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Evaluating the morphological and yield traits of Lentil (*Lens culinaris* L.) advance lines under water stress condition

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Abstract: Lentil is an important pulse crop in Pakistan which is used in combination with cereals to balance the diet. The current study was conducted to evaluate the lentil advance lines under water stress condition at Pulses Research Institute of Faisalabad. In order to examine the effect of drought stress on lentil (*Lens culinaris* M.) varieties field research were carried out in Randomized Complete Block Design (RCBD) with three replications at Ayub Agricultural Research Institute, Faisalabad, Results of combined analysis of variance showed that all the studied characters were controlled by drought stress situations. Accession 12503 showed maximum height that were 12.5cm at flowering and 38.69cm at maturity under water stress condition while the accession 11510 showed minimum height that were 9.48cm at flowering and 36cm at maturity. Accession 13502 showed maximum days to flowering that were 98 days at flowering and 137 days at maturity, while other characters showed minimum days to flowering and maturity. Accession 12503 showed maximum canopy temperature that was 19.67 ^{0}C and line 13514 showed minimum canopy temperature that was 16^{0}C. The accession 12512 had highest seed yield that was 690g and accession11508 had minimum seed yield that was 328g. It was examined that certain characters like canopy temperature, seed yield, total grain weight showed positively significant correlation and other traits like No of pod per plant, No of primary branches, No of secondary branches, plant height at flowering and maturity, Days to flowering and maturity and seed per pod showed negatively correlation under water stress. Results indicate that under water stress condition all morphological traits of lentil showed positive and negative correlation with each other, certain characters showed positive effect and some showed negative effect.
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Key words: Drought, stress, Lentil, Yield

Introduction

Lentil is an annual crop belonging to Leguminoseae (Fabaceae) family. Lentil yield include elevated protein essence, and identified the third-greater intensity of protein of any nut, subsequent to soybean and drugs ranges of grain protein substance varies from 22% to 34.6% Callaway *et al.* [4] 2004. It is a rich source of hydrocarbons (59%), reserves (2%), chlorophyl (28%), nutrition and threads. An amount of contaminated mechanism namely, to copherolsphytosterols, and squalene are showed in lentil Ryan *et al.* [11] 2007.

The consequent major developed pulse yield of Rabi season in Pakistan after chick-pea (*Cicerarietinum L.*) is lentil both in excellence and abundance Ayub *et al.* [2] 2001. In current time bean construction in Pakistan has reduced due to its poor competence ability with Major Rabi crop considerably. Water tension is the main trouble in cultivation and the capability to survive such pressure is efficiently important. Using of drought resistance plant is one of the best ways for good cultivation under drought condition.

The legume yield is mostly cultured in rain fed region of the Punjab where they bear a slighter quantity of water situation resulting in low yield of bean. The present reading is split to evaluate advance accession of legume underwater strain circumstances to recognize the budding earth contrasting lines. Generally drought stress occurs when the available water in soil is condensed and atmospheric circumstances cause continuous failure of water by transpiration or vanishing Jaleel *et al.* [8] 2009. In drought stress situation plants close up their stomata mechanism to stay away from more water loss.

Plant agriculturist utilize morphological characters such as, pod number, plant elevation range and width of sheet, days to blossoming, period of maturity, and grain harvest as assortment criterion Bayoumi [3] 2008.

Water stress is very significant constraint character at the primary stage of plant development and institution. Drought effects together enlargement and extension growth Jaleel *et al.* [8] 2009. Another water shortage effect is the lessening of vegetative growth. Water stress throughout vegetative growth has the highest effect on height of plant and biological yield Ghassemi- Golezani and Mardfar [7] 2008. Throughout the generative increase water scarcity has a consequence on crop effectiveness Costa- Franca *et al*. [5] 2000.

Low moisture stress slow down the plant growth and they start to build up active osmolyte (compounds that are characteristics as non- toxic, highly soluble and having low mol. wt) in their cells and this process is called osmotic adjustment. In all parts of the plants osmotic regulation occurs including stem, leaf root and fruit Unyayar *et al.* [15] 2004. Ionic variation is one of the main significant strategies that plants approved to tolerate under water deficiency stress condition Otieno *et al.* 2005; Afkari *et al*., 2009[9] [1]. These osmolytes help the plants to show protective reaction against drought injure Reddy *et al.* 2004; Shao *et al.* 2005[10] [13] as these helps the plants to retain water assimilation and cell turgid potential under stress condition.

Materials And Methods

A group of 14 advance lines vizV-08504, V-12503, V-10503, V-10514, V-09501V11501, V-11504, V-11507, V-11509, V-11510, V-11514V-12505, V-12512, V-12514 and two approved varieties was sown in Randomized complete block design (RCBD) with three replications at Ayub Agriculture Research institute, Faisalabad. The plot size will be 4 x 1.2m. The experiment will be sown during 1st fortnight of November; Nitrogen, Phosphorus and potassium fertilizers were applied at different rate. The level of interval and plant distance was retained at 30cm and 7.5cm. The research was planted in clammy mud and no watering was appropriate subsequently. For information recording ten guarded plants were selected and tagged data on the following characters was recorded. Each entry/accession was sown in moist soil. Fertilizers were applied at the rate of 9-23 kg N-P-K ha^{-1}. Ten similarly capable plants were designated and labeled in order to measure data on every side of the line. Plant biomass (in grams) was examined by evaluating the total mass of the entire line of seed yield subsequently picking. Correspondingly, seed yield of the entire lentil line was observed in grams using the numerical electric balance. From every ten pods of the particular plant were total and mean was observed.

Harvest index (HI) is the proportion of commercial production to entire plant biomass.

$$\text{Harvest index} = \frac{\text{Seed Yield}}{\text{Plant biomass}} \times 100$$

Five plants were planted in 1.2 meter long PVC Plastic pipes of 10cm diameter after filling the pipes with pure sand. Plants along with full root system were executed from the pipes by draining the sand out of the pipes.

Root and shoot were separated with the Scissor from the joining point. Length of the root and shoot was measured in cm and then weight in grams. The roots were placed in oven at 60 salacious for 48 hours and the material was weight in grams.

Results

Days to flowering and maturity were recorded during the whole research. Other agronomical character such as plant height, plant biomass, number of branches per plant, number of leaves plant per plant and other characters were recorded. For the assessment of the height at flowering were observed in (cm). Analysis of variance for height at flowering explained in Table 4.1 and displayed greatly substantial alterations for all selections. This signified the importance of additive as well as non-additive components of variation for this character.

Table 4.1: Randomized Complete Block ANOVA Table for Height at Flowering

Source	DF	SS	MS	F	P
Reps	2	3.4359	1.71794		
Varieties	15	24.817	1.65447	0.74	0.723
Error	30	66.7004	2.22335		
Total	47	94.9533			
Grand Mean	11.398				
CV	13.08				

Analysis of variance showed non-significant difference between genotype. All varieties are positively significant to each other.

Total seed weight:

Agronomical character such as plant height, plant biomass, number of branches per plant, number of leaves plant per plant and other characters were recorded. Analysis of variance was applied for the assessment of the total seed weight explained in Table 4.3 and displayed greatly substantial alterations for all selections. This signified the importance of additive as well as non-additive components of variation for this character.

Table 4.2 Randomized Complete Block ANOVA Table for Total seed weight

Source	DF	SS	MS	F	P
Reps	2	39371	19685.5		
Varieties	15	299318	19954.5	1	0.48
Error	30	598603	19953.4		
Total	47	937292			
Grand Mean	22.003				
CV	641.99				

Analysis of variance showed non-significant difference between genotype. All varieties are positively significant to each other.

Days to maturity:

Agronomical character such as plant height, plant biomass, number of branches per plant, number of leaves plant per plant and other characters were recorded. Analysis of variance was applied for the assessment of days to maturity explained in Table 4.3 and displayed greatly substantial alterations for all selections. This signified the importance of additive as well as non-additive components of variation for this character.

Table 4.3: Randomized Complete Block ANOVA Table for days to maturity

Source	DF	SS	MS	F	P
Reps	2	4.04	2.0208		
Varieties	15	201.92	13.4611	0.31	0.9896
Error	30	1287.96	42.9319		
Total	47	1493.92			
Grand Mean	136.79				
CV	4.79				

Analysis of variance showed non-significant difference between genotype. All varieties are positively significant to each other.

Days to flowering:

Agronomical character such as plant height, plant biomass, number of branches per plant, number of leaves plant per plant and other characters were recorded. Analysis of variance was applied for the assessment of the days to flowering explained in Table 4.3 and displayed greatly substantial alterations for all selections. This signified the importance of additive as well as non-additive components of variation for this character.

Table 4.4 Randomized Complete Block ANOVA Table for days to flowering

Source	DF	SS	MS	F	P
Reps	2	1.125	0.5625		
Varieties	15	58	3.86667	0.91	0.5584
Error	30	126.875	4.22917		
Total	47	186			
Grand Mean	95.5				
CV	2.15				

Analysis of variance showed non-significant difference between genotype. All varieties are positively significant to each other.

Canopy temperature:

Agronomical character such as plant height, plant biomass, number of branches per plant, number of leaves plant per plant and other characters were recorded. Analysis of variance was applied for the assessment of the total canopy temperature explained in Table 4.11 and displayed greatly substantial alterations for all selections. This signified the importance of additive as well as non-additive components of variation for this character.

Table 4.5: Randomized Complete Block AONVA Table for Canopy temperature

Source	DF	SS	MS	F	P
Reps	2	2.5499	1.27495		
Varieties	15	4.866	0.3244	0.51	0.9171
Error	30	19.1955	0.63985		
Total	47	26.6114			
Grand Mean	16.362				
CV	4.89				

Analysis of variance showed non-significant difference between genotype. All varieties are positively significant to each other.

Seed Yield:

Agronomical character such as plant height, plant biomass, number of branches per plant, number of leaves plant per plant and other characters were recorded. Analysis of variance was applied for the assessment of the total seed yield explained in Table 4.3 and displayed greatly substantial alterations for all selections. This signified the importance of additive as well as non-additive components of variation for this character.

Table 4.6: Randomized Complete Block AOV Table for Seed Yield

Source	DF	SS	MS	F	P
Reps	2	91377	45688.6		
Varieties	15	441015	29401	2.31	0.0248
Error	30	381684	12722.8		
Total	47	914076			
Grand Mean	462.42				
CV	24.39				

Analysis of variance showed non-significant difference between genotype. All varieties are positively significant to each other.

Height at Maturity:

Agronomical character such as plant height, plant biomass, number of branches per plant, number of leaves plant per plant and other characters were recorded. Analysis of variance was applied for the assessment of the total height at maturity explained in Table 4.3 and displayed greatly substantial alterations for all selections. This signified the importance of additive as well as non-additive components of variation for this character.

Table 4.7: Randomized Complete Block ANOVA Table for Height at Maturity

Source	DF	SS	MS	F	P
Reps	2	0.235	0.1174		
Varieties	15	250.08	16.672	0.74	0.7267
Error	30	675.723	22.5241		
Total	47	926.037			
Grand Mean	36.921				
CV	12.85				

Analysis of variance showed non-significant difference between genotype. All varieties are positively significant to each other.

Root Length: Data was recorded for seedling growth to reveal the root length and determine the data that displayed significant modification of under the water stress. Root length of lentil accession V12514, V12505 water primed seedling in non-stress situation was maximum as related to stress situation. In water primed root length was increased in stress situation while decreased in stress circumstance.

Fresh root weight: Data was recorded for seedling growth to reveal the root length and determine the data that displayed significant modification of under the water stress. Fresh root weight of water primed seedling in stress condition was increased as related to non-stress situation. In water primed root length was increased in stress situation while decreased in stress circumstance.

Dry root weight: Data was recorded for seedling growth to reveal the root length and determine the data that displayed significant modification of under the water stress. Root length of water primed seedling in stress condition was increased as related to non-stress situation. In water primed root length was increased in stress situation while decreased in stress circumstance.

Shoot length: Data was recorded for seedling growth to reveal the root length and determine the data that displayed significant modification of under the water stress. Root length of water primed seedling in stress condition was increased as related to non-stress situation. In water primed root length was increased in stress situation while decreased in stress circumstance.

Fresh root weight: Data was recorded for seedling growth to reveal the root length and determine the data that displayed significant modification of under the water stress. Root length of water primed seedling in stress condition was increased as related to non-stress situation. In water primed root length was increased in stress situation while decreased in stress circumstance.

Dry root weight: Data was recorded for seedling growth to reveal the root length and determine the data that displayed significant modification of under the water stress. Root length of water primed seedling in stress condition was increased as related to non-stress situation. In water primed root length was increased in stress situation while decreased in stress circumstance.

Table 4.8 Root length and Shoot length ratios between different varieties

Varieties	Root length (cm)	Fresh root weight (g)	Dry root weight (g)	Shoot length (g)	Fresh Shoot length (g)	Dry shoot length (g)
V11501	9.30	1.08	0.21	7.00	1.67	0.48
V11508	13.10	0.26	0.29	7.00	0.70	0.50
V11510	15.00	0.28	0.46	8.20	0.08	1.43
V11513	13.20	0.57	0.71	8.00	2.96	2.42
V11514	19.00	0.03	0.85	9.90	3.75	1.58
V12503	12.60	0.97	1.14	9.20	2.73	2.08
V12505	21.50	0.74	0.41	8.00	3.26	1.49
V12512	11.50	0.48	0.63	8.50	2.90	1.84
V12514	31.00	0.82	0.69	8.50	3.26	2.11
V13502	19.50	0.83	0.08	8.50	4.06	1.40
V13512	13.00	0.02	0.73	10.00	1.89	1.99
V13514	35.20	0.87	0.86	11.50	3.43	1.62
V13516	23.00	0.41	0.28	12.50	2.16	1.99
V10502	22.50	0.26	0.65	12.00	3.66	1.62
M-93	25.50	0.72	o.59	10.00	3.02	1.78
Pb.M-09	16.00	0.04	1.56	8.50	1.30	1.23

The explanation of above graph such as range (lowest and highest) of standard deviation and mean of sixteen traits of lentil accessions specifically pods per plant, period of flowering to maturation, height of plant, days to flowering, 100o seed weight and seed yield are displayed in (Table 4.8). The mean value of factors was plant biomass 1815.47 gm, seed yield 465.04 gm, canopy temperature17.68 ^{0}C, days to flowering 96.41, days to maturity 136.70, total grain weight 19.77 gm, height at flowering 11.39 cm, height at maturity 36.92 cm, no of primary branches 3.93, no of secondary branches12.04, no of pods per plant 73.69, seed per pod 2.35 correspondingly and the standard deviation of the traits was 535.93, 94.41, 1.32, 1.48,1.49, 1.43, 0.74, 2.35, 1.06, 3.45, 22.17 and 0.88 similarly representing significant changeability which occurs between the genotypes.

Table 4.9: Minimum, maximum, mean and standard deviation (SD) of different characters

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
TW	16	1129.333	3346.667	1815.479	535.934
SY	16	316.000	626.667	465.042	94.415
CT	16	15.857	19.710	17.681	1.324
DTF	16	93.333	98.000	96.417	1.488
DTM	16	134.000	139.000	136.708	1.490
TGW	16	17.480	23.207	19.779	1.438
HTF	16	9.637	12.343	11.398	0.743
HTM	16	31.037	40.223	36.921	2.357
PB	16	2.660	6.000	3.939	1.006
SB	16	6.340	19.000	12.043	3.456
NOP	16	47.340	130.670	73.697	22.177
SP	16	1.340	4.000	2.356	0.889

Variables: SP: Seed per pod, NOP: No of pods per plant, PB: No of primary branches, SB: secondary branches, HTF: Height at flowering, HTM: Height at maturity, TGW: Total grain weight, DTF: Days to flowering, DTM: Days to maturity, CT: Canopy temperature, SY: Seed yield and TSW: Total seed weight.

Table 4.10: Correlation matrix (Pearson)

Variables	TW	SY	CT	DTF	DTM	TGW	HTF	HTM	SB	NOP
TW	**1**									
SY	0.158	**1**								
CT	-0.084	-0.640	**1**							
DTF	-0.464	-0.123	0.209	**1**						
DTM	-0.163	-0.149	0.482	0.433	**1**					
TGW	-0.067	0.254	-0.419	0.408	-0.181	**1**				
HTF	-0.432	0.243	-0.555	0.401	0.092	0.609	**1**			
HTM	0.186	-0.034	-0.046	0.538	0.180	0.564	0.244	**1**		
PB	-0.123	0.116	-0.203	0.133	0.080	0.169	0.385	0.240	**1**	
SB	-0.234	0.328	-0.493	0.031	0.017	0.030	0.301	-0.126	0.384	**1**
NOP	-0.060	0.150	-0.481	0.203	0.158	0.061	0.401	0.060	0.188	0.750
SP	-0.325	-0.026	-0.102	-0.119	-0.380	-0.225	0.035	-0.715	0.291	0.018

Variables: SP: Seed per pod, NOP: No of pods per plant, PB: No of primary branches, SB: No of secondary branches, HTF: Height at flowering, HTM: Height at maturity, TGW: Total grain weight, DTF: Days to flowering, DTM: Days to maturity, CT: Canopy temperature, SY: Seed yield, TSW: Total seed weight. In table (4.10) total weight of plant shows significant result with total grain weight and seed yield show positive co-relation with total grain weight, canopy temperature shows negative co-relation with total grain weight and seed yield, days to flowering shows negative co-relation with total grain weight, seed yield and positive co-relation with canopy temperature, days to maturity shows negative co-relation with total grain weight, seed yield and positive co-relation with canopy temperature and days to flowering, height at flowering shows negative co-relation with total grain weight and canopy temperature and positive co-relation with seed yield, days to flowering, days to maturity and total grain weight. All traits were positively and negatively co-related with each other.

Table 4.11 Eigen value

Variables	F1	F2	F3	F4
Eigen value	3.333	2.521	1.899	1.474
Variability (%)	27.773	21.008	15.822	12.285
Cumulative (%)	27.773	48.781	64.602	76.887

Table 4.12: Eigen values and percentage of variations

Characters	F1	F2	F3	F4
TW	-0.134	-0.055	-0.578	-0.278
SY	0.248	-0.279	-0.251	-0.028
CT	-0.376	0.384	0.213	-0.076
DTF	0.238	0.414	0.270	0.188
DTM	0.024	0.392	0.267	-0.374
TGW	0.360	0.138	-0.240	0.437
HTF	0.450	0.015	0.147	0.257
HTM	0.241	0.441	-0.332	0.029
PB	0.290	0.071	0.001	-0.225
SB	0.339	-0.248	0.213	-0.397
NOP	0.345	-0.136	0.194	-0.384
SP	-0.120	-0.383	0.376	0.356

Variables: SP: Seed per pod, NOP: No of pods per plant, PB: primary branches, SB: Secondary branches, HTF: Height at flowering. HTM, Height at maturity, TGW: Total grain weight. DTF, Days to flowering: DTM, Days to maturity, CT: Canopy temperature, SY: Seed yield and TSW: Total seed weight.

Association analysis:

Principal component analysis (PCA) supported to evaluate the changes in different varieties in sixteen genotypes of lentil germplasm. In PCA the first four Eigen values for four principle component analysis along the x-axes and y-axis of germplasm lines accounted for 27.77%, 48.78%, 64.60%, 76.88% of the whole variation, while only first two principal axes values contribute between the sixteen properties explaining sixteen lines of lentil germplasm. By observing the Eigen vectors of individual components, indications may be obtained about their levels of association with the original traits. Based on the principal component score of PC1 and PC2, two dimension graphs of the genotypes are obtained. Principle component (PC1) showed 27.77% of the entire dissimilarity and correlated completely with characters of plant height at maturity, plant biomass, harvest index, no of pod/plant, 1000 grain weight, number of seed per plant, seed harvest, seeds/pod, no of nodes traits.

Principle component (PC2) showed 48.78% of the entire dissimilarity and correlated completely with characters of plant height at maturity, plant biomass, harvest index, no of shell/plant, 1000 grain mass, seed per plant, seed resign, seeds/pod, no of nodes traits.

Principle component (PC3) showed 64.60% of the entire dissimilarity and correlated completely with characters of plant height at maturity, plant biomass, harvest index, no of pod/plant, 1000 seed weight, seed per plant, grain surrender, seeds/pod, no of nodes traits.

Principle component (PC4) showed 76.88 % of the entire dissimilarity and correlated completely with characters of plant height at maturity, plant biomass, harvest index, no of shell per plant, 1000 grain mass, grain per plant, grain harvest, seeds/pod, no of nodes traits.

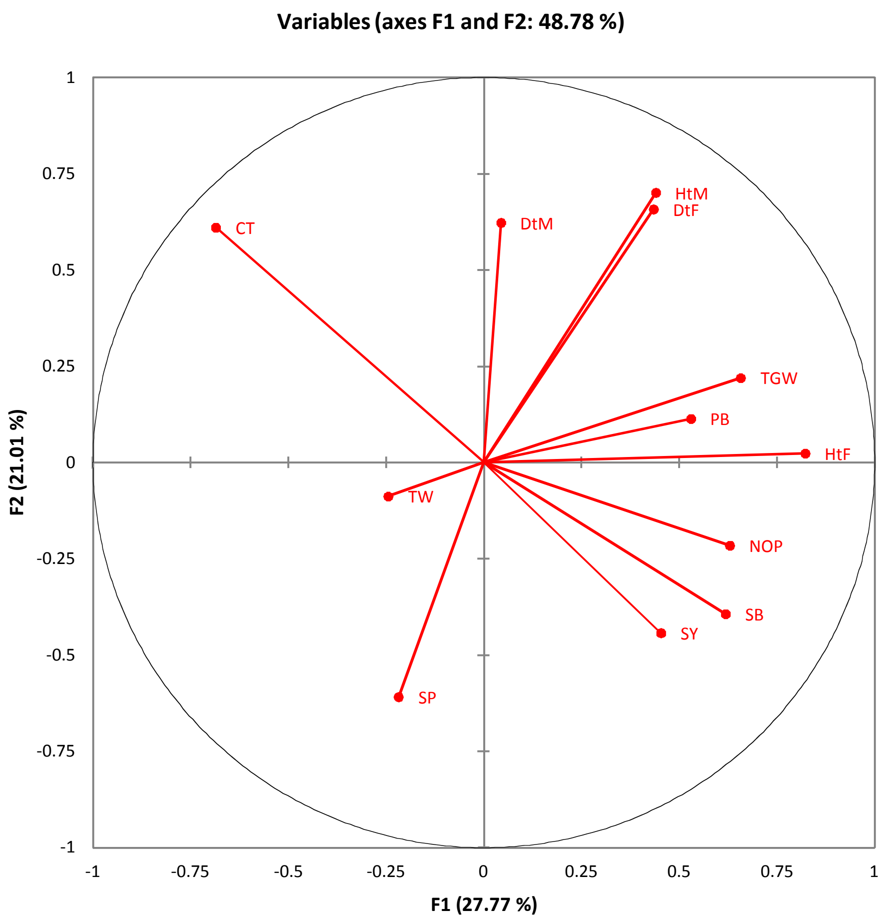

Fig 4.2: The correlation between the characters of two variables F1 and F2.

The graph explained the PC1 and PC2 distinguished sixteen groups of characters (Fig. 4.2). All these characters showed different results. In this graph each dot represented the specific properties of different characters. Some traits are greatly significant and some are non-significant. Duration of maturity, days to flowering, no of pods, height at flowering, showed highly significant results. On the other hand, plant biomass, were non-significant. Some character seeds per pod, canopy temperature were negatively relates to such character as total grain weight, seed yield and height at maturity showed positive effect to one another. They could help for high yielding program and variation of different traits.

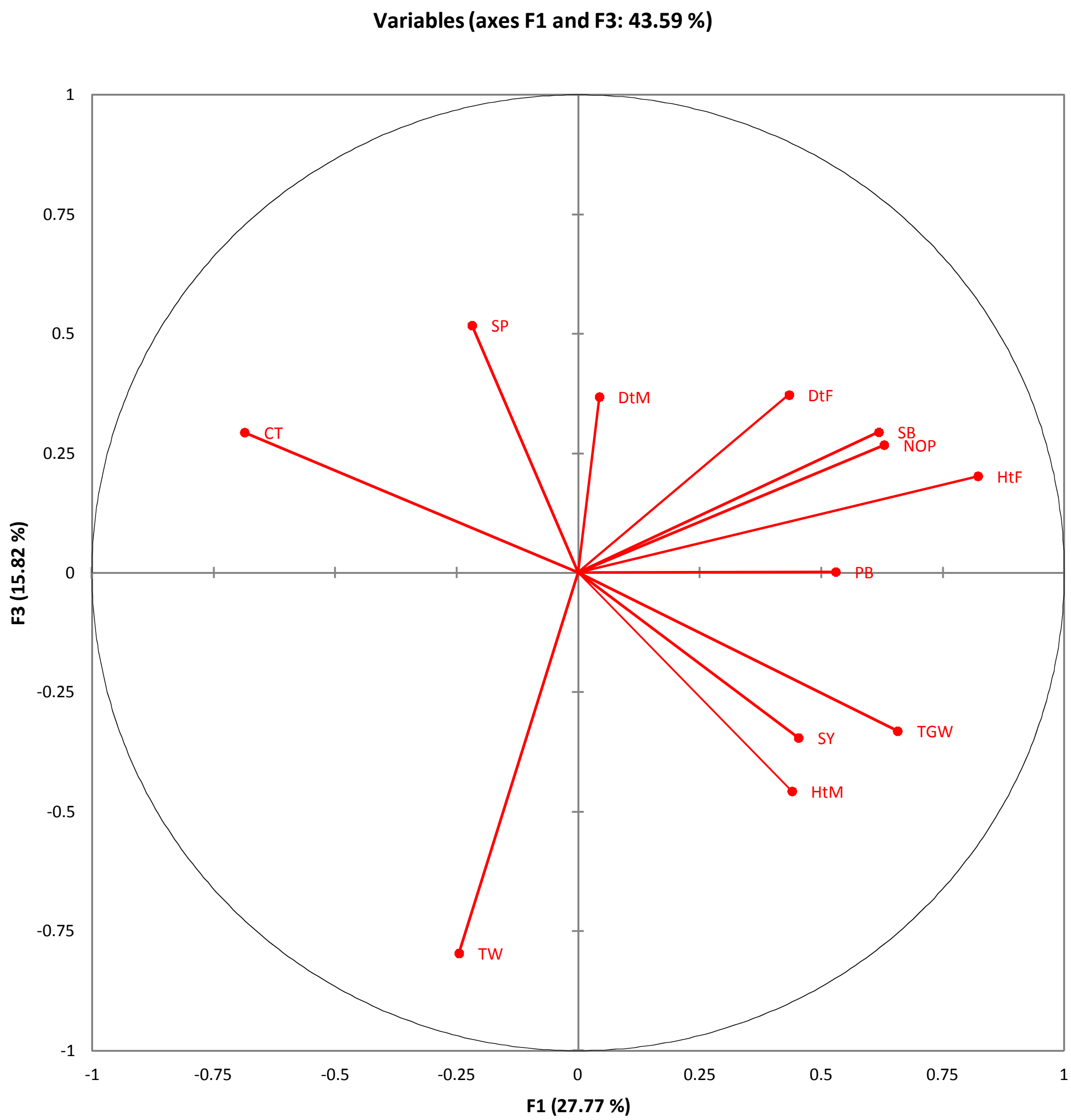

Fig 4.3: The association between the characters of two variables F1 and F3.

The graph explained the F1 and F3 distinguished sixteen groups of characters (Fig. 4.3). All these characters showed different results. In this graph each dot represented the specific properties of different characters. Some traits are highly significant and some are highly non-significant. Days to maturity and flowering, secondary branches, no of pods, height at flowering, showed highly significant results. On the other hand plant biomasses, primary branches, seeds per pod, total seed weight were non-significant. Some character plant biomass seed yield, plant height at maturity was negatively related to such character seed per pod and canopy temperature that are showed positive effect to one another. They could help for high yielding program and variation of different traits.

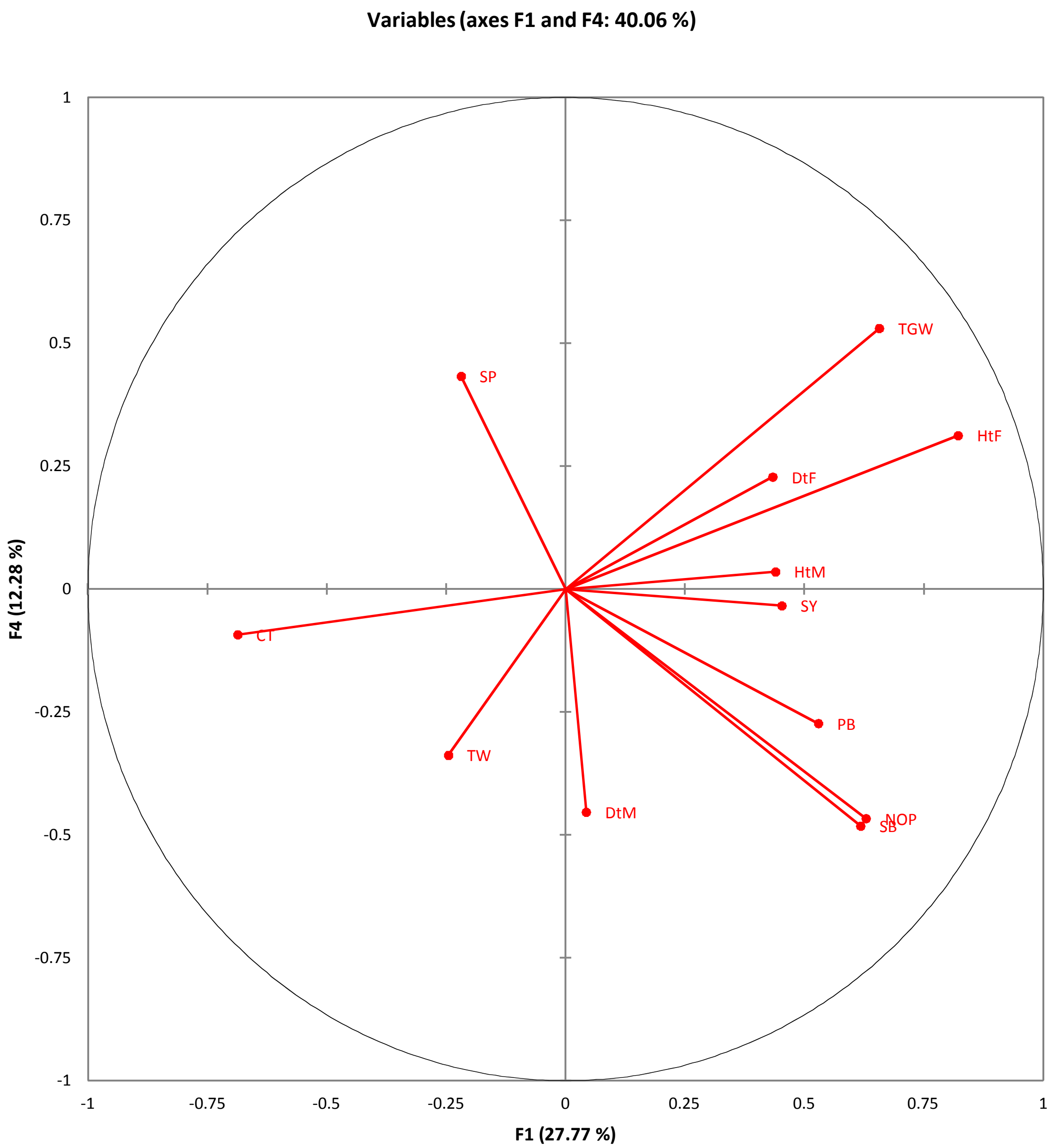

Fig 4.4: The relationship between the characters of two variables F1 and F4.

The graph explained the PC1 and PC2 distinguished sixteen groups of characters (Fig. 4.4). All these characters showed different results. In this graph each dot represented the specific properties of different characters. Some traits are highly significant and some are highly non-significant. Days to maturity, days to flowering, plant biomass, no of pods, height at flowering, showed highly significant results. On the other hand, seeds per pod, total grain weight were non-significant. Some character was negatively relates to such character that are showed positive effect to one another. They could help for high yielding program and variation of different traits.

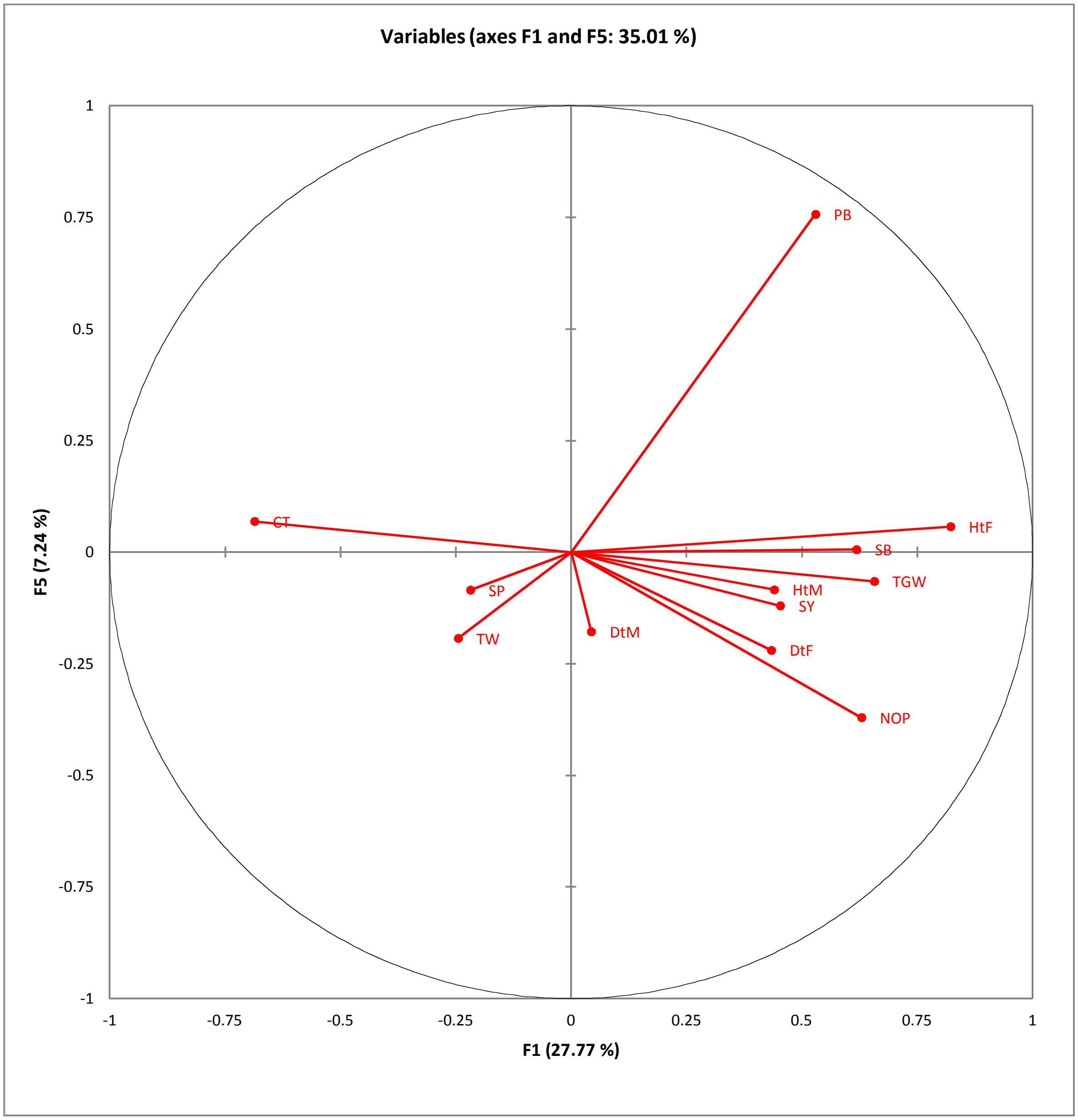

Fig 4.5: The relationship between the characters of two variables F1 and F5.

The graph explained the PC1 and PC2 distinguished sixteen groups of characters (Fig. 4.5). All these characters showed different results. In this graph each dot represented the specific properties of different characters. Some traits are highly significant and some are highly non-significant.

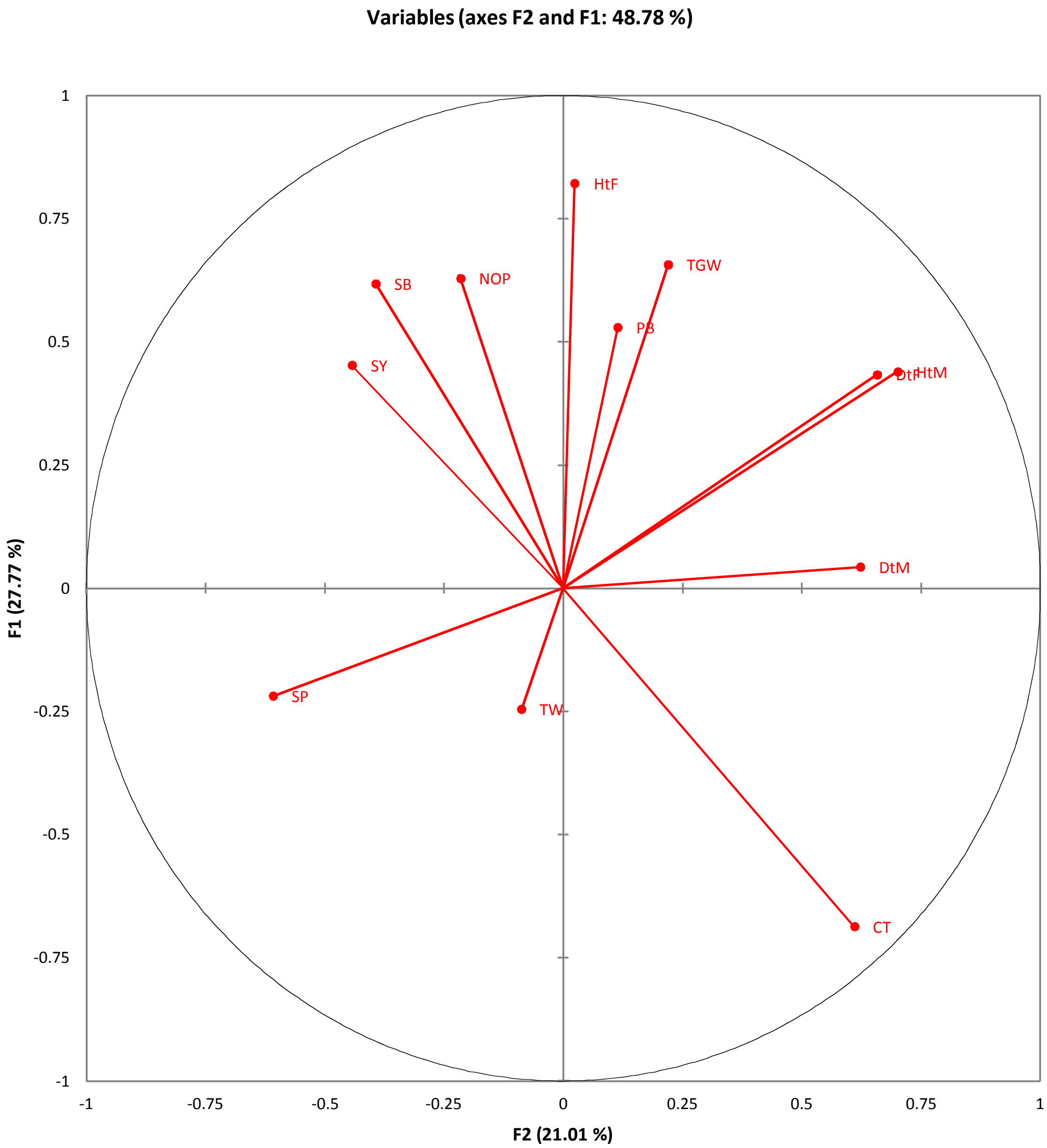

Fig 4.6: The connection among the characters of two variables F2 and F1.

The graph explained the F2 and F1 distinguished sixteen groups of characters (Fig. 4.6). All these characters showed different results. In this graph each dot represented the specific properties of different characters. Some traits are highly significant and some are highly non-significant. Height at flowering, total grain weight, primary branches, harvest index, days to maturity and flowering showed highly significant results. On the other hand, grain per pod, and total seed mass were non-considerable. Some character like canopy temperature was negatively related to such character plant biomass, seed yield, Secondary branches, Pod per plant that are showed positive effect to each other. These traits are supportive for high yielding of lentil crop.

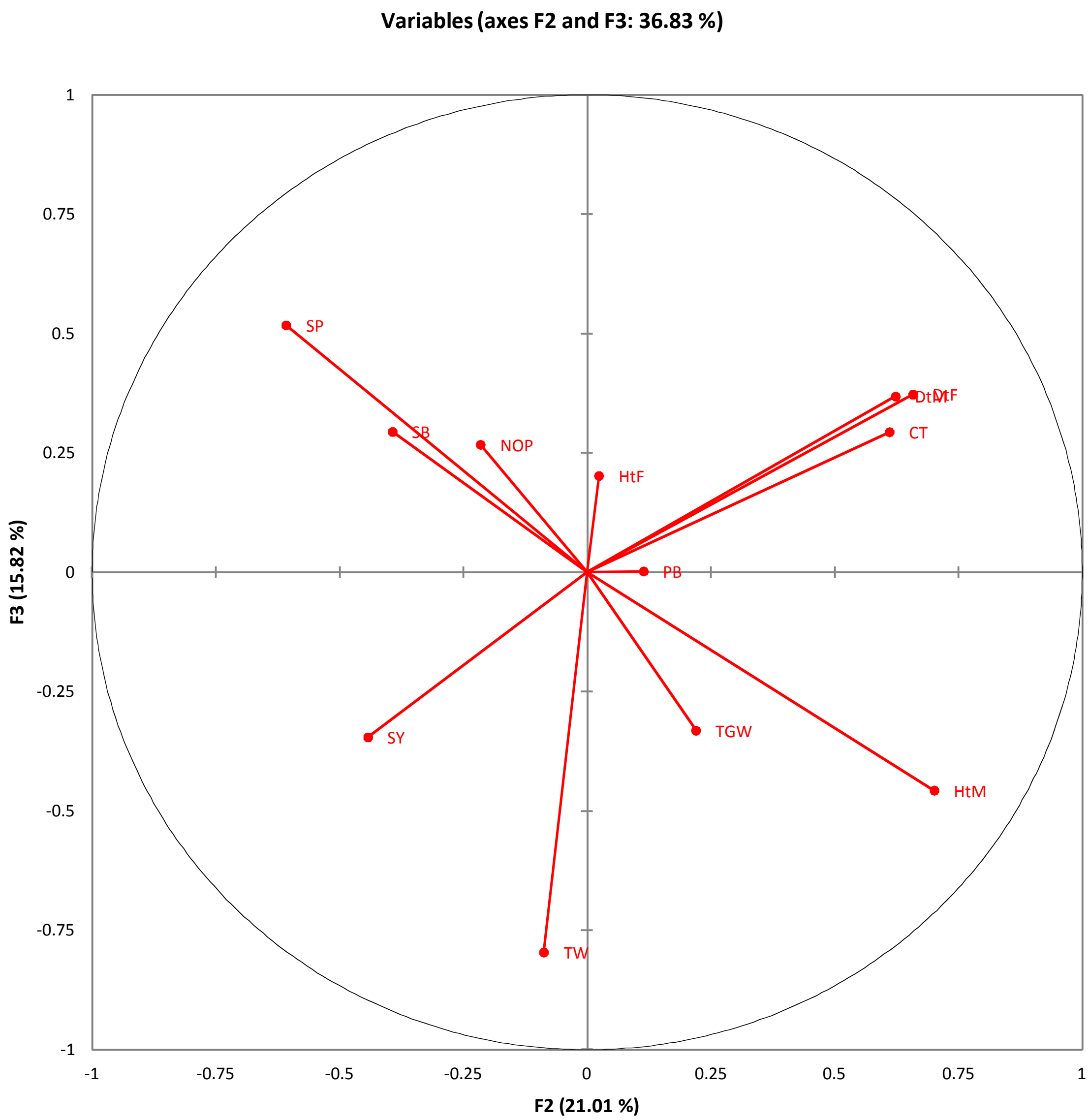

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Fig 4.7: The relation surrounded by the characters of two variables F2 and F3.

The graph explained the PC1 and PC2 distinguished sixteen groups of characters (Fig. 4.7). All these characters showed different results. In this graph each dot represented the specific properties of different characters. Some traits are highly significant and some are highly non-significant. Days to flowering and maturity, canopy temperature, primary twigs, tallness at flowering showed highly significant results. While on the other hand, total seed weight, seed harvest and plant biomass are non-significant. Some character no of pod, seed per pod, secondary branches were negatively related to certain characters such as height at maturity, total seed weight and harvest index that are showed positive effect to one another. They could help for high yielding program and variation of different traits.

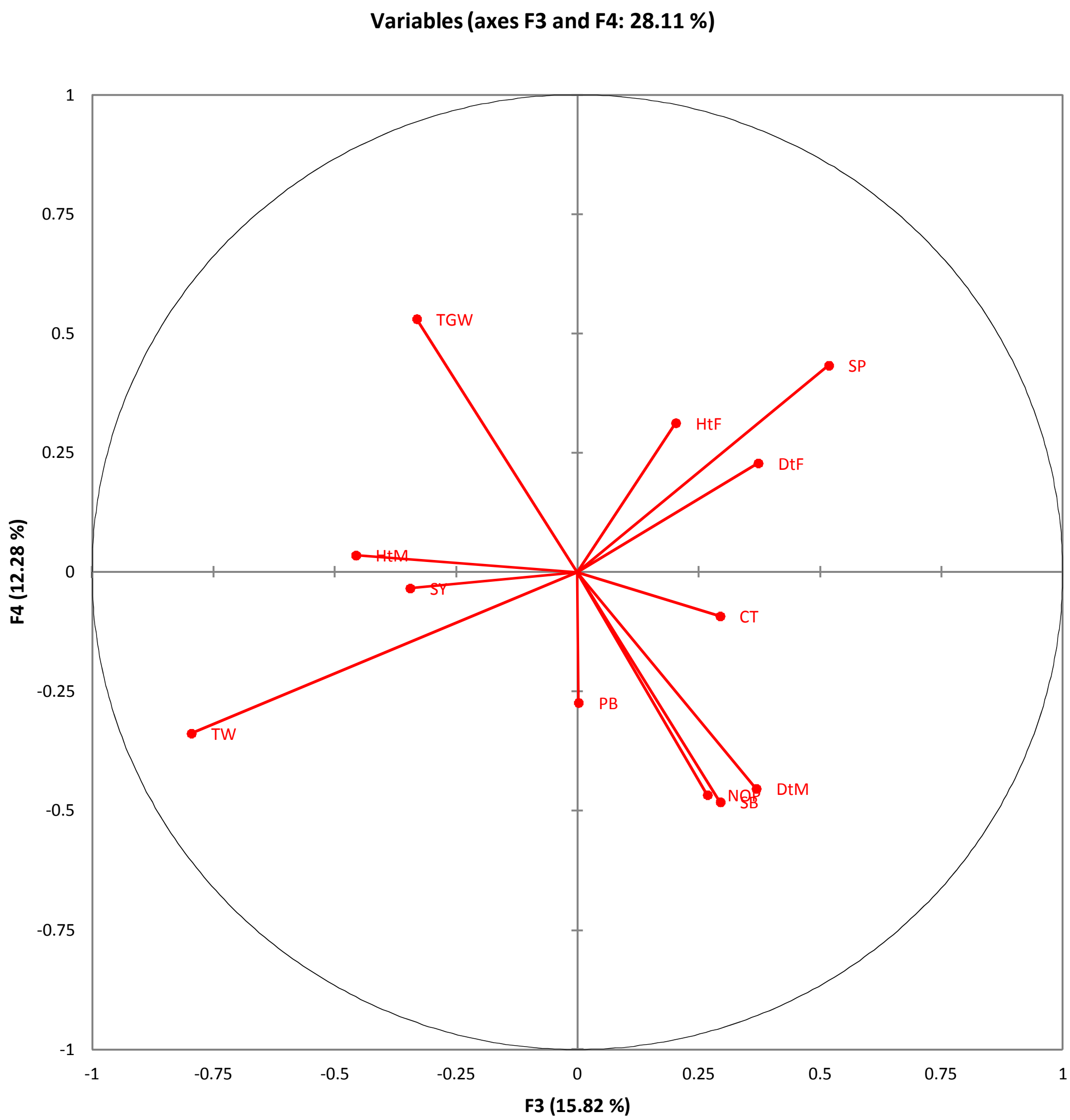

Fig 4.8: The correlation between the characters of two variables F3 and F4.

The graph explained the PC1 and PC2 distinguished sixteen groups of characters (Fig. 4.8). All these characters showed different results. In this graph each dot represented the specific properties of different characters. Some traits are highly significant and some are highly non-significant. Height at flowering, seed per pod, days to flowering, plant biomass and harvest index showed greatly substantial results. On the other hand, seeds per pod, total grain weight and seed yield were non-significant. Some character like canopy temperature, primary and secondary branches of plant, maturity time were negatively related to such characters harvest index that are showed positive effect to one another. These characters increase the yielding program and variation of different traits.

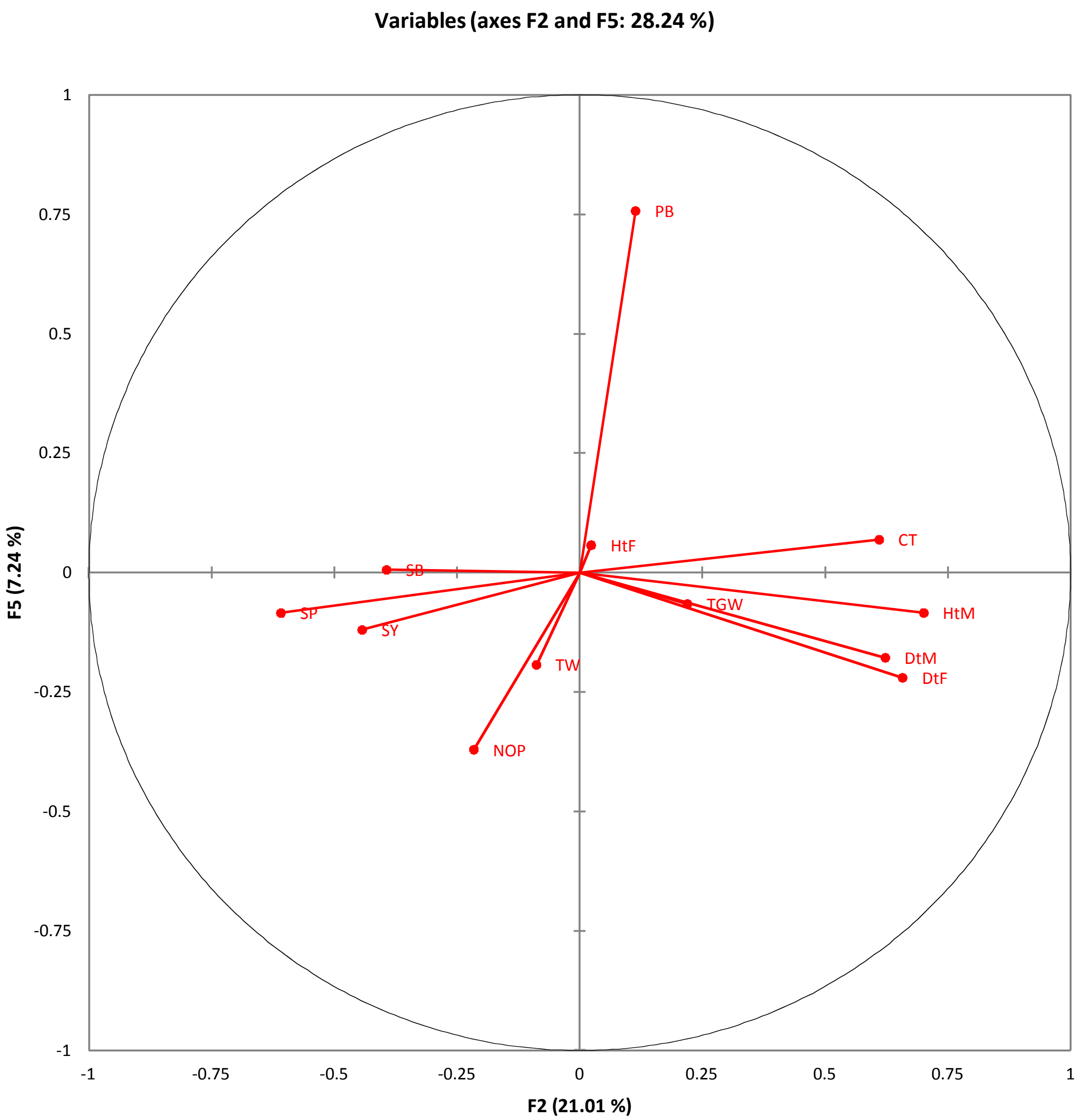

Fig 4.9: The connection among the characters of two variables F2 and F5.

The graph explained the PC1 and PC2 distinguished sixteen groups of characters (Fig. 4.9). All these characters showed different results. In this graph each dot represented the specific properties of different characters. All traits are highly non-significant except no of primary branches that are significant in PC1.

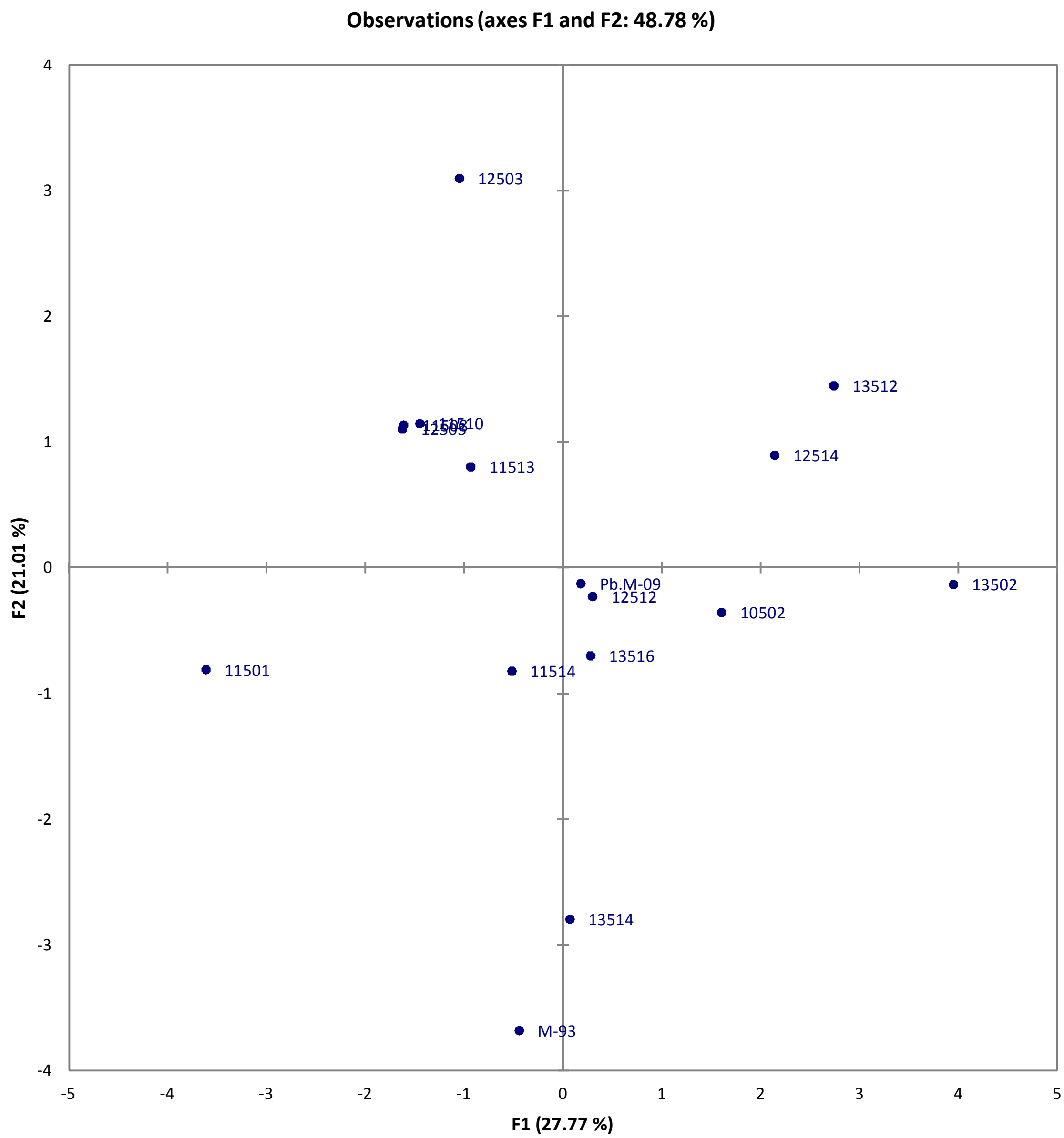

Fig 4.10: Two-dimensional ordination of 16 agro-morphological characters in genotypes of lentil advance lines on principal component axis.

Principal component analysis obtained significant change for all characters in lentil germplasm. For dependable assortment of parents scatter diagram was plotted with seed harvest per plant along the x axis and y axis (Fig. 4.10). Eight accessions were located in advance growth lines reduce yield and other two accessions seemed to be in early maturity increase yield of lentil, only one character was correlated to late maturity and maximum crop yield. Eleven lines exhibited their association with low yield and late maturity. The data recorded for all character from F1 and F2 groups were describing to principal component analysis.

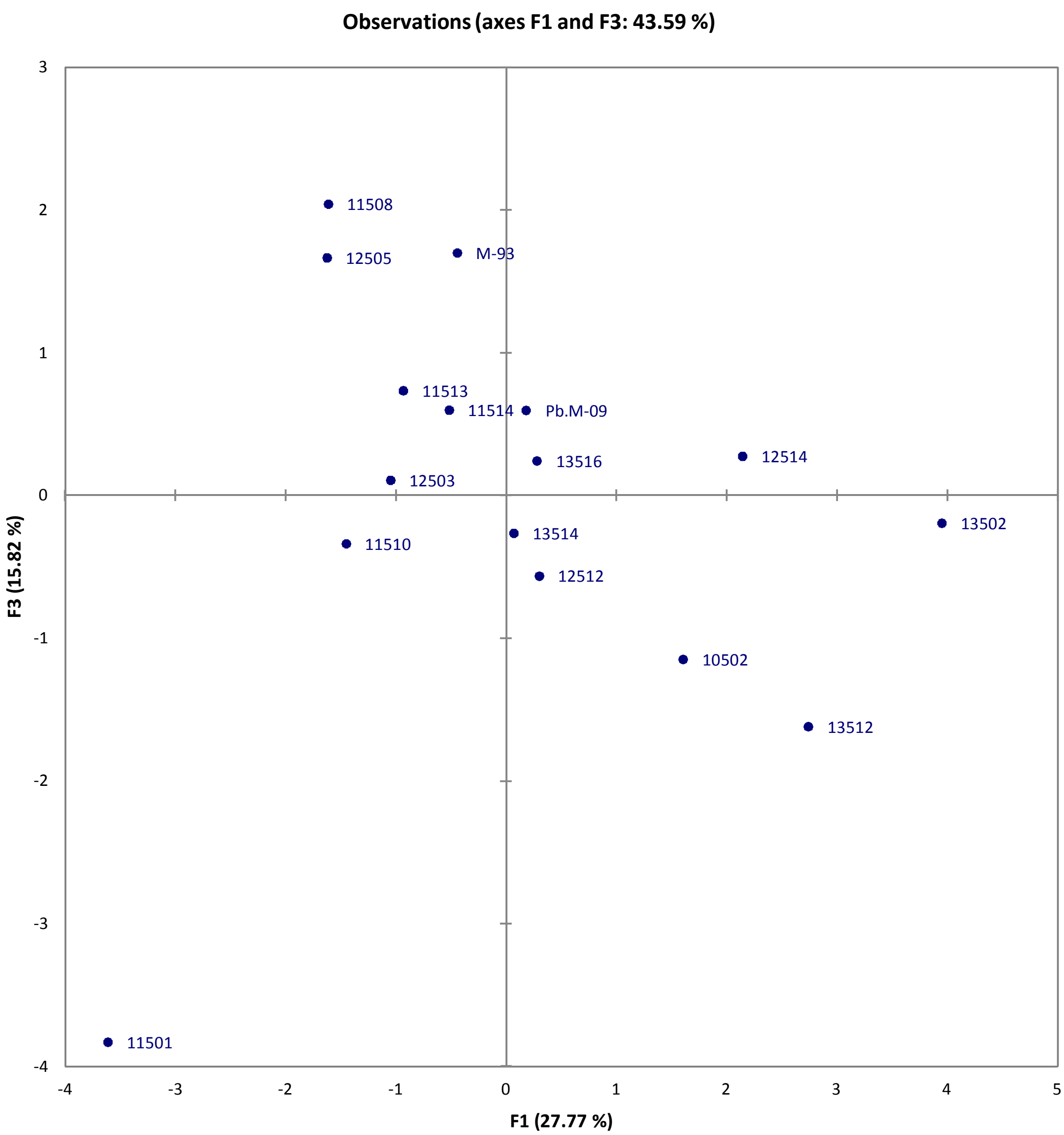

Fig 4.11: Two-dimensional ordination of 16 agro-morphological characters in genotypes of lentil advance lines on principal component axis.

Principal component analysis obtained significant result for all characters in lentil germplasm. For consistent assortment of parents scatter figure was contrive with seed yield per plant along the x axis and y axis (Fig.4.11). Six accessions were located in advance growth lines reduce yield and other twelve accessions seemed to be in primary development increase crop of lentil, four character was correlated to late maturity and maximum crop yield. Seven lines exhibited their association with low yield and late maturity. The data recorded for all character from F1 and F2 groups were describing to principal component analysis.

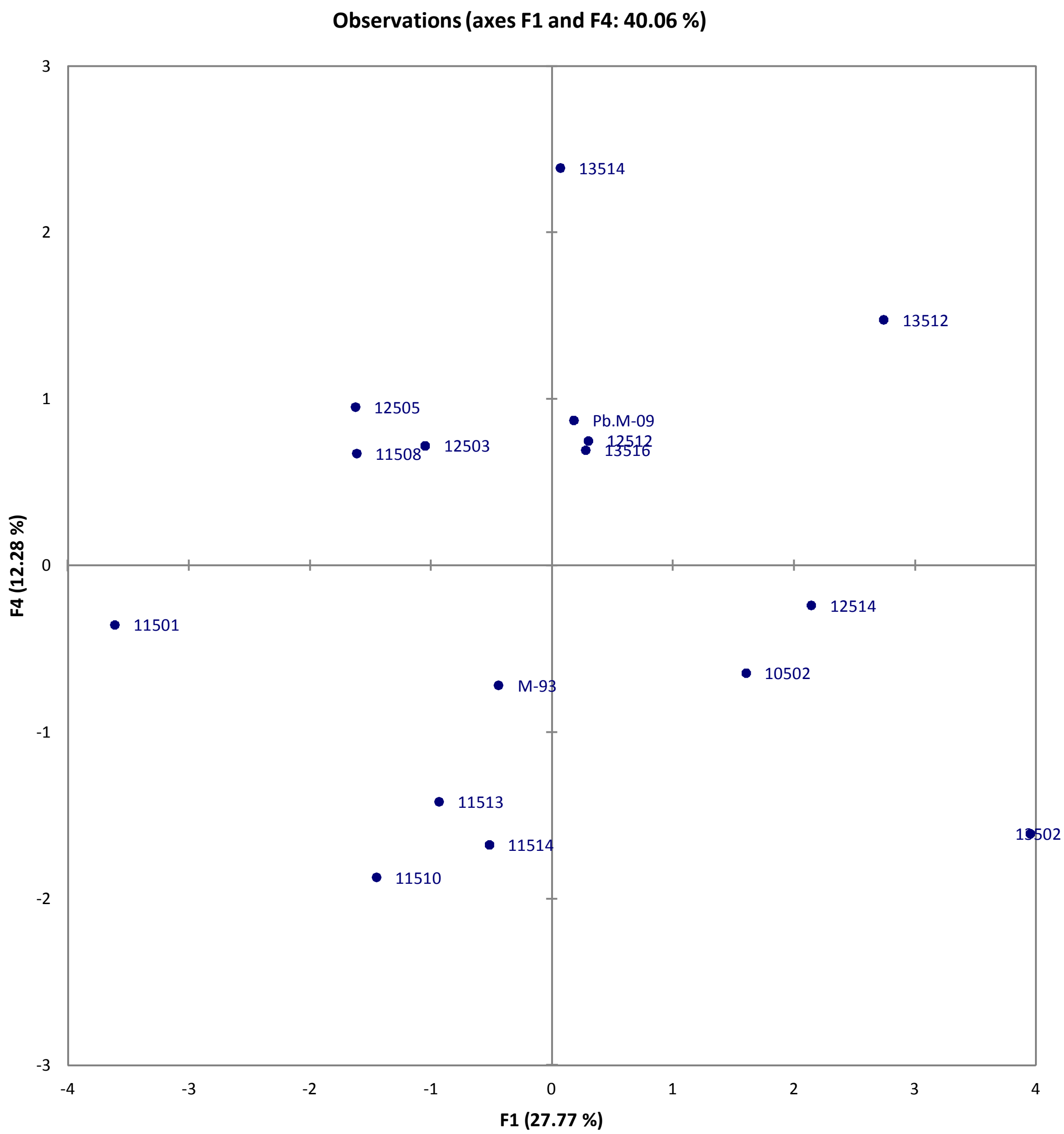

Fig 4.12: Two-dimensional ordination of 16 agro-morphological characters in genotypes of lentil advance lines on principal component axis.

Principal component analysis obtained significant change for all characters in lentil germplasm. For consistent selection of parents scatter graph was plotted with grain yield per plant along the x axis and y axis (Fig. 4.12). Two accessions were located in advance growth lines reduce yield and other two accessions seemed to be in early maturity increase yield of lentil, fourteen character was correlated to late maturity and maximum crop yield. Eleven lines exhibited their association with low yield and late maturity. The data recorded for all character from F1 and F2 groups were describing to principal component analysis.

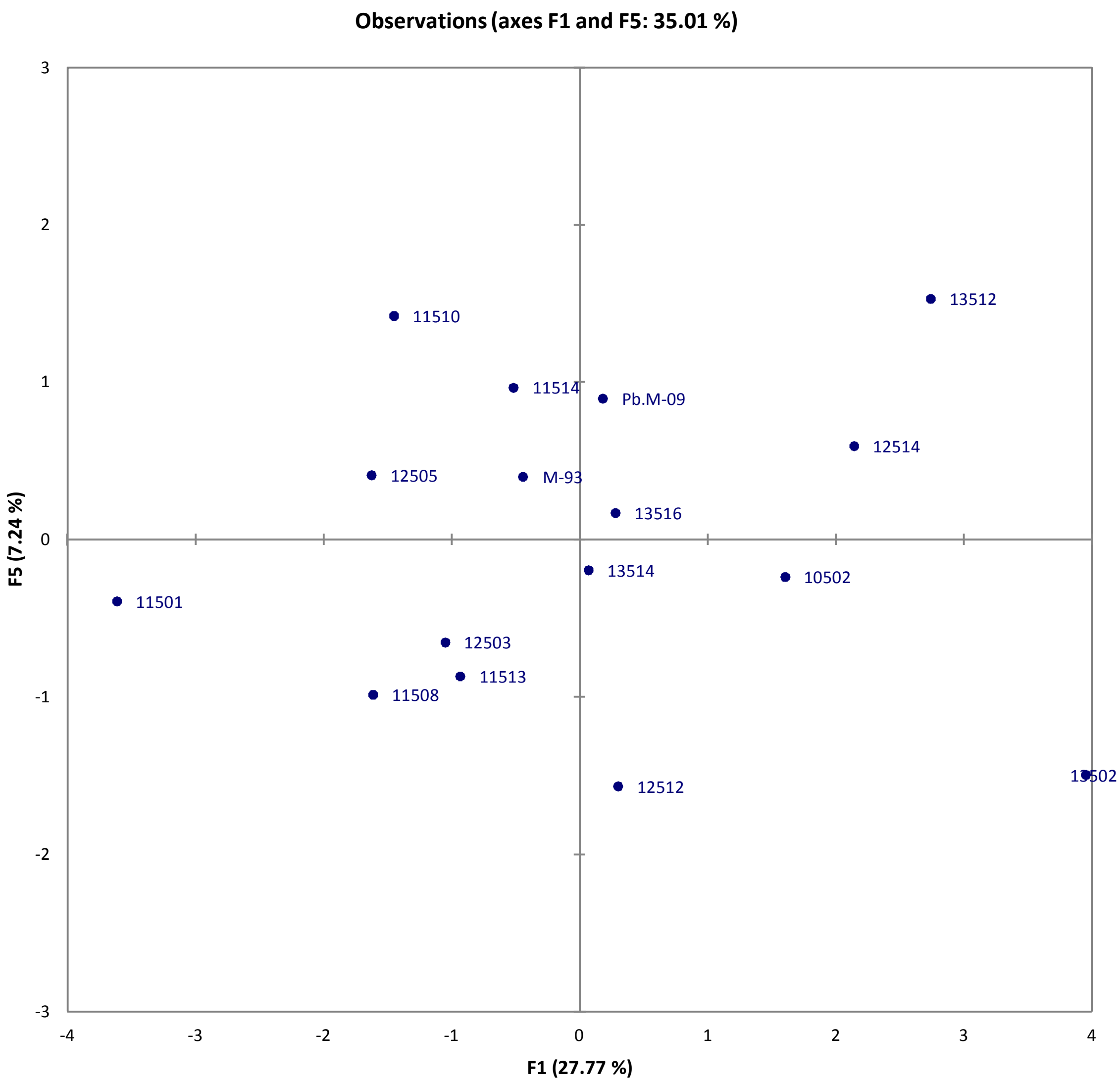

Fig 4.13: Two-dimensional ordination of 16 agro-morphological characters in genotypes of lentil advance lines on principal component axis.

Principal component analysis obtained significant change for all characters in lentil germplasm. For consistent selection of parents scatter graph was plotted with grain yield per plant along the x axis and y axis (Fig. 4.13). Two accessions were located in advance growth lines reduce yield and other two accessions seemed to be in early maturity increase yield of lentil, fourteen character was correlated to late maturity and maximum crop yield. Eleven lines exhibited their association with low yield and late maturity. The data recorded for all character from F1 and F5 groups were describing to principal component analysis.

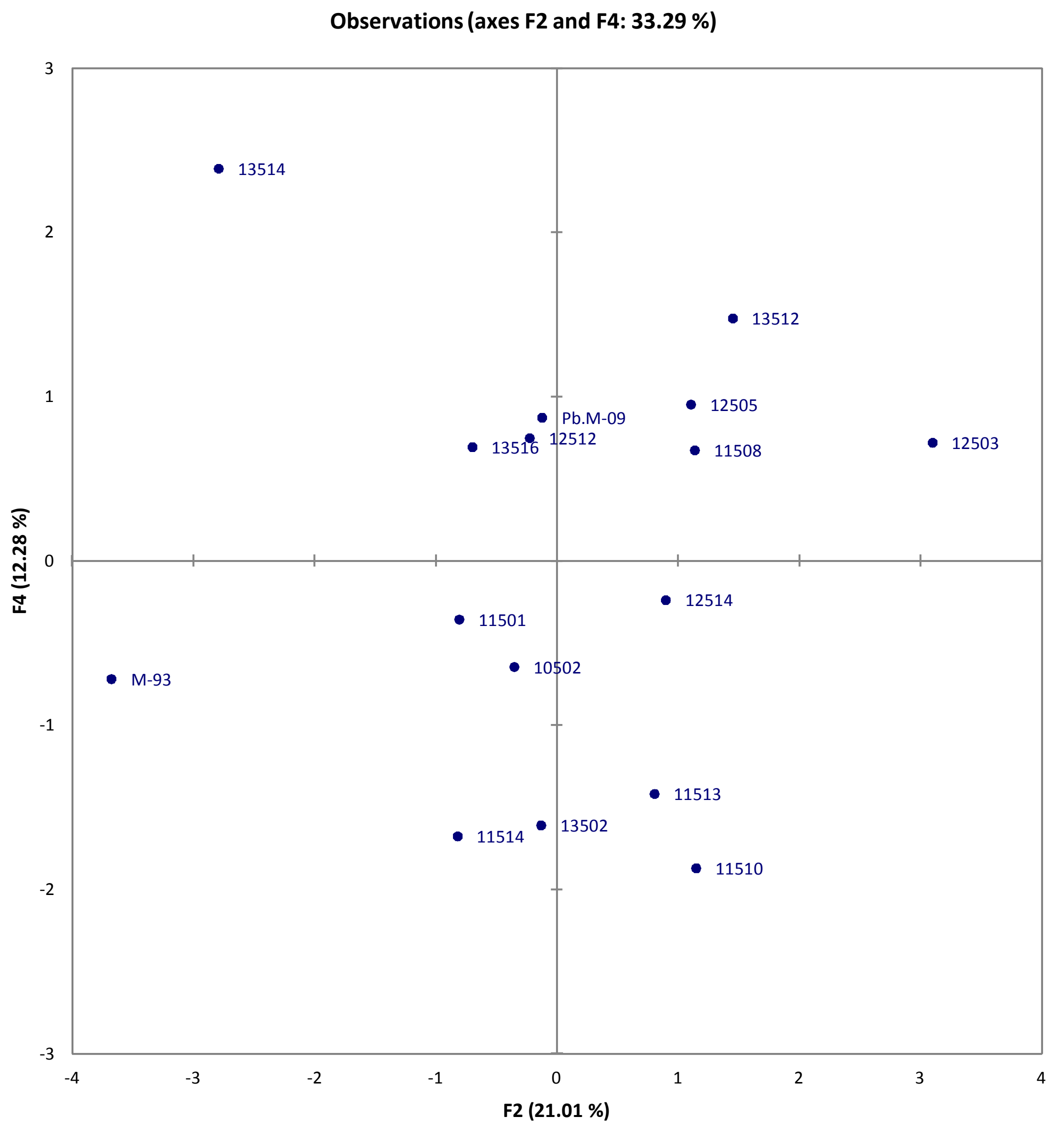

Fig 4.14: Two-dimensional ordination of 16 agro-morphological characters in genotypes of lentil advance lines on principal component axis.

Principal component analysis obtained significant results for all traits in lentil germplasm. For consistent range of parents disperse diagram was conspire with grain surrender per plant along the x axis and y axis (Fig. 4.14). Five accessions were located in advance growth lines reduce yield and other three accessions seemed to be in early maturity increase yield of lentil, only one character was correlated to late maturity and maximum crop yield. Two lines exhibited their association with low yield and late maturity. The data recorded for all character from F1 and F2 groups were describing to principal component analysis.

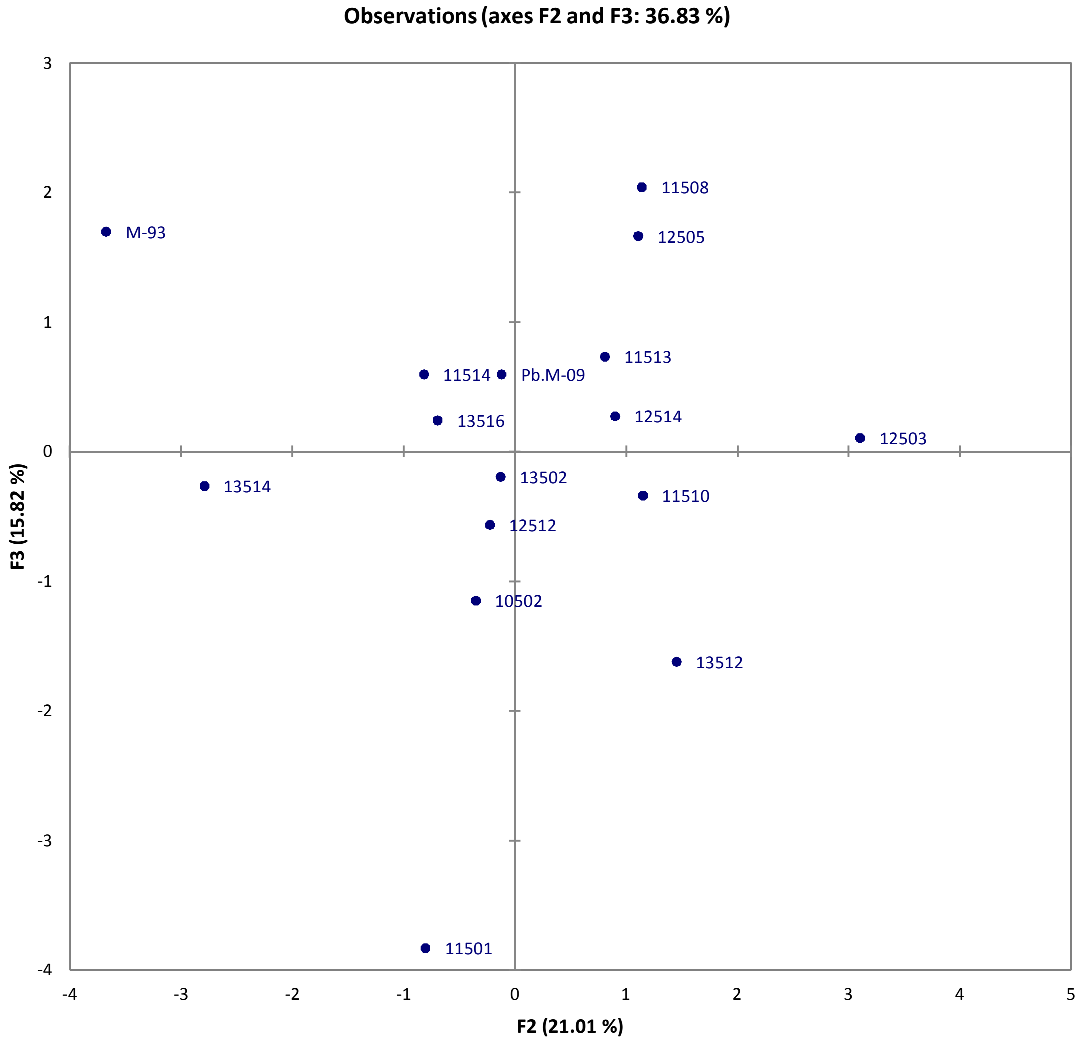

Fig 4.15: Two-dimensional ordination of 16 agro-morphological characters in genotypes of lentil advance lines on principal component axis.

Principal component analysis obtained significant change for all characters in lentil germplasm. For consistent assortment represented throw dot was strategized through particle vintage toward x axis and y axis (Fig. 4.15). Seven accessions were located in advance growth lines reduce yield and no lentil line seemed initial period and increase the crop of lentil, ten character was correlated to late maturity and maximum crop yield. Eight lines exhibited their association with low yield and late maturity. The data recorded for all character from F1 and F2 groups were describing to principal component analysis.

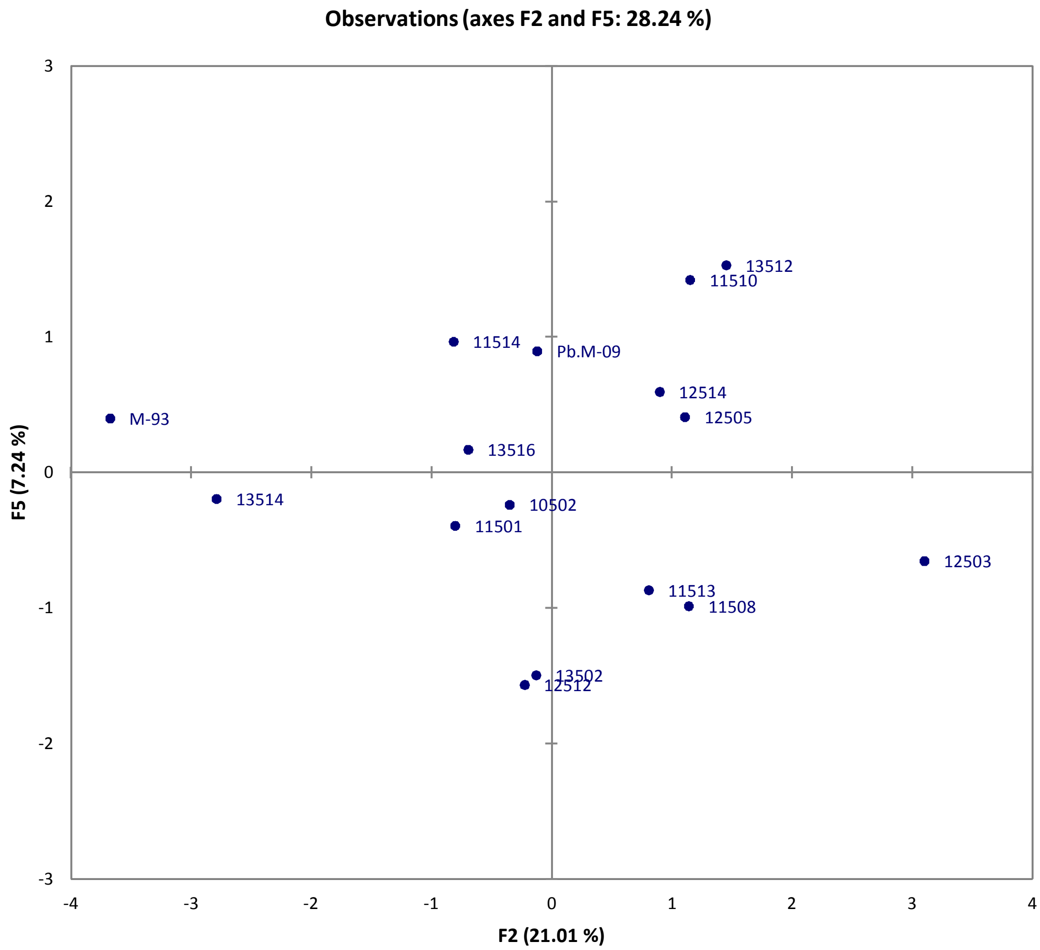

Fig 4.16: Two-dimensional ordination of 16 agro-morphological characters in genotypes of lentil advance lines on principal component axis.

Principal component analysis obtained significant change for all characters in lentil germplasm. For consistent assortment represented throw dot was strategized through particle vintage toward x axis and y axis (Fig. 4.16). Seven accessions were located in advance growth lines reduce yield and no lentil line seemed initial period and increase the crop of lentil, ten character was correlated to late maturity and maximum crop yield. Eight lines exhibited their association with low yield and late maturity. The data recorded for all character from F2 and F5 groups were describing to principal component analysis.

Discussion

Lentil is an annual crop belonging to Leguminoseae (Fabaceae) family. Lentil crop include important protein essence, and recognized the third-greater concentration of protein of any nut, succeeding to soybean and drugs ranges of grain protein substance varies from 22% to 34.6% Callaway *et al.* [4] 2009. Water is an important element for life. The distribution, morphology and composition of plants are affected by water accessibility point. Lentil requires low water capacity for continued existence and it is an important crop of Barani areas of Pakistan. Generally drought stress occurs when the available water in soil is condensed and atmospheric circumstances cause continuous breakdown of water by transpiration or vanishing Jaleel *et al.* [8] 2005. Different experiments were designed to describe the morphological traits of lentil advance lines under water stress condition. All the experiments which designed to measure the morphological traits have not same output. Struggle to examine the yield performance and their morphological traits constrained by increased height at flowering, height at maturity and canopy temperature. Current research aimed to study the yield trait under water stress condition to evaluate the morphological traits of lentil under different parameters. Experimental design was carried out in randomized complete block design (RCBD) with three replications using different treatment that were grown in field used in this study and proved to be efficient method for the evaluation of yield and morphological traits of lentil under stress and non stress condition. However, canopy temperature, primary branches of plant, secondary branches of plant, seeds per pod, seed yield were positively correlated to harvest index. Plant height at flowering and maturity was negatively correlated.

Singh *et al.* [14] 1999 reported that, first blossoming explained positive relationship with yield of seed. Days to maturity showed positive associations with plant height at genotypic and phenotypic level. Days to maturity shows negative relationship with seeds per pod, 1000 yield weight and harvest index. From all accessions, these varieties like V11505, V11510, V11512, V12505, V12512, show late maturity while the other accessions showed early maturity. The principle component analysis (PCA) showed variations among all the characters in F1and F2 factors. Same results are reported by Sadiq *et al.* [12] 2002 that showed significant variation for days to maturity and days to flowering. The principal component analysis was mainly concerned to identifying the correlations between different morphological characters and exhibited maximum variability. When principal component analysis was applied it showed different results between variables. Seed yield was positively and significantly correlated with plant height, number of branches per plant, number of seeds per pod and number of pods per plant was negatively correlated with flowering period. Same result was also obtained by Kaiser (1960) when they correlate different agro-morphological traits in their research work. Plant biomass was certainly related with, plant height at maturity and flowering, 1000-seed weight, harvest index and seed yield per plant. Grain yield was expressively related with yield biomass and showed negative correlations.

Grain yield of moonbeam was independent to plant biomass. This Study discovered that crop progress and seed yield in lentil lines was depend on atmospheric damage in various situations. Total seed weight was varying at Swat and Peshawar correspondingly. Advantageous situation on behalf appearance for feature stayed all the confirmed traits Cruz de Carvalho *et al.* [6]1998 reported negative results. Results of this study revealed that screening of lentil accessions for variation in growth and yield parameters along with their tolerance for water deficient condition will be helpful for selection of high yielding accessions.

Summary

An experiment was planned to evaluate the morphological and yield traits of Lentil (*Lens culinaris* L.) advance lines under water stress condition Seeds were grown in the field of research area of Ayub Agriculture Research Institute of Faisalabad. The seeds were sown in moist soil and no irrigation will be applied afterwards. Certain characters like height of plant at flowering and maturity, number of pods and grains per plant, 1000 grain weight, biomass of plant, seed yield and harvest index, seed per pod, primary branches, secondary branches, days to flowering, days to maturity, canopy temperature were deliberated. All these characters were statistically analyzed by randomized complete block design and principle component analysis. Results revealed that certain characters as well as seed yield, canopy temperature, total grain weight showed significant results and other traits like plant height at flowering and maturity, days to flowering, days to maturity, no of pods per plant, seed per pod, 1000 grain weight showed non-significant relationship.

- Accession 12503 showed maximum height that were 12.5cm at flowering and 38.69cm at maturity and accession 11510 showed minimum height that was 9.48cm at flowering and 36cm at maturity under water stress condition.
- Accession 13502 showed maximum days to flowering that was 98 days at flowering and 137 days at maturity while other lines showed minimum days to flowering and days to maturity under water stress condition.
- Accession 12503 showed maximum canopy temperature that was 19.67^{0}C and line 13514 showed minimum canopy temperature that was 16^{0}C.
- Accession 12512 had highest seed yield that was 690g and accession 11508 had minimum seed yield that was 328g under water stress condition.
- Canopy temperature, seed yield, total seed weight showed positive correlation and other traits like no of pod per plant, primary and secondary branches, days to flowering and maturity showed negative correlation under water stress condition.
- Pb. M-09 showed maximum average of no of primary and secondary branches that was 6.67 and8.67.

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