In this context, Bagheri (1974) in his study mentions the developmental stages of safflower as budding, stem elongation, voting buttons, flowering and physiological maturity(Able,1975; Ashri etal., 1974; Bagheri 1974; Shaneiter and Miller,1981).

In the event of crop varieties, there are different phonological stages(Shahsavari et al., 1972). It means that besides environmental factors, genetic characteristics related to the variety has determinant role during the developmental processes. The relationship between performance and development stages somewhat have been studied, but little research about this relationship in safflower has been done. However Zand (1974) in a study which conducted on three groups of genotypes with high, medium and low yield winter crop in Mashahd revealed that different groups are significantly different in terms of developmental stages. Zheng et al(1993) investigated the duration of the flowering stages in the safflower varieties and reported a significant positive correlation between flowering and performance. Pandya et al (1996) investigated 100 lines of safflower in India and reported significant and positive correlation between bush yield and days to 75% maturity. The aim of this study was to determine the relationship between under evaluated traits and also the one between two sets of variables in 26 spring safflower varieties by canonical correlation analysis.

## 2.0 Materials and Methods:

In a study, 26 spring safflower cultivars as subplots B of drought resistance in three different levels of irrigation were investigated in a split-plot form study with completely random block designs. This research was conducted in East Azerbaijan agriculture research centre located 20 km of Tabriz – Azarshahr road. 26 safflower varieties have been used: BONAB L, MIANEH L1, MARAND L1, MIANEH L2, MARANDL2, MARAND L3, LANGARMAHAN L, ZARGHAN L2, ZARGHAN L3, ZARGHAN L4, KERMAN 1, ZARAND, KERMAN 2, ZARAND, KORDESTAN 2, ESFAHAN L, BROOJERD L, NISHABOOR L, N974051, V -51-242, N51016, NEBRASKA 825, a-1, TOMJIC, N.5, 6151, D51-361 and 24-1.

Each experiment was repeated with three main plots and 26 sub-plots within the main plot of 2*3 m occurred. The evaluated traits in this study were: number of days from sowing to germination, sowing to stem growth, sowing to 50% budding, sowing to 50% flowering, sowing to 100% flowering, bush height, boll number per plant, seed number per plant, 1000-grain weight, plant performance and oil content.

## 3.0 Results and Discussion:

### 3.1 Canonical Correlation Analysis under Severe Stress:

These results are in table 1 to 7. Wilkes Lamyday Statistics levels were significantly less than 1 percent for the first function. It means that there is meaningful correlation between phonological variables in first function from one side and in yield components from another side. For the first function, a linear combination of the variables studied phonological and yield components with the coefficients obtained as follows:

$$W_1 = -0/20X_1 - 0/09X_2 - 0/02X_3 + 0/31X_4 + 0/16X_5$$
$$V_1 = -0/15Y_1 - 0/01Y_2 + 0/08Y_3 + 0/14Y_4$$

Structural correlation between measured variables of a group with the canonical functions of the same group is in tables 4 and 5. In the phonological variables, the number of days to 100% flowering, the number of days to 50% flowering, the number of days to 50% budding and the number of the days to stem germination have high and negative correlation with W1 canonical function, but the number of days to germination

had low and positive correlation. In the variables like seed performance and its components there was high and positive correlation between 1000-rgain weight and performance per bush with V1 canonical function. But the number of seeds per boll and the number of boll per bush had low correlation.

The existing correlation between measured variables of one group with another group's canonical function obtained in tables 6 and 7. In phonological variables, there is high and negative correlation between the number of days to 100% flowering, number of days to 50% flowering and the number of days to 50% budding with yield and yield components V1 canonical function, but the number of days to germination and number of days to stem growth had low correlation. In the variables of seed performance and its components there is high and positive correlation between 1000-grain weight and yield per bush but there is low correlation between the number of seeds per boll and the number of boll per bush.

In fact, under severe stress W1 function is influenced by 1000-grain weight and the performance per bush but V1 function is influenced by some phonological traits especially the number of days to 100% flowering, the number of days to 50% flowering and the number of days to 50% budding. . So for the selection of cultivars for height yield under normal conditions, we can consider the days to 100% flowering and the days to 50% flowering as appropriate phonological criterion.

**Table1**. Correlation values between the pairs of canonical variables in spring safflower varieties under severe stress

| Canonical correlation | F values | F significant level | Squared canonical correlation | Cumulative proportion |
|---|---|---|---|---|
| **0/787** | 3/75 | <0/0001 | 0/620 | 0/774 |
| **0/472** | 1/71 | 0/0740 | 0/223 | 0/911 |
| **0/376** | 1/37 | 0/2348 | 0/141 | 0/989 |
| **0/150** | 0/53 | 0/5927 | 0/022 | 1 |

**Table2**. Standardized canonical coefficients for canonical functions related to spring safflower phonological variables under severe stress.

| Trait | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| **The number of days to 100% flowering** | -0/202 | 0/443 | -0/409 | 0/586 |
| **The number of days to 50% flowering** | -0/092 | -0/286 | 0/141 | -0/850 |
| **The number of days to 50% budding** | -0/022 | 0/130 | 0/411 | 0/217 |
| **The number of days to germination** | 0/317 | 1/032 | 0/720 | -0/281 |
| **The number of days to stem growth** | 0/168 | -0/486 | 0/133 | 0/399 |

**Table3**. The standardized canonical coefficients for canonical functions related to spring safflower yield and yield component under severe stress.

| Trait | $V_1$ | $V_2$ | $V_3$ | $V_4$ |
|---|---|---|---|---|
| **The number of boll per bush** | -0/149 | 0/679 | 0/714 | -0/141 |
| **The number of seed per boll** | -0/009 | 0/280 | 0/451 | 0/022 |
| **1000-grain weight** | 0/079 | 0/210 | 0/346 | -0/143 |
| **Performance per bush** | 0/135 | -0/403 | -0/895 | 0/197 |

**Table4**. The structural correlation between phonological variables and related canonical functions under severe stress

| Trait | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| **Number of the days to 100% flowering** | -0/970 | 0/026 | 0/043 | 0/129 |
| **Number of the days to 50% flowering** | -0/948 | -0/132 | 0/201 | -0/100 |
| **Number of the days to 50% budding** | -0/773 | -0/035 | 0/602 | 0/186 |
| **Number of the days to germination** | 0/485 | 0/665 | 0/291 | -0/168 |
| **Number of the days to stem growth** | -0/620 | -0/494 | 0/296 | 0/336 |

**Table5**. The structural correlation between yields, yield components with related canonical functions under severe stress.

| Trait | $V_1$ | $V_2$ | $V_3$ | $V_4$ |
|---|---|---|---|---|
| The number of the boll per bush | -0/436 | 0/735 | -0/453 | -0/255 |
| The number of the seed per boll | 0/435 | 0/010 | 0/252 | 0/865 |
| 1000-grain weights | 0/861 | 0/122 | -0/034 | -0/493 |
| Performance per bush | 0/630 | 0/600 | -0/376 | 0/320 |

**Table6**. Correlation of phonological variables with canonical functions of yield and yield components under severe stress

| Trait | $V_1$ | $V_2$ | $V_3$ | $V_4$ |
|---|---|---|---|---|
| 1)Number of the days to 100% flowering | -0/763 | 0/012 | 0/016 | 0/019 |
| Number of the days to 50% flowering | -0/746 | -0/062 | 0/076 | -0/015 |
| 2)Number of the days to 50% budding | -0/608 | -0/017 | 0/226 | 0/028 |
| 3)Number of the days to germination | 0/382 | 0/314 | 0/109 | -0/025 |
| 4)Number of the days to stem growth | -0/488 | -0/234 | 0/111 | 0/050 |

**Table7**. Correlation of yield and yield components with canonical functions of phonological variables under severe stress

| Trait | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| 1)The number of the boll per bush | -0/343 | 0/347 | -0/170 | -0/038 |
| 2)The number of the seed per boll | 0/342 | 0/005 | 0/095 | 0/130 |
| 3)1000-grain weights | 0/678 | 0/058 | -0/013 | -0/074 |
| 4)Performance per bush | 0/496 | 0/283 | -0/141 | 0/048 |

**Table8.** The correlation values between canonical variable pairs in spring safflower varieties under mild stress

| Canonical correlation | F values | F significant level | Squared canonical correlation | Cumulative proportion |
|---|---|---|---|---|
| 1)0/645 | 2/79 | 0/0002 | 0/416 | 0/510 |
| 2)0/614 | 2/25 | 0/0136 | 0/377 | 0/944 |
| 3)0/261 | 0/58 | 0/7434 | 0/068 | 0/996 |
| 4)0/076 | 0/13 | 0/8760 | 0/006 | 1 |

**Table9**. The standardized canonical coefficients for canonical functions related to phonological variables of spring safflower varieties under mild stress

| Trait | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| 1)Number of the days to 100% flowering | -1/053 | -1/716 | 1/229 | -1/992 |
| 2)Number of the days to 50% flowering | 2/078 | 0/635 | -0/044 | 2/259 |
| 3)Number of the days to 50% budding | -0/104 | 0/190 | -1/313 | 0/691 |
| 4)Number of the days to germination | -0/172 | 0/735 | 0/794 | -0/103 |
| 5)Number of the days to stem growth | -0/052 | 1/181 | 0/257 | -1/408 |

**Table10.** The standardized canonical coefficients for canonical functions related to yield and yield components of spring safflowers under mild stress

| Trait | $V_1$ | $V_2$ | $V_3$ | $V_4$ |
|---|---|---|---|---|
| 1)The number of the boll per bush | 1/404 | 3/253 | 2/066 | 1/049 |
| 2)The number of the seed per boll | 1/148 | 3/038 | 0/761 | 1/388 |
| 3)1000-grain weights | 0/131 | 3/061 | 1/396 | 0/870 |
| 4)Performance per bush | -1/302 | -3/860 | -1/306 | -0/393 |

**Fig. Experimental Species and field studies**

**Table11.** The structural correlation between phonological variables and related canonical functions under mild stress

| Trait | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| **1)Number of the days to 100% flowering** | 0/859 | -0/217 | 0/151 | -0/268 |
| **2)Number of the days to 50% flowering** | 0/958 | -0/058 | 0/113 | -0/117 |
| **3)Number of the days to 50% budding** | 0/796 | 0/134 | -0/265 | -0/088 |
| **4)Number of the days to germination** | -0/196 | 0/475 | 0/662 | 0/456 |
| **5)Number of the days to stem growth** | 0/727 | 0/245 | -0/211 | -0/596 |

**Table12**. The structural correlation between yield and yield components and related canonical function under mild stress

| Trait | $V_1$ | $V_2$ | $V_3$ | $V_4$ |
|---|---|---|---|---|
| **1)The number of the boll per bush** | 0/410 | -0/422 | 0/794 | 0/150 |
| **2)The number of the seed per boll** | 0/214 | 0/063 | -0/625 | 0/794 |
| **3)1000-grain weights** | -0/941 | 0/239 | 0/185 | 0/153 |
| **4)Performance per bush** | -0/232 | -0/376 | 0/324 | 0/837 |

**Table13.** The correlation between phonological variables with canonical functions of yield and yield components under mild stress

| Trait | $V_1$ | $V_2$ | $V_3$ | $V_4$ |
|---|---|---|---|---|
| **1)Number of the days to 100% flowering** | 0/554 | -0/134 | 0/039 | -0/020 |
| **2)Number of the days to 50% flowering** | 0/618 | -0/036 | 0/029 | -0/009 |
| **3)Number of the days to 50% budding** | 0/514 | 0/082 | -0/069 | -0/007 |
| **4)Number of the days to germination** | -0/127 | 0/292 | 0/173 | 0/035 |
| **5)Number of the days to stem growth** | 0/469 | 0/151 | -0/055 | -0/045 |

**Table14**. The correlation of yield and yield components with canonical functions of phonological variables under mild stress

| Trait | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| **1)The number of the boll per bush** | 0/265 | -0/259 | 0/207 | 0/011 |
| **2)The number of the seed per boll** | 0/138 | 0/039 | -0/163 | 0/057 |
| **3)1000-grain weights** | -0/607 | 0/147 | 0/048 | 0/012 |
| **4)Performance per bush** | -0/150 | -0/231 | 0/085 | 0/063 |

**Table15.** The correlation values of canonical variable pairs in spring safflowers under normal conditions

| Canonical correlation | F values | F significant level | Squared canonical correlation | Cumulative proportion |
|---|---|---|---|---|
| **1)0/681** | 2/33 | 0/0022 | 0/464 | 0/721 |
| **2)0/426** | 1/20 | 0/2891 | 0/182 | 0/906 |
| **3)0/300** | 0/83 | 0/5485 | 0/090 | 0/989 |
| **4)0/117** | 0/32 | 0/7290 | 0/014 | 1 |

**Table16**. The standardized canonical coefficients for canonical variables related to phonological traits of spring safflowers under normal conditions

| Trait | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| **1)Number of the days to 100% flowering** | 0/384 | -3/018 | 1/053 | -1/331 |
| **2)Number of the days to 50% flowering** | 0/913 | 2/607 | -1/513 | 2/518 |
| **3)Number of the days to 50% budding** | -0/309 | 0/857 | -0/397 | -1/614 |
| **4)Number of the days to germination** | -0/469 | 0/212 | 0/457 | 0/095 |
| **5)Number of the days to stem growth** | -0/313 | -0/029 | 1/516 | 0/129 |

**Table17**. The standardized canonical coefficients for canonical variables related to yield and yield components of spring safflowers under normal conditions

| Trait | $V_1$ | $V_2$ | $V_3$ | $V_4$ |
|---|---|---|---|---|
| **1)The number of the boll per bush** | 0/177 | 2/465 | 1/141 | 0/228 |
| **2)The number of the seed per boll** | -0/352 | 2/719 | 0/296 | -0/398 |
| **3)1000-grain weights** | -1/048 | 1/248 | 0/435 | 0/184 |
| **4)Performance per bush** | 0/117 | -1/794 | -1/250 | 0/767 |

**Table18**. The structural correlation between phonological variables and related canonical functions under normal conditions

| Trait | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| **1)Number of the days to 100% flowering** | 0/868 | 0/132 | 0/343 | -0/151 |
| **2)Number of the days to 50% flowering** | 0/851 | 0/357 | 0/303 | -0/024 |
| **3)Number of the days to 50% budding** | 0/625 | 0/489 | 0/260 | -0/528 |
| **4)Number of the days to germination** | -0/562 | 0/276 | 0/215 | 0/270 |
| **5)Number of the days to stem growth** | 0/580 | 0/310 | 0/727 | -0/139 |

**Table19**. The structural correlation between yield and yield components with related canonical variable under normal conditions

| Trait | $V_1$ | $V_2$ | $V_3$ | $V_4$ |
|---|---|---|---|---|
| 1)The number of the boll per bush | 0/451 | 0/414 | 0/340 | 0/813 |
| 2)The number of the seed per boll | 0/080 | 0/410 | -0/821 | -0/390 |
| 3)1000-grain weights | -0/891 | -0/093 | 0/268 | 0/355 |
| 4)Performance per bush | 0/121 | 0/193 | -0/591 | 0/774 |

**Table20.** The correlations of phonological traits with canonical variable of yield and yield components under normal conditions

| Trait | $V_1$ | $V_2$ | $V_3$ | $V_4$ |
|---|---|---|---|---|
| 1)Number of the days to 100% flowering | 0/591 | 0/056 | 0/103 | -0/018 |
| 2)Number of the days to 50% flowering | 0/579 | 0/152 | 0/091 | -0/003 |
| 3)Number of the days to 50% budding | 0/426 | 0/209 | 0/078 | -0/062 |
| 4)Number of the days to germination | -0/383 | 0/118 | 0/064 | 0/032 |
| 5)Number of the days to stem growth | 0/395 | 0/132 | 0/218 | -0/016 |

**Table21.** The correlation of yield and yield components traits with canonical variable of phonological traits under normal conditions

| Trait | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
|---|---|---|---|---|
| 1)The number of the boll per bush | 0/307 | 0/060 | 0/102 | 0/095 |
| 2)The number of the seed per boll | 0/054 | 0/175 | -0/246 | -0/046 |
| 3)1000-grain weights | -0/607 | -0/040 | 0/080 | 0/042 |
| 4)Performance per bush | 0/082 | 0/082 | -0/177 | 0/090 |

## 3.2 Canonical Correlation Analysis under Mild Stress:

The result of this analysis is obtained in tables 8 to 14. As you see Wilkes Lamyday statistics with 1 percent possibility has got meaningful for first function. It means that there is significant correlation between phonological variables, yield and yield components.

The linear composition of first function is provided from Wi phonological variables, yield and yield components (Vi) with related coefficients as follows:

$$W_1 = -1/05X_1 + 2/07X_2 - 0/10X_3 - 0/17X_4 - 0/05X_5$$

$$V_1 = 1/40Y_1 + 1/14Y_2 + 0/13Y_3 - 1/30Y_4$$

Structural correlations between measured variables of a group by canonical functions of the same group are in tables 11 and 12.In phonological variables the number of days to 100% flowering, number of days to 50% flowering, number of days to 50% budding and the number of days to stem growth showed high and positive correlation with W1 canonical function. Based on the results of canonical correlation analysis and in terms of non-stress conditions, W1 function is influenced by 1000-grain weight but V1 function is influenced by some phonological traits such as the days to 100% flowering and days to 50% flowering. The number of the days to germination had low and negative correlation. There was high and negative correlation between seed yield and yield components (1000-grain weight) with V1 canonical function. But the number of the seed per boll and bush unit performance had low correlation. The correlation between measured variables of a group with another group's canonical function is in tables 13 and 14. In phonological variables, the number of the days to 100% flowering, the number of the days to 50% flowering and the number of the days to 50% budding had positive and relatively high correlation with canonical function of yield and yield components. The correlation of other variables was low level. In seed yield variables and its components there was high and negative correlation between 1000grain weights with the canonical function of W1 phonological traits. Other variables had low correlation. Under mild stress, W1 function is influenced by 1000-grain weight but V1 function is influenced by some phonological traits such as the number of the days to 100% flowering, the number of the days to 50% flowering and the number of the days to 50% budding.

## 3.3 Canonical Correlation Analysis under Stress-Free Conditions

The results of this analysis are in tables 15 to 21. As you see Wilkes Lamyday statistics with 1 percent possibility has got meaningful for first

function. It means that there is significant correlation between phonological variables and yield components in first function. The linear composition of first function is provided from Wi phonological variables, yield and yield components (Vi) with related coefficients as follows:

$$W_1 = 0/38X_1 + 0/91X_2 - 0/30X_3 - 0/46X_4 - 0/31X_5$$
$$V_1 = 0/17Y_1 - 0/35Y_2 - 1/04Y_3 + 0/11Y_4$$

The structural correlations between measured variables of a group with canonical functions of the same are in tables 18 and 19. In phonological variables, the number of the days to 100% flowering, the number of the days to 50% flowering, the number of the days to 50% budding and the number of the days to stem growth have high and positive correlation with W1 canonical function. The number of the days to germination had negative correlation. In seed yield and yield components variables there is high and negative correlation between 1000-grain weight with V1 canonical function but the number of the boll per bush, the number of the seed per boll and the performance of bush flower had low and positive correlation. The correlation between measured variables of a group with another group's canonical function is in tables 20 and 21. In phonological variables the number of the days to 100% flowering and the number of the days to 50% flowering had positive and relatively high correlation with V1 canonical function. Other correlations were low. There was negative and high correlation between 1000-grain weights with W1 canonical function. Other variables had low and positive correlations. In fact under stress-free conditions, W1 function is influenced by 1000-grain weights but V1 function is influenced by some phonological traits especially like the number of the days to 100% flowering and the number of the days to 50% flowering. So for the selection of figures related to high performance, the number of the days to 100% flowering and the number of the days to 50% flowering can consider as appropriate phonological criterion.

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