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# EARLINESS AND YIELD PERFORMANCE OF SUNFLOWER HYBRIDS IN UPLANDS OF BALOCHISTAN, PAKISTAN

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**Abstract**

Sunflower hybrids were evaluated for adoptability, earliness and yield potential through multi-locations trials during summer cropping season 2006 (after wheat harvest) in uplands of Balochistan, Pakistan. Stability analysis was carried out for hybrids at three different locations in one year. Early maturity and achene yield were used as criterion for selection. All the hybrids matured in less than 95 days due to summer intensive and longer day's photoperiod. Therefore, all the hybrids were found suitable to grow in June (after wheat harvest) and to complete their growth cycle before commencing of low temperature during colder nights of October. Hybrids Parsun-1 and Hysun-33 were found early maturing and medium maturing, respectively and suitable for growing in wheat cropping pattern. Complete hybrid stability over all parameters was not proved. Therefore, sunflower hybrids sensitivity authenticated to further intensify breeding work for development of local hybrids with early maturity and good yield.

## Introduction

Pakistan is dependent on cultivation of exotic sunflower hybrids, and the newly local developed sunflower hybrids did not receive much attention due to lack of seed sector. Owing to the fact, it was realized that Balochistan province is very conducive for seed production due to low temperature and humidity at the time of maturity. An additional benefit of sunflower is that crop mature in 85 to 95 days if sown in mid to last June after wheat harvest in uplands of Balochistan.

Sunflower offers a great promise as one of the major edible oil crop in many countries. In Pakistan, during 1991-92, the area under sunflower cultivation was 63328 ha with production of 83312 tones. However, during 2010-11, the area increased to 448000 ha with production of 643000 and 244000 tones of seed and oil, respectively (Anonymous, 2012). During 2010-11, Pakistan spent Rs. 224 billion on the import of edible oils (Anonymous, 2012). In our country, the major growing areas have more focus on staple food crops. Therefore, it is Govt. policy to shift sunflower to marginal lands.

A sunflower hybrid with early maturity and high yield is one of the major objectives to have its cultivation on fellow uplands of Balochistan. If sown in July after wheat harvest and crop maturity needs to be ensured until September end otherwise low temperature at night (below 15ºC) will delay maturity with yield losses (Taran *et al.*, 2010). There is a continuous spectrum of earliness in sunflower ranging from 85 to 130 days. In my personal experience, in uplands of Balochistan the summer sown crop took only 85 to 95 days to reach physiological maturity.

Sunflower is day neutral crop and can be grown in summer, autumn and spring, and long/short day photoperiod are equally important for sunflower cultivation.

Photoperiod has an important role in maturity and grain yield of sunflower. Soil temperature of 10-12$^{o}$C at sowing gave more grain yield as compared to sowing made at 14-16$^{o}$C. Similarly, growth period in early sowing (4-8$^{o}$C soil temp) was 3-6 days longer than mid sowing (10-12$^{o}$C) and 7-13 days longer than late sowing (14-16$^{o}$C), however, days to maturity decreased when sunflower crop was sown on first April as compared to first March (Habil, 2006). Therefore, days to maturity in sunflower were significantly affected by environmental conditions. During warmer months, the plants complete their vegetative growth earlier while in cooler season the period for vegetative growth lingers on (Taran *et al.*, 2010).

Genotype × environment interaction dominated to be a challenging issue among plant breeders, geneticists and production agronomists as studied crop performance across diverse environments. Stability should be considered as an important aspect of yield studies. Researchers need a statistic that provides a reliable measure of stability/consistency of performance across a range of environments, particularly, one that reflects contribution of each genotype to total G × E interaction. Adoptability and genetic make-up information of sunflower hybrid development is an important consideration. To overcome this problem multi-location testing are needed for selection of sunflower hybrids with earliness and good yield.

Yield levels and stability are two important issues that are heavily debated in both participatory and formal research, mainly because of the question whether a stable cultivar could also be high-yielding (Masood *et al*., 2003). The concept is rather essential to determine that for which region a particular cultivar is actually suitable. Some theoretical aspects, with examples of these issues will therefore be briefly discussed in the following sections. Yield is determined by genetic make-up of plant in interaction with environment in which it grows.

In present study, several stability statistics have been evaluated through two-way genotypes × environment interaction. A number of statistics have been proposed to measure genotypic stability. Some of these have been summarized and compared by Lin *et al.,* (1986) and Peterson (1989). Those are genotype variance (si2), genotypic coefficient of variation (CVi) (Francis & Kannenberg, 1978), ecovalence (Wi2) (Wricke, 1962), interaction variance (σi2) (Shukla, 1972). Eberhart & Russell (1966) regression slope (bi) are other two measures used for goodness of fit of a linear model i.e. a) Deviation from regression means square (δi2) b) Coefficient of determination (R2). Finlay and Wilkinson (1963) pointed out about slope b. They pointed out that a genotype, which has a slop b = 1 is most stable but genotypes which have slope significantly greater than 1 and less than 1 are specifically adapted to high yielding environments and better adapted to low yielding environments, respectively.

Despite its considerable importance as edible oil crop, little work has been done on sunflower with particular reference to its ability to grow well in summer season. Therefore, the present studies were planned to determine the mechanism and genetic basis of earliness in sunflower as a step toward the development of early maturing stable hybrids with high yield (Yousaf *et al*., 1989).

## Materials and Methods

The research work was conducted on sunflower hybrids developed within the country and abroad on the basis of earliness, yield and stability. Multi-location testing was carried out at three different locations Quetta (67ºE and 30.3ºN), Loralai (68.6ºE and 30.4ºN) and Khuzdar (66.7ºE and 27.8ºN) in Balochistan, Pakistan during 2006 for their suitability as a summer crop (Fig. 1).

The three isolated places were considered as main designated areas for agricultural activities in uplands of Balochistan. Soil type and pH of experimental sites were tested at Soil Fertility Laboratory, Agricultural Research Institute Sariab, Quetta, Pakistan. Data pertaining to soil type at Quetta were clay loam with pH of 7.8, at Khuzdar sandy loam with pH of 8.2 and at Loralai red loam having pH of 7.6. The breeding material comprised of fourteen hybrids i.e., Super sun, Hysun-33 (Check), Parsun-1, Parsun-2, LG-56-60, FH-106, NK-S-278, 64-A-93, FH-37, Hysun-38, Helios-360, Ausigold-61, LG-53-80 and NK-Amoni which were tested at three different locations. All the experiments were laid out in a randomized complete block (RCB) design with four replications, having 5 m row length with 75 and 30 cm row and plant spacing, respectively. Recommended cultural practices, inputs and plant protection measures were equally adopted for all the experiments.

Analysis of variance was carried out to establish the level of significance among hybrids and locations for all the traits (Gomez & Gomez, 1984). Recommended stability parameters methods exist to analyze yield stability (Peterson, 1989 edited by Khan). Those are genotype variance (si2), genotypic coefficient of variation (CVi) (Francis and Kannenberg, 1978), Ecovalence (Wi2) (Wricke, 1962). Interaction variance (σi2) (Shukla, 1972), Regression slope (bi) and two other measures used for goodness of fit of a linear model were a) deviation from regression means square (δi2), b) coefficient of determination (R2) (Eberhart & Russell, 1966). Although, these all types of stability statistics were used in combination with Lin *et al*., (1986).

## Results and Discussion

Analysis of variance revealed highly significant ($p \leq 0.01$) differences among hybrids, locations and their interaction (hybrids × locations) for days to maturity and achene yield kg $ha^{-1}$ (Table 1), which not only exhibited variability among locations but also pronounced genetic variability among hybrids. Hybrids by locations significance also indicated that each location should be treated as a separate environment. Significant differences among sunflower genotype mean values for yield related traits have been reported (Bange *et al.,* 1997; Aslam & Ashfaq, 2002).

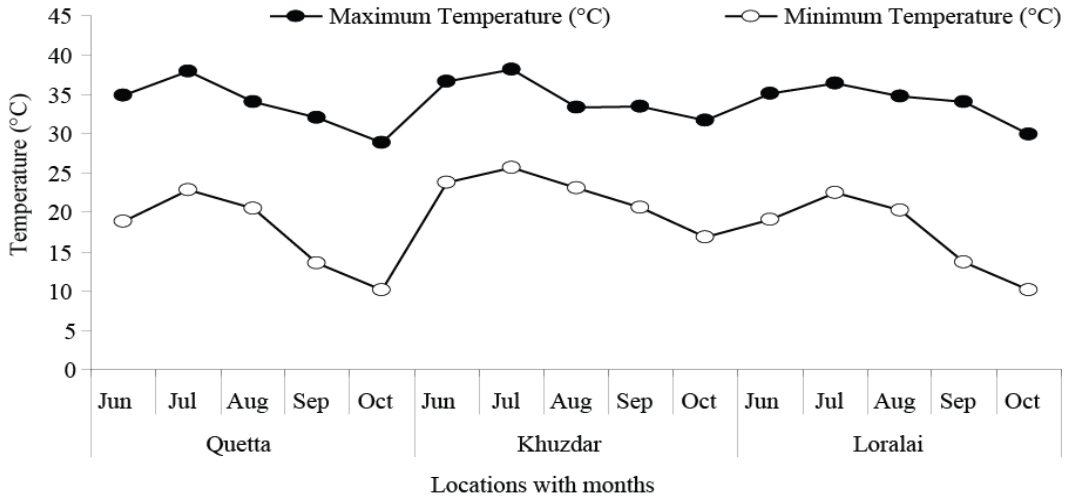


Fig. 1. Maximum and minimum temperatures (°C) for five months at three locations during 2006.

**Table 1. Mean squares for days to maturity and achene yield.**

| Source | DF | Mean Square (MS) | |
|---|---|---|---|
| | | Days to Maturity | Yield (kg ha$^{-1}$) |
| Hybrids | 13 | 95.669** | 169489** |
| Locations | 2 | 873.054** | 4982748** |
| Hybrids × Locations | 26 | 23.919** | 279111** |
| Error | 123 | 1.903 | 4051 |

****** Significant at $p \leq 0.01$

**Days to maturity:** Sunflower hybrids were screened for days to maturity at multi-locations and showed significant variations for 14 hybrids and three locations (Table 2, Fig. 2). Days to maturity ranged from 84.6 to 94.1 among hybrids, which confirming that most of the hybrids were early maturing due to dry summer weather, scant rain, longer days and high temperature as a result of maximum solar insulation which forced sunflower hybrids to accumulated more energy through increase of photosynthesis in shorter period of time. Earliness is critical character and has important role in selection of genotypes for general cultivation and even five days difference is important in sunflower hybrid selection (Masood *et al*., 1991; Baker *et al*., 1988).

The response of sunflower hybrids to days to maturity at Quetta ranged from 88.75 to 99.75 days. Similarly at Khuzdar the hybrids have range of 80.5 to 89.25 days, while at Loralai the hybrids varied from 82.5 to 97.25 days.

Comparatively Parsun-1 was early maturing at Quetta and Loralai as compared to Khuzdar instead of Hysun-38 (80.5 days) was early while Parsun-1 (82.5 days) followed by Hysun-38. Although, according to genotype means, Parsun-1 was early with 84.6 days followed by Hysun-38 (85.4 days), respectively. However, the late maturing hybrids were not consistent because hybrids responded differently in different environments. This was further confirmed that Helios-360 matured in 99.75 days at Quetta and Hysun-33 in 89.25 days at Khuzdar, while Supersun took 97.25 days at Loralai and observed with maximum days to maturity (Table 2). In case of location means, the days to maturity were least at Khuzdar (85.04 days) followed by Loralai (91.04 days) and Quetta (92.48 days). In overall perspective means, Khuzdar produced early maturing hybrids, while at Quetta the hybrids were late maturing than other two locations. Quetta station is cooler than other two locations while Khuzdar is warmer than other two sites. Therefore, earliness was mostly defined by environmental factors and up to some extent by genetic makeup of the hybrids. Earliness is greatly influenced by environment and genetic potential of genotypes (Fouchteau *et al*., 2001). Relationship between maturity and sunflower hybrids yield have been determined (Aslam & Ashfaq, 2002). Present results were also confirmed by Yousaf *et al*., (1989).

Mean square stability statistics of hybrids ranged from (6.3 to 44.3). Hysun-33 and LG-53-80 attained their lowest values (6.3 and 9.3) while CV ranged from 2.73 to 7.08. Hysun-33 (2.73) was stable than other hybrids due to its low value and belongs to medium maturing hybrids.

In light of two stability measure i.e. ecovalance (W) and interaction variance (F) as proposed by Wricke (1962), the contribution to interaction variance was quite variable for various genotypes. Based on these two stability statistics, it can be concluded that sunflower hybrids i.e. 64A93 and NK-S-278 with values of 0.72 and 1.45, -0.08 and 0.35, were stable hybrids because of having low values of ecovalance and interaction variance, respectively (Wricke, 1962).

Next stability measures are very important to identify both linear (bi) and non-linear (s2di) components of G × E interaction for judging the stability of a genotype (Eberhart & Russell, 1966). Linear regression for average days to maturity of a single hybrid on average of all hybrids in each environment resulted in regression coefficients (bi values) ranged from 0.5048 to 1.6740. This variation in regression coefficients indicated varied responses of genotypes to environmental changes (Table 2). The regression coefficient of genotypes i.e. 64-A-93 (0.9581) and NKS-278 (1.0781) for days to maturity was near (bi = 1.0) and has a small deviation from regression (s2di), although lowest value of deviation is attributed to 64-A-93 (0.67) and Parsun-2 (0.93) and their Ri has highest percentage for fair stability.

Genotypes with less and maximum days to maturity did not showed stability while genotypes with medium maturity were stable either at one or other stability measure. Accordingly, the sunflower hybrids i.e. Parsun-2, 64-A-93 and NKS-278 were relatively more stable for days to maturity, because their regression coefficients were almost equal to unity and have lower deviations from regression and their Ri values were relatively higher in percentage. In overall perspective of stability, the hybrids 64-A-93, Super-sun, LG-53-80, Ausigold-61 and Parsun-1 have the potential to face environmental fluctuation while FH-106, NK-S-278 and Hysun-38 provided best performance in ideal environment, and same findings quoted bye Finlay & Wilkinson (1963).

**Achene yield:** For achene yield, the sunflower hybrid means ranged from 1724.9 (63-A-93) to 2128.4 kg ha$^{-1}$ (Hysun-33) (Table 3, Fig. 3). On average, the Hysun-33 and parsun-1 were high yielding hybrids. The hybrid Ausigold-61 attained highest achene yield at Quetta, while Parsun-2 at Khuzdar, and Hysun-33 at Loralai. Results were in conformity with previous findings of Akhtar *et al*., (2004).

**Table 2. Stability statistics of sunflower hybrids grown at three locations.**

| Hybrids | Days to maturity (#) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quetta | Khuzdar | Loralai | Average | MS | CV | ECO | Inter | Bi | Div | Ri |
| Super sun | 92.25 | 88.25 | 97.25 | 92.58333 | 20.3 | 4.87 | 20.81 | 11.64 | 0.8184 | 19.78 | 0.5135 |
| Hysun-33 (C) | 92 | 89.25 | 94.25 | 91.83333 | 6.3 | 2.73 | 12.24 | 6.64 | 0.5048 | 4.59 | 0.6336 |
| PARSUN -1 | 88.75 | 82.5 | 82.5 | 84.58333 | 13.0 | 4.27 | 20.17 | 11.27 | 0.5942 | 15.03 | 0.4227 |
| PARSUN-2 | 97.25 | 88.25 | 94.25 | 93.25 | 21.0 | 4.91 | 1.61 | 0.44 | 1.1477 | 0.93 | 0.9779 |
| LG-56—60 | 95.75 | 84.75 | 91.5 | 90.66667 | 30.8 | 6.12 | 7.02 | 3.59 | 1.3743 | 2.65 | 0.9570 |
| FH-106 | 93.75 | 83.5 | 87 | 88.08333 | 27.1 | 5.92 | 14.08 | 7.71 | 1.1448 | 13.43 | 0.7527 |
| NK-S-278 | 92.75 | 85.25 | 92.75 | 90.25 | 18.8 | 4.80 | 1.45 | 0.35 | 1.0781 | 1.26 | 0.9665 |
| 64A93 | 90.25 | 83.5 | 90 | 87.91667 | 14.6 | 4.35 | 0.72 | -0.08 | 0.9581 | 0.67 | 0.9772 |
| FH-37 | 88.75 | 85.5 | 93.75 | 89.33333 | 17.3 | 4.65 | 21.41 | 11.99 | 0.7106 | 18.80 | 0.4558 |
| Hysun -38 | 89.75 | 80.5 | 86 | 85.41667 | 21.6 | 5.45 | 2.94 | 1.21 | 1.1471 | 2.26 | 0.9478 |
| Helios360 | 99.75 | 86.75 | 95.75 | 94.08333 | 44.3 | 7.08 | 15.45 | 8.52 | 1.6740 | 1.29 | 0.9855 |
| Ausigold-61 | 91.75 | 84.5 | 85 | 87.08333 | 16.4 | 4.65 | 19.47 | 10.86 | 0.7136 | 16.91 | 0.4842 |
| LG-53 -80 | 89.5 | 85.5 | 91.5 | 88.83333 | 9.3 | 3.44 | 7.92 | 4.12 | 0.6724 | 4.57 | 0.7551 |
| NK-Amoni | 92.5 | 82.5 | 93 | 89.33333 | 35.1 | 6.63 | 10.19 | 5.44 | 1.4618 | 3.54 | 0.9496 |
| Total | 1294.75 | 1190.5 | 1274.5 | 1253.25 | 296.0 | 69.86 | 155.47 | 83.72 | 14.0000 | 105.71 | 11 |
| Mean | 92.48214 | 85.03571 | 91.03571 | 89.51786 | 21.1 | 4.990 | 11.105 | 5.98 | 1.00 | 7.55 | 0.770 |

**Table 3. Stability statistics of sunflower hybrids grown at three locations.**

| Hybrid | Achene yield (kg ha$^{-1}$) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quetta | Khuzdar | Loralai | Average | MS | CV | ECO | Inter | Bi | Div | Ri |
| Super sun | 1985.3 | 1567.8 | 2034.3 | 1862.4667 | 65721.6 | 13.76 | 55536.90 | 26581.81 | 0.7133 | 40907.66 | 0.6888 |
| Hysun-33 (C) | 2235.5 | 1937.8 | 2211.8 | 2128.3667 | 27377.2 | 7.77 | 52801.98 | 24986.44 | 0.5055 | 9285.01 | 0.8304 |
| PARSUN -1 | 2303.5 | 1844.5 | 2177.3 | 2108.4333 | 56227.2 | 11.25 | 14724.63 | 2774.65 | 0.7746 | 5683.57 | 0.9495 |
| PARSUN-2 | 2096.5 | 1940.5 | 1702.8 | 1913.2667 | 39306.2 | 10.36 | 169511.64 | 93067.07 | 0.2446 | 67966.11 | 0.1354 |
| LG-56-60 | 2351.5 | 1623.3 | 1391 | 1788.6 | 251133.1 | 28.02 | 257250.03 | 144247.80 | 1.1884 | 250931.26 | 0.5004 |
| FH-106 | 2229.3 | 1755 | 1937.5 | 1973.9333 | 57235.7 | 12.12 | 10608.64 | 373.66 | 0.7918 | 2897.12 | 0.9747 |
| NK-S-278 | 2145.3 | 1733.5 | 1883.3 | 1920.7 | 43443.9 | 10.85 | 20324.41 | 6041.19 | 0.6870 | 2893.73 | 0.9667 |
| 64A93 | 1952.8 | 1265.5 | 2101 | 1773.1 | 198734.1 | 25.14 | 156233.36 | 85321.41 | 1.1778 | 150607.05 | 0.6211 |
| FH-37 | 2283 | 1473.8 | 2200.8 | 1985.8667 | 198348.4 | 22.43 | 85975.92 | 44337.90 | 1.3731 | 61210.97 | 0.8457 |
| Hysun-38 | 1963 | 1274.8 | 1936.8 | 1724.8667 | 152091.6 | 22.61 | 65705.89 | 32513.72 | 1.1701 | 60559.23 | 0.8009 |
| Helios360 | 2109.8s | 1501.8 | 1771.5 | 1794.3667 | 92808.2 | 16.98 | 1636.26 | -4860.23 | 1.0169 | 1585.19 | 0.9915 |
| Ausigold-61 | 2602.8 | 966.3 | 2196.8 | 1921.9667 | 726183.1 | 44.34 | 646583.32 | 371358.88 | 2.7641 | 92818.11 | 0.9361 |
| LG-53 -80 | 2267.5 | 1751.8 | 1815.5 | 1944.9333 | 79051.4 | 14.46 | 32193.02 | 12964.54 | 0.8538 | 28388.17 | 0.8204 |
| NK-Amoni | 2289.5 | 1830 | 1479.3 | 1866.2667 | 165092.5 | 21.77 | 245105.87 | 137163.71 | 0.7391 | 232988.47 | 0.2944 |
| Total | 30815.3 | 22466.4 | 26839.7 | 26707.13 | 2152754.0 | 261.86 | 1814191.88 | 976872.55 | 14.0000 | 1008721.64 | 10 |
| Mean | 2201.093 | 1604.743 | 1917.121 | 1907.652 | 153768.1 | 18.704 | 129585.134 | 69776.61 | 1.00 | 72051.55 | 0.740 |

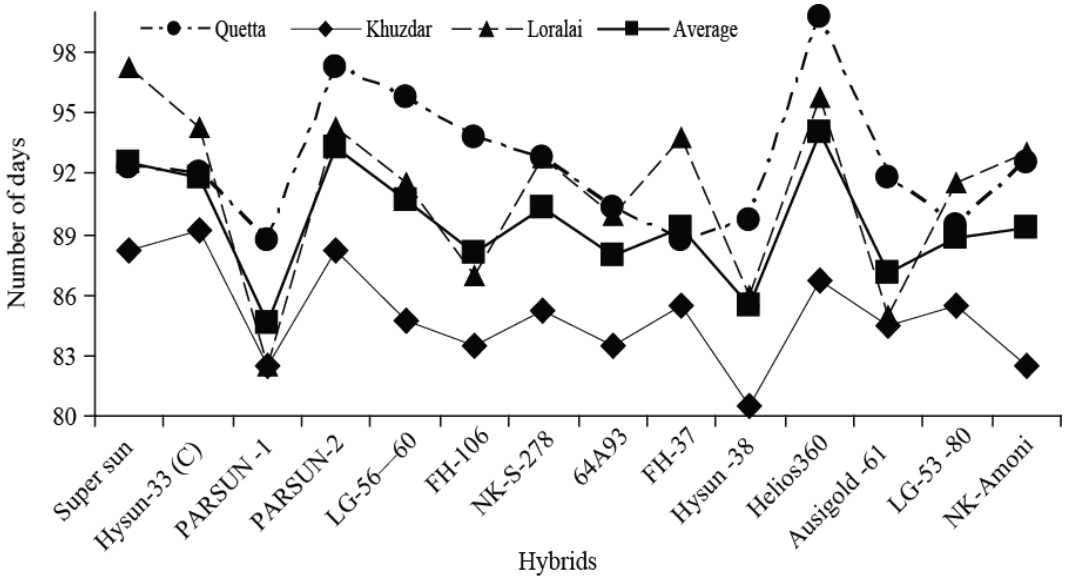


Fig. 2. Sunflower hybrids maturity at various locations.

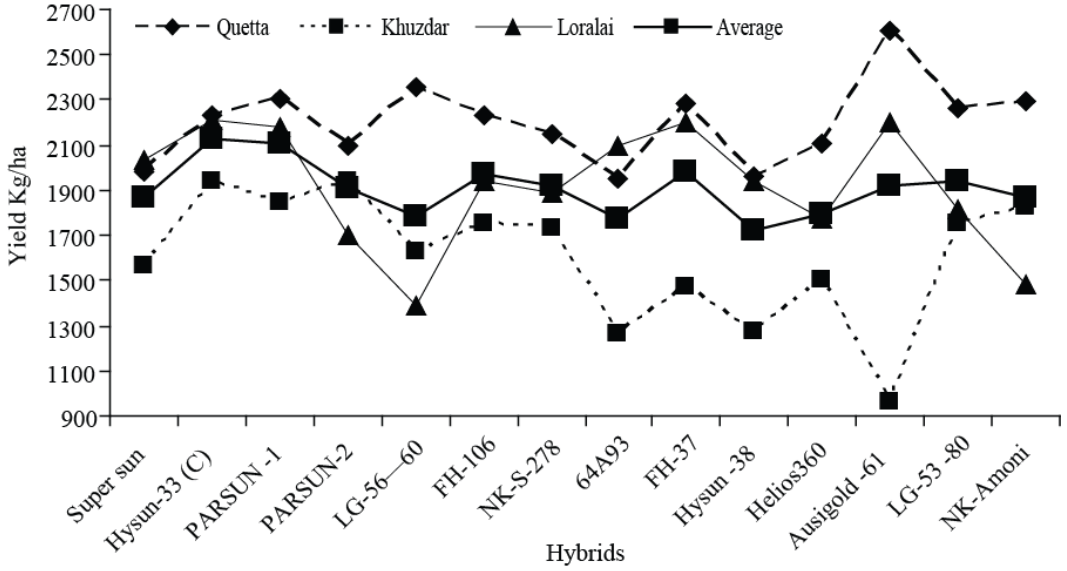


Fig. 3. Sunflower hybrids yield at various locations.

First type stability measure like mean square ranged from 27377.2 to 726183.1. Hysun-33 and Parsun-2 were observed with their lowest values (27377.2, 39306.2) while CV ranged from 7.77 to 44.34. CV for Hysun-33 (7.77) and Parsun-2 (10.36) has lowest values and were stable hybrids. However, the lowest ecovalance and interaction values (1636.26, -4860.23 and 10608.64, 373.66) were owned by hybrids Helios-360 and FH-106, respectively. According to Eberhart & Russell (1966) stability statistics linear (βi) and non-linear (S2di) components of genotype by environment interaction, a wide adaptability genotype with βi = 1.0 and high stability as one with S2di = 0 matches with LG-53-80, Helios-360 and Hysun-38, with regression coefficients of almost close to unity (0.8538, 1.0169, 1.1701), respectively, revealed that hybrid LG-53-80 in stress environment and hybrids Helios-360 and Hysun-38 in favorable environments can provide better grain yield at these locations. Hybrid Helios-360 also proved with lowest value on non linear model and highest Ri value, while hybrids LG-53-80 and Hysun-38 were not confirmed on other two statistics.

Sunflower hybrids based on early and high yielding capacity, with low and high values (closer to bi = 1) having stability for other parameters could be incorporated in breeding program for their performance under stress and favorable environments. Hybrid Parsun-1 developed locally can stand with harsh dry summer of Balochistan and proved to be high yielder with early maturity. Hybrid Hysun-33 being an exotic hybrid belongs to medium maturity group, proved to be high yielder than other hybrids at all sites. Present studies revealed that sunflower hybrids were sensitive to environmental factors, and due to which none of the sunflower hybrid showed complete stability for all the parameters (Singh & Yadava, 1986; Bange *et al*., 1997).

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