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Original Research

Genetic analysis of a few traits in tomato (*Lycopersicon esculentum* L.)

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ABSTRACT:

A full diallel was established in 2015 at Abu-Ghraib region to determine heterosis, the effect of general, specific and reciprocal combining of ability (GCA, SCA and RCA) respectively, for the growth and yield components in five lines (HA-1001, HA -1004, HA1006, HA-1007 and HA-1015) of tomato (*Lycopersicon esculentum* L.). The results showed that the hybrid (4×5) gave the highest heterosis value for fruit yield per plant (111.03%). The same hybrid gave the greatest mean for same character (5.93kg.), whereas, their reciprocal hybrid (5×1) has possessed the highest heterosis. Results of genetic analysis showed that MSgca, MSsca and MSrca were significantly differences in all the studied traits. The parent 2 (HA-1004) revealed as the best general combiner for each plant height and number of leaves per plant (13,97), while the parent (HA-1007) was the best general combiner for a number of fruits per plant (6.38), whereas, the parent (HA-1015) was the best general combiner for fruit weight (8.29). The diallel cross (2×5) was (4x2) the best SCA effect for plant height and leaves number and the cross (1×5) was the best SCA for the fruit number per plant (19-54) fruit yield per plant (1.39) and cross (2x4) was the best SCA for the fruit weight (17.78). The reciprocal cross (5×4) was found to be the best specific combiner effect for plant height (40.5) fruit number per plant (56.34) leaves number per plant (26.53) and fruit yield per plant (2.04). The ratio of δ2gca/δ2sca for diallel crosses and δ2gca/δ2rca for reciprocal crosses was less than one for all studied traits except the ratio of δ2gca/δ2rca were more than one for fruit weight (1.19) and fruit length (2.90). The values of δ2D were more than that δ2A for all traits except for fruit length the δ2A was more that δ2D, and this effect the exceeded one for the value of average degree of dominance for all studied traits in both diallel and reciprocal crosses except fruit weight and length which were less than one in reciprocal crosses. This showed that all the studied traits for diallel crosses and for most reciprocal crosses were under over dominance of gene action.

Keywords:
Tomato, Genetic analysis, Combining ability.

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INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is an important vegetable crop in Iraq. It is being a moderate nutritional crop and is considered as an important source of vitamin A and C and minerals which are important ingredients for table purpose. The yield and yield quality improvement in the world production is in progress, but the production of this crop in Iraq exhibits very low rates as compared to the world production. Breeders concentrated in there studies on how to improve yield traits and use suitable means such as best breeding programs to produce hybrids that have high hybrid vigor and high combining ability which reflect on yield improvement. Sekhar *et al*. (2010) found the number of significant heterosis hybrids in desirable direction for better parent and was highest for and the ratio of GCA to SCA variance was less than one for all the studied characters. Saleem *et al.* (2013) found in diallel cross among five local varieties of tomato, the hybrid (B25×B26) and HS reciprocal produced higher number of fruits per plant. Diallel cross applied among some varieties of tomato by many researchers Chishti *et al.* (2008), Saidi *et al.* (2008), Ahmad *et al.* (2009), Singh *et al.* (2010) and Saleem *et al.* (2013), who illustrated that mean square of General and Specific Combining Abilities (GCA and SCA) were significant in many studied traits, with predominant of one combining ability over the other according to the studied traits. Some of those researchers distinguished varieties in their good combining ability which produced hybrids characterized with good specific combining ability. Parental inbred with good General Combining Ability (GCA) are necessary for hybrid development, and the hybrids with good Specific Combining Ability (SCA) for yield and yield components traits that are also important. The study aimed to produce and evaluate the best single hybrids of tomato that gives highest values of heterosis in growth and yield traits and to select the best parents with high combining ability.

MATERIALS AND METHODS

Seeds of five lines of tomato (HA1001, HA1004, HA1006, HA1007 and HA1015) which were developed locally and differed considerably in many important traits were selected, and sown in polystyrene tray with 100 seeds in 15/1/2014. The plants were transplanted after showing six definitive leaves and were cultivated in field in the fall season of 20/1/2014 and stay to make crossing among five parent using full diallel mating design to produce 20 hybrids (10 diallels + 10 reciprocals). All the seeds of the 25 hybrids and their parents and control hybrid (Anfas) the and source were sown in trays at 15/12/2015. The plants were transplanted after showing six definitive leaves and were planted in tunnel house at 20/1/2015 in a completely randomized design with 25 treatments (parents and hybrids) in four replicates. The genotypes were grown in single line plot at 5m long and width 1.5m. The other normal agricultural practices for tomato production i.e. irrigation, fertilization, plant protected against weeds and pests control were practiced as recommended. Eight traits studied were evaluated namely: plant height, number of branches per plant, number of leaves per plant, fruit diameter, fruit weight, fruit length, number of fruit per plant and fruit yield per plant.

The data of all characters of 25 genotype (hybrids and their five parents) were subjected to the analysis of variance in order to test the significant of the differences among the various means of tested genotypes according to Steel and Torrie (1980). Differences among means for all characters were tested for significant, according to the Least Significant Differences (L.S.D.) at 5% probability. The diallel analysis was performed by the Griffing method (1956) and fixed model, from this the GCA and SCA estimated were obtained by using the following formula as outlined by Singh and Chaudhary (2007):

"δ2gca" = (MSgca-MSe)/2P and δ2sca=MSsca-MSē

"MSē =MSe/r "

Table 1. Mean parent and hybrids in studied traits

S. No	Genotypes / Parent	Plant height (cm)	Branches number per plant	Fruit number per plant	Fruit diameter (cm)	Fruit weight (g)	Fruit length (cm)	Fruit yield per plant (kg)	Number of leaves
1	1	93.75	7.58	29.92	4.38	78.42	4.93	2.35	94.08
2	2	119	10.92	35.83	4.92	90.58	6.29	3.92	128.17
3	3	110.67	9	29.08	4.92	93.25	5.45	2.71	106.17
4	4	91.75	8.65	63.67	4.51	77.58	5.04	2.81	107.17
5	5	105.5	6.75	17.92	5.46	101.83	6.32	1.82	110.42
	Diallel								
6	1x2	119.25	6.75	27.25	5.28	73	5.05	1.98	107.58
7	1x3	123.92	8.92	38.67	4.92	97.42	5.43	3.06	119.79
8	1x4	139.75	10.42	41.92	4.72	73.5	4.33	2.85	125.08
9	1x5	136.58	10.17	51.75	4.89	91.17	5.12	3.99	107.5
10	2x3	125.5	11.33	49.42	4.76	92.75	7.16	3.92	152.08
11	2x4	165.42	14	50.92	5.51	112.33	5.62	5.8	173.5
12	2x5	166.0	12.67	39.57	5.48	124.75	7.19	4.97	157.83
13	3x4	94.17	7.67	52.75	4.06	120.58	6.48	4.45	110.17
14	3x5	95.57	9.17	28.25	5.99	112.92	6.38	3.11	118.92
15	4x5	160.58	11.5	57.33	4.43	103.75	6.88	5.93	148.58
	Reciprocal								
16	2x1	124.67	9.83	31.83	4.06	75.25	4.42	2.43	111.17
17	3x1	132.58	12.17	32.83	4.45	101.08	5.35	3.4	122.17
18	3x2	86.75	10.17	30.83	4.72	94	6.23	3.04	129.42
19	4x1	139.58	11.75	52.42	4.88	81.58	4.5	4.2	140.17
20	4x2	141.58	11.5	47.92	4.98	116.08	5.42	5.45	146.33
21	4x3	97.08	11.0	58.33	4.43	80.67	6.98	4.67	149
22	5x1	87.42	10.83	58.58	4.74	90.42	5.6	4.99	127.42
23	5x2	167.42	12.75	35.58	5.75	114.33	6.88	4.11	166.83
24	5x3	83.08	8.5	26.33	5.38	104.92	6.58	2.74	98.58
25	5x4	79.58	8.03	21.72	4.37	84.39	5.37	1.85	95.53
26	Control hybrid (Anfas)	114	10.11	43.4	4.6	120.4	5.9	1.85	159.92
27	Mean								
28	LSD 0.05	16.41	2.59	6.33	0.42	17.09	0.35	0.67	26.66
	0.01	21.84	3.45	8.42	0.55	22.74	0.47	0.89	35.48

"δ2rca=(MSrca-MSē)"

GCA, SCA and RCA effects were estimated by following formula (Singh and Chaudhary 2007)

"ĝi= 1/2P (Xi+X.j)-(1/P2)X."

"Ŝij= 1/2(Xij+Xji)-1/2 P(Xi.+X.i+Xj.+X.j)+(1/P2)X.."

"Řij= 1/2(Xij-Xji) "

RESULTS AND DISCUSSION

Means squares of all studied traits are showed in Table 1. Means squares of genotypes were highly significant for all studied traits indicating the presence of variability among hybrids and their parents. The mean performance of hybrids (diallel and reciprocal) and their parents are listed in Table 2. Tomato parent (2) had the highest for plant height (119.0 cm), branches number per plant (10.92), fruit yield per plant (3.92 kg) and number of leaves (128.17), while the parent (5) had the highest mean for fruit diameter (5.46 cm), fruit weight (101.83), fruit length (6.32cm), whereas the parent (4) had the highest mean for fruit number per plant (63.67). Tomato diallel hybrid (2×5) was the highest mean for plant height (166 cm), fruit weight (124.75), fruit length (7.19cm), while the diallel hybrid (2×4) was the highest for braches number per plant (14), number of leaves (173.50), whereas the hybrid (4×5) was the highest for fruit number per plant (57.33) and the highest for fruit yield per plant (5.93kg). Tomato reciprocal hybrid (5×2) was the highest for plant height (167.42 cm), branches number per plant (12.75), Fruit diameter (5.75 cm) and for number of leaves (166.83), while the reciprocal hybrid (4×2) was the highest for fruit weight (116.08 gm) and for fruit yield per plant (5.45 kg), whereas the reciprocal hybrid (5×1) was the highest for fruit number per plant (58.58) and the hybrid (4×3) was the highest for fruit length (6.98cm). These results are in agreement with those of Ahmad *et al*. (2009) and Singh *et al*. (2010) who found significant differences in all studied traits.

The results of Table 2 showed positive heterosis over better parent; eight diallel hybrids were superior in

Table 2. Percentage heterosis to the better parents for the studied traits

S. No	Genotypes Diallel cross	Plant height (cm)	Branches number per plant	Fruit number per plant	Fruit diameter (cm)	Fruit weieght (g)	Fruit length (cm)	Fruit yield per plant (kg)	Number of leaves
1	1x2	19.25	-38.18	-23.94	7.31	-19.4	-19.71	-39.44	-16.06
2	1x3	11.97	-0.88	29.24	0	-14.83	0.36	12.91	12.71
3	1x4	39.75	20.46	14.31	4.65	73.5	-20.36	1.42	-1.95
4	1x5	36.58	32.99	72.96	10.43	-10.46	-20.55	69.78	-2.64
5	2x3	25.5	3.75	37.92	3.25	-0.53	13.83	19.87	18.65
6	2x4	65.42	28.2	41.58	11.99	24.01	-10.65	77.37	35.36
7	2x5	66	16.02	10.71	0.36	40.18	13.76	51.98	23.14
8	3x4	-5.85	-14.77	43.85	17.47	29.3	18.89	58.36	15.07
9	3x5	-4.25	1.88	-2.85	9.7	10.89	0.94	14.76	12
10	4x5	60.58	32.94	56.34	-18.86	1.88	8.86	111.03	34.55
				Reciprocal cross					
11	2x1	24.67	-9.98	-11.16	-17.47	-16.92	-29.72	-25.68	-13.26
12	3x1	32.58	35.32	9.72	-9.55	8.39	-1.83	25.46	15.07
13	3x2	-13.25	-6.86	-13.95	-4.06	0.8	-0.95	-7.03	-12.65
14	4x1	39.85	35.83	42.95	8.2	42.58	-10.71	49.46	30.79
15	4x2	41.85	5.31	30.67	1.21	28.15	-13.83	66.66	14.16
16	4x3	-2.92	22.22	59.06	-9.95	-13.49	28.07	-95	39.03
17	5x1	-32.58	42.87	95.78	-13.18	-11.2	-11.39	112.34	15.39
18	5x2	67.42	16.75	-0.69	5.31	12.27	8.86	25.68	30.16
19	5x3	-16.92	-5.55	-9.45	-1.46	3.03	4.11	1.1	-10.72
20	5x4	-20.42	-7.16	-40.76	-19.96	-17.12	-15.03	-34.16	-13.48

Table 3. Analysis of variance for genotype general, specific combining ability for studied traits

S. No	SOV	Plant height (cm)	Branches number per plant	Fruit number per plant	Fruit diameter (cm)	Fruit weight (g)	Fruit length (cm)	Fruit yield per plant (kg)	Number of leaves
1	Genotype	3089.7**	15.1**	584.4**	1.03	992.6**	3.10**	5.96**	2039.35
2	GCA	91.03**	3.95**	149.2**	0.568**	621.81**	2.87**	1.32**	916.3**
3	SCA	875.88**	4.80**	196.3**	0.261**	212.05**	0.496**	1.97**	521.5**
4	RCA	266.08**	2.68**	94.7	0.132*	134.84**	0.213**	1.08**	335.6**
5	Error	34.0	0.850	5.06	0.022	36.86	0.016	0.57	89.76
6	σ^2Gca/ σ^2Sca	0.104	0.078	0.075	0.229	0.334	0.594	0.066	0.191
7	σ^2Gca/ σ^2Rca	0.342	0.339	0.322	0.992	1.194	2.897	0.247	0.672

the desirable direction over better parent value. The diallel hybrid (1×5) gave the highest positive heterosis in branches number per plant (32.99%) and for fruit number per plant (72.96%), also the reciprocal hybrid (5×1) gave the highest positive heterosis in the same, characters (42.87 and 95.78%) respectively, and for fruit

Table 4. Estimates of general, specific, and reciprocal combining ability effects for each parental hybrids

S. No	Genotypes parent	Plant height (cm)	Branches number per plant	Fruit number per plant	Fruit diameter (cm)	Fruit weight (g)	Fruit length (cm)	Fruit yield per plant (kg)	Number of leaves
1	1	-0.37	-0.48	0.12	-0.21	-12.52	-0.83	-0.44	-11.25
2	2	13.97	1	-0.78	0.16	3.62	0.25	0.23	13.97
3	3	-13.48	-0.39	-1.83	-0.02	2.54	0.35	-0.21	-4.91
4	4	0.63	0.24	6.38	-0.24	-1.94	-0.23	0.49	4.13
5	5	-0.75	-0.37	-3.88	0.32	8.29	0.46	-0.06	-1.94
6		1.649	0.261	0.636	0.042	1.717	0.035	0.067	2.68
				Diallel hybrid					
7	1x2	-11.13	-2.31	-9.19	-0.16	-11.72	-0.49	-1.18	-19.48
8	1x3	22.66	1.33	-1.93	0.04	5.48	0.08	0.29	10.93
9	1x4	19.91	1.25	1.28	0.37	-2.75	-0.32	-0.12	13.61
10	1x5	-6.37	1.27	19.54	-0.17	0.28	-0.07	1.39	4.51
11	2x3	-13.86	0.06	3.35	-0.27	-7.53	0.29	-0.13	5.55
12	2x4	19.41	1.43	4.93	0.45	17.78	-0.3	1.13	15.68
13	2x5	34	1.99	2.9	0.26	12.89	0.52	1.31	24.16
14	3x4	-11.02	-0.59	11.61	-0.37	5.28	0.82	0.69	4.22
15	3x5	-15.85	-0.49	-6.38	0.52	3.34	-0.13	-0.39	-10.55
16	4x5	0.71	-0.18	-2.35	-0.56	-7.02	0.1	-0.13	-6.28
17	SEsij hybrids	1.852	0.885	1.265	0.426	1.882	0.399	0.515	2.248
				Reciprocal hybrid					
18	2x1	-2.71	-1.54	-2.29	0.61	-1.13	0.32	-0.23	-1.79
19	3x1	-4.33	-1.63	2.92	0.23	-10.83	0.04	-0.17	-1.25
20	3x2	19.38	0.58	9.29	0.02	-0.63	0.47	0.44	11.33
21	4x1	0.08	-0.67	-5.25	-0.08	-4.04	-0.08	-0.68	-7.54
22	4x2	11.92	1.25	2	0.27	-1.88	0.1	0.17	13.58
23	4x3	-1.46	-1.67	-2.79	-0.19	19.96	-0.25	-0.11	-19.42
24	5x1	24.58	-0.33	-3.42	0.07	0.38	-0.24	-0.5	-9.96
25	5x2	-0.71	-0.04	2.04	-0.13	5.21	0.16	0.43	-4.5
26	5x3	6.33	0.33	0.96	0.3	4	-0.10	0.19	10.17
27	5x4	40.5	1.74	17.81	0.03	9.68	0.76	2.04	26.53
28	SERij reciprocal	4.123	0.652	1.59	0.105	4.294	0.089	0.168	6.699

yield per plant (112.34%). The hybrid (3×4) gave the highest positive heterosis in fruit diameter (17.47%) while the hybrid (4×5) gave the highest fruit length (18-89%). Where as the reciprocal (4×1) gave the highest positive heterosis in fruit diameter (8.2%) and for fruit weight (42.58%). Table 3 shows the results of variance analysis for genotypes, specific and reciprocal effect. It is clear that the significant difference were present among genotypes for all studied traits. General, specific and reciprocal combing ability mean squares were highly and significantly different for all the studied traits. Similar results were also presented by Chishti *et al.* (2008), Saidi *et al.* (2008), Saleem *et al.* (2009), Singh *et al.* (2010) and Saleem *et al.* (2013) in most of the studied traits. On the other hand, the ratio between variance of general and specific combining ability was found to be less than one in all the studied traits. This is in conformity with the finding of Chishti *et al*. (2008), Saidi *et al.* (2008), Ahmad *et al.* (2009), Saleem *et al.* (2009; 2013) and Sekhar *et al.* (2010).

To evaluate the parent according to their combining ability. The effect of general combining ability was estimated for each parent as shown in Table 4. It is obvious that parent (2) was a good combine and highest value for plant height (13.97), branch number per plant (1.00), and number of leaves (13.97). While, parent (4) was a good combiner for fruit number per plant (6.38) and for fruit yield per plant (0.49), whereas parent (5) was a good combiner for fruit weight (8.29) and for fruit length (0.46). The same table shows the estimation of SCA effects for each diallel hybrid in the studied traits. It was observed that hybrid (1×5) had the highest SCA effect in desirable direction for fruit number per plant (19.54) and for fruit yield per plant (1.39), while, the hybrid (2×5) had the highest SCA effect in desirable direction for plant height (34,00), branches number per plant (1.99) and for number of leaves (24.16), whereas, the hybrid (2×4) had SCA effect in desirable direction for fruit weight (17.78).

Reciprocal effect

Also the result of the same Table 4 showed the estimation of reciprocal effect for each reciprocal hybrid in the studied traits. It was observed that the reciprocal hybrid (3×2) had RCA effect for plant height (19.38), fruit number per plant (9.29) and number of leaves (11.33). While, the reciprocal hybrid (4×2) had RCA effect for plant (11.92), branches number per plant (1.25) and for the number of leaves (13.58), the reciprocal hybrid (4×3) had RCA effect in desirable direction for fruit weight (19.96), also the reciprocal hybrid (5×1) had RCA effect for plant height (24.58), whereas the reciprocal hybrid (5×4) had highest RCA effect in desir-

Table 5. Estimates of genetic parameter in tomato genotype for studied traits

S. No	Genetic parameters	Plant height (cm)	Branches number per plant	Fruit number per plant	Fruit diameter (cm)	Fruit weight (g)	Fruit length (cm)	Fruit yield per plant (kg)	Number of leaves
1	δ2gca	91.03	0.31	14.42	0.055	58.494	0.286	0.126	82.654
2	δ2sca	875.88	3.952	191.232	0.239	175.186	0.481	1.908	431.709
3	δ2rca	266.08	0.913	44.796	0.055	48.984	0.099	0.512	122.9
4	δ2A	182.07	0.62	28.836	0.109	116.987	0.57	0.253	165.308
5	δ2D	875.883	3.952	191.232	0.239	175.186	0.481	1.908	431.709
6	A	3.102	3.571	3.642	2.091	1.731	1.30	3.886	2.285
7	H2.b.s	96.886	84.329	97.754	94.077	88.795	98.5	97.44	86.93
8	H2.n.s	16.674	11.434	12.809	29.524	35.554	53.5	11.397	24.07
9	δ2D2r	266.084	0.913	44.796	0.055	48.984	0.099	0.512	122.932
10	a-r	1.71	1.716	1.763	1.004	0.915	0.588	2.012	1.22
11	H2bs.r	92.948	64.342	93.573	88.231	81.824	97.71	93.087	76.258
12	H2ns.r.	37.762	26.017	36.646	58.672	57.675	83.33	30.782	43.732

able direction for plant height (40.50), branches number per plant (1.74), fruit number per plant (17.81), fruit yield per plant (2.04), and for number of leaves (26.53). These findings were similar to those obtained by Chisti *et al.* (2008), Saidi *et al.* (2008), Ahmad *et al*. (2009), Saleem *et al.* (2009), Sekhar *et al.* (2010) and Saleem *et al.* (2013).

Genetic parameter

Table 5 shows the results of genetic parameters for all studied traits. It was observed that the highest δ2SCA value indicates that non additive effects, played a more role than δ2GSA additive effects in the control for all studied traits, this indicated that non-additive gene action was dominance in the control for all studied traits. Similar reports were also reported by Chishti *et al.* (2008), Ahmad *et al.* (2009), Sekhar *et al.* (2010) and Saleem *et al.* (2013). The values of δ2D were more than δ2A for all studied traits except for fruit length which was δ2A and this reflects the exceeded one for the value for average dominance degree for studied traits. All studied traits showed high values of broad sense heritability for both diallel and reciprocal crosses, whereas narrow sense heritability had low values for all traits except fruit diameter, weight and length in some reciprocal crosses.

CONCLUSION

It was concluded that parents P_2 and P_5 were the best two parents to be used in breeding programs to produce superior tomato hybrids, in addition hybridization was proved as a best breeding method to improve tomato fruit yield.

REFERENCES

Ahmad S, Quamruzzaman AKM and Uddin MN. 2009. Combining ability estimates of Tomato (*Solanum lycopersicum*) in late summer. *SAARC Journal of Agriculture,* 7(1): 43-55.

Chishti SAS, Khan AA, Sadia B and Khan LA. 2008. Analysis of combining ability for yield, yield components and quality characters in Tomato. *Journal of Agricultural Research*, 46(4): 325-331.

Griffing B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Australian Journal of Biological Sciences*, 90: 463-492.

Saidi M, Warde SD and Prabu T. 2008. Combining ability estimates for yield and its contributing traits in tomato (*Lycopersicon esculentum*). *International Journal of Agriculture and Biology*, 10: 238-240.

Saleem MY, Asghar M, Haq A, Rafique T, Kamaran A and Khan AA. 2009. Genetic analysis to identify suitable parents for hybrid seed production in Tomato (*Lycopersicon esculentum* Mill.). *Pakistan Journal of Botany*, 41(3): 1107-1116.

Saleem MY, Asghar A and Iqbal Q. 2013. Augmented analysis for yield and some yield components in Tomato (*Lycopersicon esculentum* Mill.). *Pakistan Journal of Botany*, 45(1): 215-218.

Saleem MY, Asghar M, Iqbal Q, Rahman A and Akram M. 2013. Diallel analysis of yield and some yield components in tomato (*Solanum lycopersicum*). *Pakistan Journal of Botany*, 45(4): 1247-1250.

Sekhar L, Prakash BG, Salimath PM, Hiremath Ch P, Sridevi O and Patil AA. 2010. Implication of heterosis and combining ability among productive single cross hybrids in tomato. *Electronic Journal of Plant Breeding*, 1(4): 706-711.

Singh RK and Chaudhary BD. 2007. Biometrical Methods in Quantitative Genetic Analysis. Rev. ed., Kalani publishers Ludhiana, New Delhi-India, 318 p.

Singh SP, Thakur MC and Pathania NK. 2010. Reciprocal cross differences and combining ability studies for some quantitative traits in Tomato-under mid hill

conditions of Western Himalayces. *The Asian Journal of Horticulture*, 4(2): 473-477.

Steel RCD and Torrie JH. 1980. Principle and procedures statistics. A biometrical Approach 2nd ed. McGraw Hill Book Co., New York, USA. 485 p.