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# Short Communication: Evaluation of quantitative and qualitative morphological characters of sunflower (*Helianthus annuus*) germplasm

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**Abstract.** *Purwati RD, Herwati A. 2016. Evaluation of quantitative and qualitative morphological characters of sunflower (*Helianthus annuus*) germplasm. Biodiversitas 17: 461-465.* Sunflower (*Helianthus annuus* L.) germplasm collection in ISFCRI was characterized aiming to distinguish the morphological characters of each genotype. Based on that information it would be possible to observe the diversity and to choose appropriate parent genotypes for successful hybridization. The investigation was carried out in the Pasirian Experimental Station, Lumajang District, East Java, Indonesia located at 110 m above the sea level (113° E, 8° S) in the 2015 growing season. Thirty-three germplasm accessions were characterized. Each accession was planted in 32 m² plot size with four lines. Fertilizer dose was 75 kg Nitrogen + 30 kg $P_2O_5$ + 30 kg $K_2O$ per ha. The results showed that the low variation value in some quantitative characters such as seed size, weight of 100 seeds, seeds thickness, plant height, leaf size, ray floret length, bract length, head diameter, the flowering time, and seed oil content. The qualitative characters exhibited high coefficient of variation values with only one exception-pollen formation in sunflower inflorescences. These results indicated that on the base of their qualitative morphological characters, sunflower accessions possessed high diversity. The seed size and seed thickness showed significant positive correlation with 100 seeds weight. These two characters might be used as selection criteria in sunflower breeding programs for appropriate screening of parental genotypes included in hybridizing process aiming the increase of plant productivity.

**Key words:** Characters, diversity, quantitative, qualitative, sunflower

## INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important oil seed crop that belongs to family Asteracae (Compositae) originated from North America (Bukhsh et al. 2011). Domesticated (cultivated) sunflowers have a single stalk topped by a large flower (inflorescences). The wild sunflowers from the genus Helianthus are branched annuals and perennials species with different ploidy level (Aboki et al. 2012). Sunflower plants have great potential and have been utilized for different purposes. In Malaysia, a research of biodiesel production from waste sunflower cooking oil and pure sunflower cooking oil had been done (Hossain and Boyce 2009). Meanwhile smallholder farmers in Nigeria have been using sunflower for animal feed, seed oil extraction, snack production, manure or fertilizer, ornamental, and traditional medicine (Torimiro et al. 2014). Recently sunflower oil was evaluated for anti-microbial properties on different pathogenic organisms (Aboki et al. 2012). Sunflower also appeared as an economically important crop in Pakistan due to its significant portion in vegetable oil production (Nasim et al. 2012).

In Indonesia, sunflower has been studied since 1970 but in the beginning it was known only as ornamental plant. Recently, many farmers and stakeholders are interested in developing this crop due to their usefulness. Most people cultured sunflower for both human consumption and as a raw material for the processing industry. But, the development of sunflower was faced in several constraints mainly limited varieties appropriated for Indonesia. Indonesian Sweetener and Fibre Crops Research Institute (ISFCRI), Malang, East Java, Indonesia is a research institue which have mandate to carry out the experiments of this crop and have started in sunflower breeding aiming the development of some high yield varieties.

The success of a breeding program depends on the variability of the initial materials. Selection of parents is the most important stage in any breeding program to develop new varieties having desirable trait. For instance, the most important goal of sunflower breeding in Croatia is increasing of oil yield (Mijic et al. 2009). Study on genetic variability of germplasm collection was very important activity in identification different genotypes (Siddiqi et al. 2012). Characterization of the existing collection by phenotype is essential for the breeders to identify different genotype. The evaluation of sunflower referred to Guidelines for the Conduct of Tests for Distinctness, Uniformity and Stability. The International Union for The Protection of New Varieties of Plants (UPOV 2000) and Germplasm database of The International Plant Genetic Resources Institute (IPGRI 2005). This study was conducted to evaluate the sunflower germplasm collection on the basis on quantitative and qualitative morphological characters.

## MATERIALS AND METHODS

### Study area

The field study was performed in Pasirian Experimental Station, Lumajang District, East Java, Indonesia located at 110 m above the sea level (113°E, 8°S). The annual rainfall was 1.700 mm with 120 rainy days per year (C type climate according to the classification of Schmidt Ferguson). The soil type was sandy loam clay (0-15 cm, top soil) as classified of entisol/regosol.

### Procedures

The research was conducted from March to December in the 2015 growing season. Thirty-three accessions, each one of 32 m² plot size were included in the study (Table 1). In this study, some accessions from abroad were included due to the limited local accessions. Fertilizer was applied three times as follow: 75 kg Nitrogen + 30 kg $P_2O_5$ + 30 kg $K_2O$ $h^{-1}$ (full dose) on sowing date, 1/3 dose of N on 14 days after planting (DAP), and 2/3 dose of N -on 30 DAP.

The quantitative characters observed were: leaf size, plant height at full flowering, time of flowering (50% of the plants are in flower), ray floret length, bract length of tip, head diameter, seed size, seed thickness, weight of 100 seeds, and seed oil content. Seed oil content was measured by soxhlet method (Akpan et al. 2006) and calculated on dry matter (D.M.) basis. Leaf size was measured using modified gravimetric method (Chaudhary et al. 2012)

The qualitative characters measured were: absent or present hypocotyls anthocyanin coloration, hypocotyls intensity of anthocyanin coloration, leaf green color, leaf blistering, leaf serration, leaf shape of cross section, leaf shape of distal part, leaf auricles, leaf wings, leaf angle of lowest lateral veins, leaf height of the tip of the blade compared to insertion of petiole (at 2/3 height of plants), stem hairiness at the top (last 5 cm). Also the characteristic of inflorescence were monitored such as ray florets density, shape, floret disposition, and color, disk flower color, absent or present of anthocyanin coloration of stigma, intensity of anthocyanin coloration of stigma, production of pollen, bract shape, bract green color of outer side, bract attitude in relation to head, plant branching (excluding environmental branching), type of branching, plant natural position of highest lateral head to the central head, head attitude, head shape of grain side, seed shape, seed main color, seed stripes on margin, seed stripes between margins, seed color of stripes, and seed spots on pericarp. All characters were measured according to “Guidelines for the Conduct of Tests for Distinctness, Uniformity and Stability” of sunflower (*H. annuus*) (UPOV 2000) and Germplasm data base (IPGRI 2005). In each accession, ten plants in the center of population were observed as samples.

### Data analysis

Data analysis of characters observed was conducted using average ± standard deviation. The correlation between each character was analyzed using Pearson correlation.

**Table 1.** The sunflower accessions included in the study

| Accessions | Origin |
|---|---|
| Ha.1 | Pati, Central Java, Indonesia |
| Ha.2 | Australia |
| Ha.3 | Pati, Central Java, Indonesia |
| Ha.4 | Netherland |
| Ha.5 | Indonesia |
| Ha.6 | Australia |
| Ha.7 | Australia |
| Ha.10 | Waingapu, NTT, Indonesia |
| Ha.12 | NTB, Indonesia |
| Ha.14 | Malang, East Java, Indonesia |
| Ha.15 | Pati, Central Java, Indonesia |
| Ha.16 | Malang, East Java, Indonesia |
| Ha.17 | Malang, East Java, Indonesia |
| Ha.18 | Malang, East Java, Indonesia |
| Ha.19 | Indonesia |
| Ha.21 | Indonesia |
| Ha.23 | Indonesia |
| Ha.25 | Australia |
| Ha.29 | Malang, East Java, Indonesia |
| Ha.34 | Pekanbaru, Riau, Indonesia |
| Ha.39 | Pekanbaru, Riau, Indonesia |
| Ha.41 | Pekanbaru, Riau, Indonesia |
| Ha.42 | Pekanbaru, Riau, Indonesia |
| Ha.43 | Pekanbaru, Riau, Indonesia |
| Ha.44 | Pekanbaru, Riau, Indonesia |
| Ha.52 | Turkey |
| Ha.54 | Turkey |
| Ha.56 | Turkey |
| Ha.58 | Turkey |
| Ha.60 | Turkey |
| Ha.62 | Turkey |
| Ha.65 | Turkey |
| Ha.70 | Turkey |

## RESULTS AND DISCUSSION

All investigated quantitative characters showed low differences between accessions, thus indicating the low diversity of germplasm investigated (Table 2). This result was different from Terzić et al. (2006) who obtained highly variability in plant height and type of branching of F1 generation. Encheva et al. (2008) also observed significant differences in plant height of various sunflower lines and hybrids. Onemli and Gucer (2010) found significant differences in plant height, head diameter, and period of flowering of sunflower wild genotypes. Highly significant differences was also reported in leaf number, plant height, days to flowering and days to maturity in sunflower by Siddiqi et al. (2012). It might be concluded that the results obtained in the current study reflect the origin of germlasm accessions which evidently have close genetic background. The above mentioned researchers used wild species, parental lines and their hybrids. It is well known that wild species and hybrid genotypes normally have highly genetic diversity.

Time of flowering character was important for selection of early maturity accessions. Accessions with time of flowering less than 60 days after planting indicated as early maturity accessions. In this study, 19 accessions were identified as early maturity (Table 2.). These accessions were potential as parental in sunflower hybridization to produce new high yield early maturity varieties.

From Table 2. could be identified three accessions as short type plants with plant height less than 150 cm. Accessions with short type had some superiority e.g. the plants were not easy damage by wind flow and easier to harvest. There were also found that four accessions produced 100 seed weight more than 16 g, and nine accessions had high oil content (> 55%). Accessions which have high seed weight and oil content are categorized as potential accessions because seed weight is one of yield components (Dehkhoda et al. 2013; Rafiei et al. 2013; Ion et al. 2015).

Coefficient of variation (CV) was used to measure genetic variability of sunflower genotypes. The low genetic variability (2.60-12.06%) was observed for quantitative characters of all accessions (Table 3). According to Hadi et al. (2014), the genetic variability is low when CV varied from 0 to 25%. Similar results were reported by Sudrik et al. (2014) sunflower germplasm characterization showed that no accession was found to be promising for all quantitative characters.

The results indicated that sunflower accessions have higher variability based on the qualitative morphological characters. All investigated qualitative traits exhibited differences between accessions except formation of pollen (Table 4). The results were in conformity to previous report of Makane et al. (2011), characterization of sunflower germplasm indicated wide variation for all the qualitative characters among accessions. Tan and Tan (2011) also reported that the morphological variation on the observed characters was found highly variable for some characters. There was no variation of pollen fertility. All accessions released the fertile pollen. Diederichsen (2010) found the variability of qualitative characters i.e. leaf dimensions and leaf margin serration in wild species (*Helianthus tuberosus* L). These two characters could be used to distinguish extreme genotypes.

The diversity of qualitative characters between the different lines was also investigated by Khoufi et al. (2013) on 73 adapted sunflowers and 7 hybrids. Shamshad et al. (2014) analyzed 31 lines of sunflower germplasm and obtained a lot of diversity between these lines which can be exploited in hybrids breeding program. Meanwhile Presotto et al. (2009) reported that the populations of *H. annuus* naturalized in Argentina presented a high degree of phenotypic variability.

**Table 3.** Variability of quantitative morphological characters of sunflowers germplasm

| Quantitative characters | Initial | Average ± SD | CV (%) |
|---|---|---|---|
| Leaf size (cm²) | LS | 332.25 ± 91.01 | 8.85 |
| Plant height (cm) | PH | 191.60 ± 39.47 | 9.62 |
| Time of flowering (day) | TF | 64.43 ± 12.63 | 4.37 |
| Ray floret length (cm) | RF | 6.72 ± 0.81 | 7.32 |
| Bract length of tip (cm) | BL | 3.37 ± 0.72 | 12.06 |
| Head diameter (cm) | HS | 18.15 ± 4.76 | 6.87 |
| Seed size (mm²) | SS | 105.08 ± 33.25 | 3.51 |
| Weight of 100 seeds (g) | WS | 11.08 ± 3.82 | 2.60 |
| Seed thickness (mm) | ST | 4.07 ± 0.58 | 4.82 |

**Table 4.** Variability of some qualitative morphological characters of sunflower germplasms

| Characteristics | Expression | Percentage (%) |
|---|---|---|
| Hypocotyl: anthocyanin coloration | Absent | 81.82 |
| | Present | 18.18 |
| Leaf: size | Small | 12.12 |
| | Medium | 84.85 |
| | Large | 3.03 |
| Leaf: green color | Light | 10.00 |
| | Medium | 60.61 |
| | Dark | 30.30 |
| Stem: hairiness at the top (last 5 cm) | Weak | 24.24 |
| | Medium | 51.52 |
| | Strong | 15.15 |
| | Very strong | 9.09 |
| Time of flowering | Early | 60.60 |
| | Medium | 18.18 |
| | Late | 6.06 |
| | Very late | 15.15 |
| Ray floret: shape | Fusiform | 51.52 |
| | Narrow ovate | 48.49 |
| | Broad ovate | 0 |
| | Rounded | 0 |
| Ray floret: color | Light yellow | 12.12 |
| | Orange yellow | 39.39 |
| | Orange | 48.49 |
| Disk flower: color | Yellow | 45.46 |
| | Orange | 24.24 |
| | Purple | 30.30 |
| Disk flower: production of pollen | Absent | 0.00 |
| | Present | 100 |
| Bract: length of tip | Short | 6.06 |
| | Medium | 21.21 |
| | Long | 54.55 |
| | Very long | 18.18 |
| Plant: natural height | Very short | 12.12 |
| | Short | 51.51 |
| | Medium | 27.27 |
| | Tall | 9.09 |
| Plant: type of branching | Predominantly basal | 9.09 |
| | Overall | 18.18 |
| | Predominantly apical | 9.09 |
| | Only one | 54.54 |
| Head: size | Small | 30.30 |
| | Medium | 60.61 |
| | Large | 6.06 |
| Head: shape of grain side | Weakly concave | 18.18 |
| | Flat | 69.70 |
| | Weakly convex | 6.06 |
| | Strongly convex | 3.03 |
| | Deformed | 3.03 |
| | Elongated | 15.15 |
| Seed: shape | Narrow ovoid | 45.46 |
| | Broad ovoid | 36.36 |
| | Rounded | 3.03 |
| Seed: main color | White | 9.09 |
| | Whitish grey | 6.06 |
| | Grey | 18.18 |
| | Light brown | 6.06 |
| | Medium brown | 12.12 |
| | Dark brown | 1818 |
| | Black | 30.30 |

**Table 2.** Quantitative characters of sunflower accessions

| Accession | Leaf size (cm²) | Time of flowering (day) | Ray floret length (cm) | Bract length of tip (cm) | Plant height (cm) | Head diameter (cm) | Seed size (mm²) | Seed thickness (mm) | 100 seed weight (g) | Oil content (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ha.1 | 536.3±97.0 | 96.8±5.7 | 7.2±0.2 | 2.4±0.2 | 242±39.3 | 23.3±3.3 | 75.2±6.1 | 3.4±0.5 | 7.2±0.2 | 48.17 |
| Ha.2 | 349.5±83.8 | 61.5± 4.5 | 7.5±0.9 | 3.5±0.5 | 176±29.1 | 20.2±4.3 | 126.7± 7.9 | 4.2±0.3 | 13.8±0.6 | 58.81 |
| Ha.3 | 312.0±35.0 | 90.2±4.2 | 6.6±0.3 | 1.7±0.4 | 252±11.1 | 17.5±4.5 | 96.2±8.3 | 3.6±0.4 | 9.7±0.2 | 51.98 |
| Ha.4 | 333.3±40.8 | 59.4± 6.9 | 6.5±0.6 | 3.2±0.8 | 168±29.1 | 21.7±1.7 | 116.9± 9.9 | 4.0±0.5 | 13.9±0.4 | 49.99 |
| Ha.5 | 418.0±46.7 | 56.4±2.7 | 6.7±0.8 | 3.1±0.6 | 185±18.1 | 9.2±2.2 | 149.9±12.7 | 5.5±0.7 | 14.6±1.1 | 48.02 |
| Ha.6 | 277.5±39.9 | 65.9±4.1 | 7.4±0.9 | 3.7±0.6 | 219±33.7 | 23.0±4.2 | 73.3±7.7 | 3.2±0.3 | 7.2±0.3 | 57.33 |
| Ha.7 | 271.0±12.9 | 55.4±5.3 | 5.8±0.8 | 3.5±0.6 | 125±26.7 | 11.4±1.9 | 53.6±9.4 | 2.9±0.4 | 3.9±0.1 | 62.68 |
| Ha.10 | 402.3±30.1 | 62.9±5.8 | 6.7±0.7 | 3.7±0.9 | 195±32.4 | 21.2±2.4 | 118.8±21.2 | 4.2±0.7 | 17.5±0.6 | 50.20 |
| Ha.12 | 336.0±50.4 | 56.0±5.8 | 7.1±0.9 | 3.5±0.5 | 137±25.8 | 23.4±3.3 | 99.4±13.6 | 4.2±0.5 | 11.7±0.4 | 44.11 |
| Ha.14 | 255.3±48.7 | 51.9±4.9 | 6.9±1.0 | 3.8±0.9 | 117±16.6 | 16.0±5.8 | 157.3±13.8 | 5.5±0.8 | 16.4±1.3 | 44.50 |
| Ha.15 | 434.5±63.6 | 85.5±3.8 | 6.5±0.7 | 4.1±0.3 | 172±11.0 | 13.7±3.8 | 50.4±3.9 | 3.2±0.4 | 4.1±0.1 | 60.13 |
| Ha.16 | 516.6±47.2 | 61.9±6.4 | 7.2±0.8 | 3.6±0.7 | 219±33.5 | 11.0±1.8 | 63.1± 6.7 | 3.5±0.4 | 7.8±0.4 | 56.91 |
| Ha.17 | 316.3±34.1 | 59.7±4.5 | 7.2±1.1 | 3.3±0.4 | 214±38.4 | 20.7±2.7 | 124.2±12 | 3.5±0.4 | 12.7±0.6 | 47.87 |
| Ha.18 | 347.5±5.0 | 74.4±8.3 | 7.3±1.1 | 4.2±0.8 | 242±39.3 | 11.8±2.4 | 79.4±7.1 | 4.2±0.6 | 9.2±0.2 | 57.97 |
| Ha.19 | 332.5±44.0 | 57.2±4.4 | 6.7±0.9 | 4.4±0.9 | 184±35.0 | 17.8±3.4 | 152.7±16.2 | 4.6±0.4 | 16.7±0.6 | 51.38 |
| Ha.21 | 229.8±39.4 | 54.0±3.8 | 5.7±1.5 | 2.4±0.8 | 127±41.2 | 13.4±1.5 | 105.4±7.5 | 4.3±0.6 | 13.2±0.3 | 40.00 |
| Ha.23 | 319.5±8.0 | 57.2±2.9 | 5.3±1.1 | 2.5±0.8 | 154±15.9 | 11.1±0.9 | 84.9±4 | 3.6±0.4 | 13.7±0.4 | 56.75 |
| Ha.25 | 347.5±1.0 | 85.0±3.8 | 7.2±0.8 | 3.7±0.4 | 254±37.2 | 13.2±2.0 | 71.1±5.1 | 3.6±0.5 | 7.5±0.7 | 53.01 |
| Ha.29 | 383.3±44.2 | 61.3±7.3 | 7.0±1.1 | 3.9±0.6 | 232±22.0 | 20.9±1.4 | 97.8± 8.6 | 3.7±0.5 | 9.8±0.2 | 56.00 |
| Ha.34 | 327.0±39.0 | 58.4±4.1 | 6.3±0.9 | 3.4±0.7 | 172±23.3 | 17.4±2.8 | 95.0± 7.2 | 3.9±0.7 | 5.9±0.8 | 55.81 |
| Ha.39 | 305.5±26.5 | 54.8±4.6 | 7.0±1.0 | 3.5±0.7 | 175±23.3 | 17.6±2.5 | 139.7±16.8 | 4.4±0.5 | 15.0±0.2 | 48.09 |
| Ha.41 | 327.0±25.2 | 55.6±3.6 | 6.1±1.0 | 3.0±0.7 | 173±14.4 | 9.1±1.3 | 118.6±15.6 | 3.9±0.6 | 11.7±0.6 | 41.71 |
| Ha.42 | 316.0±25.2 | 55.0±7.6 | 8.4±1.5 | 3.3±0.6 | 190±44.0 | 23.8±2.0 | 140.5±7.9 | 4.2±0.6 | 14.2±0.4 | 49.62 |
| Ha.43 | 319.8±34.0 | 58.3±4.4 | 7.1±1.1 | 3.9±0.9 | 204±22.4 | 22.2±1.2 | 184.7±20.2 | 5.0±0.7 | 16.7±0.3 | 44.95 |
| Ha.44 | 311.8±49.4 | 84.1±5.3 | 8.4±0.5 | 5.0±0.4 | 224±46.9 | 17.7±1.8 | 129.2±8.2 | 4.9±0.6 | 15.1±0.8 | 38.20 |
| Ha.52 | 299.3±37.3 | 54.8±2.9 | 6.5±1.2 | 3.1±0.6 | 175±22.0 | 22.1±2.7 | 81.1±31.4 | 4.3±0.6 | 7.1±0.4 | 45.31 |
| Ha.54 | 237.8±60.5 | 56.4±2.1 | 6.8±1.2 | 3.1±0.9 | 180±31.2 | 24.0±1.9 | 79.1±14.9 | 4.2±0.7 | 7.6±0.5 | 50.00 |
| Ha.56 | 319.3±45.1 | 74.1±7.6 | 7.3±0.9 | 5.0±1.1 | 260±21.2 | 17.4±4.2 | 90.1±6.1 | 4.4±0.5 | 10.6±0.2 | 45.87 |
| Ha.58 | 304.3±13.9 | 60.2±4.4 | 6.8±0.9 | 3.3±0.8 | 198±26.5 | 21.4±4.2 | 132.1±11.6 | 4.4±0.5 | 13.9±0.6 | 46.16 |
| Ha.60 | 254.3±23.3 | 58.1±3.3 | 5.4±1.2 | 3.3±0.5 | 152±16.7 | 22.5±3.2 | 72.5±7.3 | 4.3±0.3 | 7.3±0.3 | 46.22 |
| Ha.62 | 320.3±30.9 | 56.0±2.4 | 7.3±1.0 | 2.7±0.5 | 180±27.5 | 24.3±4.8 | 139.8±18.6 | 4.1±0.7 | 12.6±0.5 | 41.91 |
| Ha.65 | 291.5±35.4 | 59.2±3.2 | 6.7±0.9 | 3.0±0.9 | 169±17.8 | 20.7±2.6 | 109.7±15.3 | 4.0±0.3 | 11.9±0.4 | 49.55 |
| Ha.70 | 164.3±9.0 | 89.2±3.1 | 5.8±0.3 | 2.0±0.4 | 239±13.6 | 18.2±1.2 | 70.0±6.3 | 3.7±0.4 | 7.7±0.3 | 41.03 |

**Table 5**. Correlation coefficients of quantitative morphological characters of sunflower genotypes

| Characters | | HS | BL | RL | LS | PH | ST | WS | SS |
|---|---|---|---|---|---|---|---|---|---|
| Time of flowering (day) | TF | -0.058 | -0.052 | 0.041 | 0.233 | 0.724** | -0.362* | -0.365* | -0.428** |
| Head diameter (cm) | HS | | -0.037 | 0.352* | -0.101 | 0.074 | 0.088 | 0.142 | 0.189 |
| Bract length of tip (cm) | BL | | | 0.321 | 0.013 | 0.111 | 0.308 | 0.145 | 0.120 |
| Ray floret length (cm) | RL | | | | 0.260 | 0.443** | 0.335 | -0.399* | 0.415* |
| Leaf size (cm²) | LS | | | | | 0.341* | -0.174 | -0.051 | -0.079 |
| Plant height (cm) | PH | | | | | | -0.199 | -0.156 | -0.181 |
| Seed thickness (mm) | ST | | | | | | | 0.769** | 0.808** |
| Weight of 100 seeds (g) | WS | | | | | | | | 0.904** |
| Seed size (mm²) | SS | | | | | | | | |

Note: * significant at $p \leq 0.05$, ** significant at $p \leq 0.01$

Tan and Tan (2010) reported that sunflower landraces have significant diversity in Turkey as one of the micro-gene centers for sunflower. Since some accessions evaluated in this experiment were also originated from Turkey, it was found the significant diversity of qualitative characters. According to Vear et al. (2011), the phenotypic and genotypic differentiation between accessions must be managed in the best way since it was very useful as resources in breeding.

Correlation coefficients are useful since it allow to determine the component character on which selection can be based, thus improving seed yield (Jockovic et al. 2012). In the current study, plant height showed negative correlation with weight of 100 seed and seed size (Table 5). These results are similar to Arshad et al. (2007) who found that association between plant height and seed yield was negative at both genotypic and phenotypic levels. Also, plant height was highly significant and positively

**Table 6.** Promising accessions of sunflower for different characters

| Characters | Germplasm accessions |
|---|---|
| Time to flowering (< 60 days) | Ha.4, Ha.5, Ha.7, Ha.12, Ha.14, Ha.17, Ha.19, Ha.21, Ha.23, Ha.34, Ha.39, Ha.41, Ha.42, Ha.43, Ha.52, Ha.54, Ha.60, Ha.62, Ha.65 |
| Plant height (<150 cm) | Ha.7, Ha.12, Ha.21 |
| 100-seed weight (>16 g) | Ha.10, Ha.14, Ha.19, Ha.43 |
| Seed size (≥ 141 mm2) | Ha.5, Ha.14, Ha.19, Ha.43 |
| Seed thickness (≥ 4.6 mm) | Ha.5, Ha.14, Ha.19, Ha.43, Ha.44 |
| Seed oil content (>55%) | Ha.2, Ha.6, Ha.7, Ha.15, Ha.16, Ha.18, Ha.23, Ha.29, Ha.34. |

correlated with days to flowering. This result was in agreement with finding of Jockovic et al. (2012) who reported a significant and positive correlation between plant height and days to flowering. The longer flowering of plant will have more time to grow. On the other hand, plant height has negative correlation with 100 seed weight which corresponded to the yield.

Seed size and seed thickness have highly significant and positive correlation with weight of 100 seeds. Based on this result, seed size and seed thickness showed the highest positive effect on seed yield. These two characters could be used as selection criteria in sunflower breeding programs for screening the parental genotypes for development of sunflower cultivars with higher productivity.

Based on quantitative characters, it can be concluded that some accessions were identified as promising for different characters (Table 6.). These accessions can be used to generate a gene pool by constituting the germplasm lines of interest or by creating a broad based cross. Such accessions were very useful as a base population to develop promising populations and lines.

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