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Research Article

Efficacy of different quantitative characters in sunflower genotypes (*Helianthus annuus* L.) under Tandojam climate conditions

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Abstract

Sunflower is an important oilseed crop that is beneficial not for humans as well as animals. Looking toward the importance of this crop, the present research aimed to study correlation and regression analyses in various sunflower genotypes for yield and its related traits. This study was conducted at Oil Seed Section. Agriculture Research Institute (ARI), Tando Jam during 2020. Ten genotypes viz. Corolla, Melabour, Vulgar, Sputnik, Samsun-20, HO-1, Parson, TJ-1, Mehran-2, Turkish were used to assess the correlation and regression analyses in sunflower (*Helianthus annuus* L.). The results showed that all the genotypes were largely significant at $p \leq 0.01$ position of probability for the no: of seed heads^{-1}, seed yield plant^{-1}, and harvest index & significant at $p \leq 0.05$ position of probability for the plant height, seed index, & the biological yield plant^{-1}. Whereas non-significant result showed for germination %, 75% flowering days, 90% maturity days, & head diameter. The mean performance revealed that Mehran-2 depicted a larger head diameter coupled with stronger seed yield and biological yield plant^{-1}, whereas variety vulgar observed a taller plant with a greater seed index. Whereas significant and positive correlation had been observed for biological yield plant^{-1}, harvest index, head diameter, number of seed heads^{-1}, seed index & seed yield plant^{-1}. This research work is valuable for providing high yielding and early maturity genotypes. Though this crop is valuable for its oil purpose and better genotypes grown under various environments can be used for production of sunflower.

Keywords: Correlation; Head diameter; Quantitative traits; Regression analysis; Seed yield plant^{-1}

Introduction

Sunflower (*Helianthus annuus* L.) is an allogamous plant and is a cross-pollinated crop **[1]**. The edible seeds are strong in soluble vitamins A, B, E, and K and contain 44% of high-quality oil that is low in cholesterol **[2]**. Sunflower being a diploid crop with haploid genome size of about 3000 Mb chromosome number 2n = 34 **[3]**.

Presently, Pakistan is being deficient in comestible oil production. Sunflower contributes 22.36% of total domestic edible oil, which is mainly due to local oil extraction facilities and its cultivation is grown in both spring and summer seasons [4]. Being its high economic importance, the developments of effective hybrids and genotypes are required with superior yield and quality traits. Seed yield and oil content in sunflower are complex characters which are affected by various factors and may contribute individually or collectively. The knowledge of relationship of several characters with yield and among themselves will be important and essential for planning for successful breeding program [5].

Yield is a complex character which depends upon various yield traits and is polygenic in nature [6]. For efficient selection, the interrelationship between yield and its components is useful in understanding the potential of genotypes [7]. The yield traits related to yield in sunflower assure polygenic inheritance and control several pairs of genes located at different loci on the chromosomes [1]. Correlation represents variables having dependent and independent contribution towards characters [8]. However, for efficient selection, programmed interrelationship between yield and its components is inevitable and mutual association of plant characters, which is determined by correlation coefficient and is used to find out the degree (strength), mutual relationship between various plant characters and the component character on which selection can be relied upon the genetic improvement of yield [9].

Correlation is crucial in establishing the relationships between the characteristics, since mutual associations among the many characters that contribute to yield are also significant [7]. Through correlation and regression analysis, several researchers have assessed the yield and other contributing qualities of the various sunflower varieties to identify the relationships between them. The correlation and regression analysis makes it possible to differentiate between various cultivars based on their character traits [10]. Hence, looking forward to the above mention importance, a research was established to select potential sunflower genotypes for yield and its associated traits.

Materials and Methods

The present experiment was conducted to assess correlation and regression analysis in different sunflower genotypes at the experimental area of Oil Seed Section. Agriculture Research Institute (ARI), Tando Jam during 2020. Randomized Complete Block Design (RCBD) was applied with three replications during the year 2020. In this experiment, ten commercial varieties were evaluated viz. Corolla, Melabour, Vulgar, Sputnik, Turkish, Samsun-20, HO-1, Parson, TJ-1, and Mehran -2. After two weeks of seeding, the sunflower plantation was thinned to preserve the spacing between the rows and plants. Five plants had been chosen for the observation from each replication and genotype. The analysis was applied as [11]. Correlation coefficients and regression analyses were made as [12].

Results

The experiment was held to determine the potential sunflower genotypes (*Helianthus annuus* L.) in order to explore correlation and regression analyses. Ten sunflower genotypes, including Corolla, Melabour, Vulgar, Sputnik, Samsun-2, HO-1, Parson, TJ-1, Mehran -2, and Turkish, were used as the genotypic material in this study to compare mean performance.

Mean squares of the analysis showed that the characters viz. the number of seed heads^{-1}, seed yield plant^{-1}, and harvest index were highly significant at $p \leq 0.01$ level of probability and significant at $p \leq 0.05$ level of probability for the seed index, plant height, & biomass plant^{-1}. Whereas non-significant for head diameter, germination %, 75% flowering days & for 90% maturity days (Table 1 & Fig. 1).

Mean performance results depicted that Maximum germination% was displayed in varieties Melabour and spuntik (95%). Corolla and Samson-20 tool 55 days to 75% flowering. However, HO-1 took more to flowering as 66 days. Similarly, Samson-20 revealed fewer days to mature as 100 days, while maximum days to 90% maturity (115.33) observed in the variety Melabour. Regarding of the plant height (cm), in the variety of Corolla (71.37 cm), depicted dwarf plant height meanwhile the taller plant height (134.83 cm) observed in the variety of Vulgar. Head diameter was found maximum as 44.78cm in the variety of HO-1 observed maximum number of seeds head^{-1} (1473.2). Regarding of the seed yield plant^{-1} the maximum seed yield plant^{-1} depicted (54.22) in the variety of Mehran-2. The seed index depicted maximum in the variety Turkish (4.18g). Similarly, Mehran-2 recorded maximum biological yield (g) as 111.97 g and maximum harvest index was (49.76 g) found by the variety of Vulgar (Table 2).

Correlation studies in Sunflower *(Helianthus annuus* L.)

Percentage of germination vs. days to 90% flowering

Negative but insignificant (r =-0.0007) correlation was established between the percentage of germination and the number of days 90% flowering. Negative but substantial (r =-0.45*) correlation between germination percentage and 90% maturity days was recorded. Plant stature & germination % had positive although non-significant association (r =0.0068). Head diameter and germination percentage had a weak but significantly significant negative correlation (r =-0.71**). Positive, but not statistically significant (r = 0.04), association was discovered between the number of seeds heads^{-1} and the germination percentage. Negative but significant connection was established between seed yield plant^{-1}and germination percentage (r = -0.41*). A negative but not statistically significant (r = -0.30) correlation was recorded between the seed index and the percentage of germination. The biological yield plant^{-1} and germination percentage had a weak but not statistically significant negative connection (r =-0.30). The connection between the harvest index and the germination percentage was shown to be non-significantly negative (r = -0.28). 75% flowering days and 90% maturity days expressed positive although significant correlated (r= 0.41*) whereas 90% maturity days and harvest index showed negatively but significantly correlated (r = -0.41*).

90% Maturity days v/s plant height

90% maturity days and plant height had a weak whereas significant negative association (r = -0.38*). Head diameter and 90% maturity days showed significant & positive correlation (r= 0.46**). The number of seeds head^{-1} & 90% maturity days was observed positive although not significant correlation (r = 0.14). Seed biomass plant^{-1} & 90% maturity days showed positive although not statistically correlated (r = 0.13). Days to 90% maturity and seed index are shown to be negatively non-significantly correlated (r = -0.0021). Seed biomass Plant^{-1} & 90% maturity days were shown to be positive but not statistically correlated (r = 0.25). Harvest index and days to maturity have a positive but non-significant association (r = 0.0085).

Plant height v/s head diameter

Plant height and head diameter had a weak but negative correlation (r = -0.12). Negative but not statistically significant (r = -0.17) results were reported between plant height & seed yield plant^{-1}. No: of head plant^{-1}, plant stature & seed biomass plant^{-1} expressed favorable, although not statistically significant (r= 0.03), association. It was discovered that there was a weak but negative association in middle of plant stature and seed index (r= -0.0027). Plant stature and biological yield plant^{-1} showed to be negatively correlated but not statistically significant (r = -0.27). Positive, but not statistically significant (r = 0.10), the association was discovered between plant height and harvest index (Table 3).

Head diameter v/s no: seed head^{-1}

The head diameter & no: of seeds head^{-1} expressed significant although positive correlation (r = 0.38*). Head diameter & seed biomass plant^{-1} expressed significant although positive association (r= 0.61**). The head diameter and seed index showed a positive but significant correlation (r = 0.39*). Head diameter and biological yield plant^{-1} expressed positive although very significant correlation (r= 0.83**). Positive although not statistically significant (r = 0.24) was discovered to exist between head diameter and harvest index (Table 3).

Number of seed head^{-1} v/s grain biomass plant^{-1}

Seed biomass plant^{-1} & no: of grain head^{-1} expressed positive although significant correlation (r = 0.64**). The no: of seeds head^{-1} & seed index showed significant but very positve association (r = 0.56**). Biological yield plant^{-1} and the number of seeds head^{-1} shown to be positively yet extremely significantly correlated (r = 0.52**). The number of seeds head^{-1} and the harvest index was shown to be positively but significantly correlated (r = 0.38*).

Seed biomass plant^{-1} v/s grain index

It was discovered that there was a positive but very significant association between seed yield plant-^{1} and grain index (r = 0.76**). Biological yield plant^{-1} & seed biomass plant^{-1} showed positive & highly significant correlation (r = 0.53**). It was also recorded that there is a positive but extremely significant link between seed biomass plant^{-1} and harvest index (r= 0.84**). Biological biomass plant^{-1} & the seed index revealed to be significant although positive correlation (r = 0.43*). A positive but extremely significant association between the seed index and the harvest index was discovered (r = 0.62**).

Regression studies in sunflower

The correlation of seed biomass plant^{-1} expressed significant & positive with head diameter (r= 0.061**), grain head^{-1} (r=0.64**), grain index (r= 0.76**), biological biomass plant^{-1} (r=0.53**) & harvest index (r =0.84**) whereas significant but negative (r = 0.41*) with germination%. The highest positive correlation displayed by harvest index afterwards by seed index co-efficient of determination showed changes in to seed biomass plant^{-1} cause to variation in the associated biomass components. Whereas highest changes observed in seed yield plant^{-1} (70%) cause of the changes in harvest index followed seed index (57.76%) and the lower changes is cause to changes in plant length (0.09%). The regression coefficient showed the increase in seed yield cause to increasing in seed components. The higher increasing obtained in seed yield (2.69 g) cause to increasing in seed index afterwards by harvest index (1.02) while late one day in flowering showed the decrease (-1.64 g) in seed biomass (Table 4).

Table 1: Mean square analysis of variance in various quantitative traits in sunflower genotypes (*Helianthus annuus* L.)

Source of variation	Replication DF=03	Genotypes DF=09	Error DF=27
Germination percentage%	430.00	413.33ns	663.33
Days to 75% flowering	76.30	30.92ns	23.63
Days to 90% maturity	76.80	61.68^{NS}	80.24
Plant height (cm)	790.25	1080.44*	409.58
Head diameter (cm)	182.25	285.46^{NS}	234.86
Number of seeds head^{-1}	66970	249086**	32760
Seed yield plant^{-1}	543.59	314.55**	70.13
Seed Index	1.86	1.35*	0.54
Biological yield plant^{-1}	70.32	80.70*	32.66
Harvest index %	332.22	172.04**	45.15

****** = 0.01 level of probability, ***** = 0.05 level of probability, ns = non-significant

Table 2: Mean performance of yield & its related constitute of sunflower (*Helianthus annuus* L.) genotypes

Genotype	Germination %	75% flowering days	90% maturity days	Plant stature (cm)	Head diameter (cm)	No: of grains head^{-1}	Seed biomass plant^{-1}	Seed Index	Biological biomass plant^{-1}	Harvest index %
Corolla	88.33	55.33	110.33	71.37	17.75	1337.9	38.82	2.58	104.38	37.26
Melabour	95.00	62.66	115.33	113.50	13.33	1084.0	28.47	2.95	105.57	26.43
Vulgar	71.66	61.66	111.67	134.83	15.71	1218.0	49.71	3.56	96.78	49.76
Spuntik	95.00	60.66	107.00	133.10	13.10	661.8	30.57	2.30	98.37	30.55
Turkish	71.66	58.33	110.00	122.83	15.03	922.3	41.36	4.18	95.17	35.41
Samsun-20	81.66	56.66	100.00	134.13	15.83	1042.5	51.92	3.99	99.82	43.26
HO-1	88.33	66.33	107.67	129.82	15.48	1473.2	40.44	3.06	97.45	31.11
Parson	65.00	62.66	109.3	128.87	22.46	619.2	28.39	2.32	96.82	27.38
TJ-1	88.33	60.66	102.00	129.20	10.88	1012.2	27.67	3.21	100.37	27.59
Mehran-2	65.00	62.00	110.67	125.20	17.78	1378.7	54.22	3.99	111.97	37.22
LSD 5%										

****** = 0.01 level of probability, ***** = 0.05 level of probability, ns = non-significant

Table 3: Phenotypic correlation for biomass & it constitute in sunflower (*Helianthus annuus* L.) genotypes

CHARACTER	Germination %	75% flowering days	90% maturity days	Plant stature (cm)	Head diameter (cm)	N: of grains head^{-1}	Seed biomass plant^{-1}	Seed Index	Biological biomass plant^{-1}	Harvest index %
Germination percentage%	1.00									
Days to 75% flowering	-0.0007 ns	1.00								
Days to 90% maturity	-0.45*	0.41*	1.00							
Plant height (cm)	0.006ns	0.18 ns	-0.38*	1.00						
Head diameter (cm)	-0.71**	0.16 ns	0.46**	-0.12 ns	1.00					
Number of seeds head^{-1}	0.04 ns	0.32 ns	0.14 ns	-0.17 ns	0.38*	1.00				
Seed yield plant^{-1}	-0.41*	-0.17 ns	0.13 ns	0.03 ns	0.61**	0.64**	1.00			
Seed Index	-0.30 ns	-0.34 ns	-0.002 ns	-0.002 ns	0.39*	0.56**	0.76**	1.00		
Biological yield plant^{-1}	-0.30 ns	0.02 ns	-0.27 ns	-0.27 ns	0.83**	0.52**	0.53**	0.43*	1.00	
Harvest index %	-0.28 ns	-0.41*	0.008 ns	0.10 ns	0.24 ns	0.38*	0.84**	0.62**	0.17 ns	1.00

**= 0.01 level of probability, *= 0.05 level of probability and ns = non-significant

Table 4: Correlation & regression coefficient determination for seed yield and it constitute in sunflower (*Helianthus annuus* L.) genotypes

Characters	Correlation(r)	Coefficient of determination (r^2)	Regression coefficient (b)
GP	-0.41*	0.168	-0.238
DTF	-0.17NS	0.028	-1.644
DM	0.13NS	0.016	0.368
PH	0.03NS	0.009	0.337
HD	0.61**	0.372	0.757
NOSPD	0.64**	0.409	0.006
SYPP	0.76**	0.577	2.690
SI	0.53**	0.281	0.483
BYPP	0.84**	0.705	1.028

**= 0.01 level of probability, *=0.05 level of probability and ns = non-significant

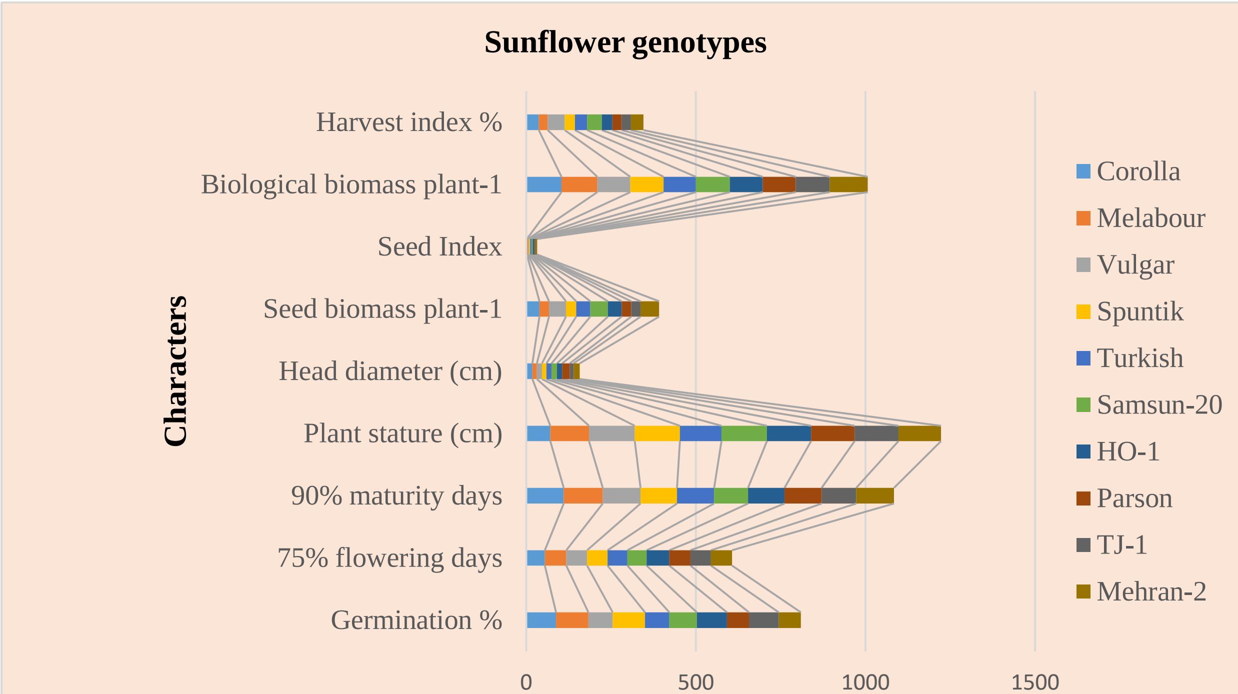

Figure 1. Genotypic variation among different characters of sunflower (*Helianthus annuus* L.)

Discussion

The mean squares for biomass & it constitutes are present in (Table 1). that showed highly significant genotypes at p≤0.01 level of probability for the number of seeds head^{-1}, the seed yield plant^{-1}, and the harvest index, while significant at the level of probability p≤0.01 for plant height, the seed index, and the biological yield plant^{-1}, and non-significant for the germination per cent, days of 90% flowering, days to 90% maturity, and head diameter [7], prior researchers, revealed that genotypes were very important for the qualities evaluated in their research, which supports the findings of this study. The average yield performance and its constituent parts are shown in (Table 2), which also showed that the germination percentage of ten commercial types is not statistically significant. Melabour and sputnik had the highest germination percentage (95%) whereas Parson and Mehran-2 showed the lowest germination percentage (65%) among the types. The variety corolla, followed by Samson-20, had the lowest number of days to flowering (55.33) while variety H0-1 had the highest number of flowering days (66.33). Samsun-20 and TJ-1 varieties had the lowest number of days to reach maturity (100.00), whereas Melabour needed the most number of days to reach maturity (115.33). [13] Revealed that flowering and head width had the biggest direct negative influence on seed output. Researchers like [14] performed experiment on 104 sunflower cultivars to observe genetic variation between them. In terms of plant height (cm), the variety corolla had the smallest plant height (71.37cm) and the variety vulgar had the largest plant height (134.83cm). In terms of head diameter (cm), the variety mehran-2 recorded a maximum head diameter (cm) of 44.78 and a minimum head diameter (cm) of 10.88, both of which were displayed by the variety TJ-1. The variety H0-1 displayed the highest number of seeds head^{-1} at (1473.2), while the variety Parson had the lowest number of seeds head-1 at (619.2). The parameters total leaf area and yield revealed the largest genetic diversity, according to, [14] who studied ten sunflower cultivars. In terms of seed yield plant^{-1}, the variety Mehran-2 had the highest seed yield plant^{-1} (54.22) while Tj-1 had the lowest seed yield plant^{-1} (27.67). In the case of seed index (g), Turkish was the variety with the highest seed index (4.18), while spuntik had the lowest seed index (2.30). The variety Mehran-2 recorded the highest biological yield (g), which was 111.97, while the variety Turkish recorded the lowest biological yield (g), that were 95.17. The variety of vulgar had the highest harvest index (49.76), while melabour had the lowest (26.43). While [15] experimented on advanced sunflower genotypes, seed index and seed yield^{-1} showed the highest negative significant correlation effect. [13] Worked on eight sunflower genotypes to determine the relationship among different characters, but seed yield-1 showed the highest negative significant correlation. Higher significant but adverse relationships between germination percentage and head diameter, maturity, and seed yield, as well as non-significant but adverse relationships between germination percentage and blooming, seed index, biological yield, and harvest index. Positive correlation with plant height and the seed head, although not significant. Another study [16] studied the effects of different temperatures on germination and found that the field and laboratory tests showed the strongest correlation coefficients, followed by the cool and cold tests. While non-significant were plant statures, head diameter, no: of seeds head^{-1}, seed yield plant^{-1}, seed index, & biological yield, flowering had two significant associations with maturity and harvest index, one of which is positive and one of which is negative. However, a different researcher [13] examined 25 sunflower genotypes to determine the link and contribution to seed output, although days of blooming revealed the biggest negative significant influence to advance the breeding program for sunflowers in the early generation. While plant height was very significant but showed negative correlation with the maturity, the no: of seeds head^{-1}, seed yield plant^{-1} and harvest index were not significant correlation with maturity but positive correlation with harvest index and biological yield. When forty different genotypes of sunflower were evaluated by [17] the genotypes that were independent at 90 percent maturity exhibited higher mean values based on distance to enhance traits. Plant height was not statistically significant, but seed yield and harvest index were positive; in contrast, head diameter, the no: of seed head^{-1}, seed index, & biological yield were negative. Whereas [18] indicated that increasing seed production in the breeding program for confectionery was adversely significant link with plant height. The biological yield and seed yield had two very significant but positive effects on head diameter, whereas the seed index and the number of seeds per head had two significant but positive effects and the harvest index had no significant but positive effects. Using thirty-eight sterility maintainer lines B and thirty-eight sterility maintainer lines R, [16] found that head diameter had the strongest significant link with seed yield based on high genetic potential. While, harvest index was significant but positive, number of seed head^{-1} exhibited a highly significant but positive correlation with seed yield, seed index, and biological yield. A different researcher [19] examined 31 sunflower genotypes to determine the association between characters; nevertheless, no results regarding seed output revealed a significant positive correlation. The correlation in middle of seed yield & seed index, biological yield, and harvest index were highly significant but favorable. However, a different study [16] examined 20 sunflower genotypes while finding a highly substantial positive correlation between seed yield. Harvest index and seed index showed a highly substantial but positive correlation, although biological yield was also strong and favorable. While [15] worked on advanced sunflower genotypes, the seed index revealed a substantial positive association for the development of high yielding sunflower genotypes. The harvest index for biological yield was non-significant but favorable. Another researcher [20] conducted experiments on a number of significant features, but harvest index showed a strong positive correlation with sunflower output. The relationship between harvest index and seed yield was extremely positive and highly significant (0.84**), and it was followed by seed index (0.76**), according to the correlation between yield component and seed yield/plant. Due to variance in related yield components, the coefficient of determination showed variation in seed yield. Harvest index variation caused the most variance in seed production (70 percent), followed by seed index variation (57.76 percent) and plant length variation (which is the least variation) (0.09 percent). The increase in seed production brought about by an increase in seed components was shown by the regression coefficient. The biggest increase in seed output (2.69 g) was discovered as a result of an increase in seed index, followed by harvest index (1.02); however, a one-day delay in flowering revealed a loss in seed production (-1.64 g). Other researchers [21] used five different kinds of sunflowers to evaluate correlations, coefficients, and regressions. The results revealed that plant height and head diameter are the key yielding factors to be taken into consideration in next breeding program. Regression analysis performed by [21] on 104 sunflower genotypes revealed that increasing 100-kernel weight, number of seed heads per seed, and stem length might boost seed output. Similarly, to the hybrid sunflower tested on by [22] the analysis of regression coefficient revealed that the days of blooming being 50% was a very significant coefficient into sunflower yield. Another study [21] used a split plot design to study hybrid sunflowers during the winter. The results revealed a significant positive relationship between the regression's independent variables, such as plant height, seed weight, seed index and the dependent variable seed yield.

Conclusion

It was concluded from the above that Mehran 2 showed taller plants with a large head diameter and greater seed production, biological yield plant^{-1}. However, HO-1 also showed better performance with yield and other traits. The biological yield/plant, harvest index, head diameter, number of seed head^{-1}, and seed index all demonstrated extremely positive and significant relationships with grain biomass plant^{-1}. The greatest fluctuation in grain biomass was caused by the harvest index, followed by the seed index, and the greatest rise in seed yield is caused by the rising seed index, then the harvest index. Variety Mehran-2 and vulgar are suitable breeding materials, and selections in seed index and harvest index might be made to increase production.

Authors' contributions

Conceived and designed the experiments: B Ali & S Memon, Performed the experiments: B Ali, S Memon, & LA Bhutto, Analyzed the data: LA Bhutto & SA Memon, Contributed materials/ analysis/ tools: ZA Soomro, LA Bhutto, SA Memon & A Memon, Wrote the paper: B Ali.

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