Effect of Plant Densities on Growth, Yield Components and Quality of Some Sunflower Cultivars (*Helianthus annuus* L.)

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Abstract:

A field experiment was conducted for two consecutive seasons 2008-2009, 2009-2010 at AL-Quba location in the west north region of Mosul city at Nineveh region to study the effect of planting density on the performance of two sunflower cultivars; namely, Mehran and Sunbred. The plants were sown at four planting densities: 41666, 47619, 55555 and 66666 plants.ha^{-1}, respectively. The data were statistic analyzed by using factorial experiments in randomized complete block design with three replications. The results indicated that the stem diameter, leaf area, head diameter, number of seeds per head, weight of thousand seed, hulls, fertility percent, harvest index and seed yield per plant, oil and protein content of the seeds decreased with increasing plant density. Increasing plant density cases significantly increase in seed yield per unit area and oil, protein yield. The differences between the two cultivars cultivation were significant in all the studied characters, except protein yield in 2008-2009 season, protein content of the seeds in 2009-2010 season. The higher seed yield of Mehran cultivar was associated with higher flower disc diameter and greater number of seeds per flower disc. Based on what has been presented in this study, could be concluded that the plant density of approximately 66666 plants.ha^{-1} is the optimum for sunflower crop cultivation, and Mehran cultivar proved be more promising than Sunbred cultivar.

تأثير الكثافات النباتية في النمو ومكونات الحاصل والنوعية لبعض أصناف زهرة الشمس (***Helianthus annuus L.***)

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ملخص البحث:

أجريت تجربة حقلية للموسمين المتتاليين 2008-2009 , 2009-2010 في منطقة القبة الواقعة شمال غرب مدينة الموصل ضمن محافظة نينوى، لدراسة تأثير الكثافة النباتية على أداء صنفين من زهرة الشمس، هما مهران وسنبرد.

زرعت النباتات بأربع كثافات نباتية هي 41666، 47619، 55555 و66666 نبات/هكتار على التوالي. حللت البيانات إحصائيا باستخدام التجارب العاملية بتصميم القطاعات العشوائية الكاملة بثلاثة مكررات.

أشارت النتائج بأن قطر الساق، المساحة الورقية، قطر القرص، عدد البذور في القرص، وزن الألف بذرة ونسبتي اللب والإخصاب، دليل الحصاد ،حاصل البذور لكل نبات ومحتوى البذور من الزيت والبروتين قد انخفضوا بزيادة الكثافة النباتية. سببت زيادة الكثافة النباتية زيادة معنوية في حاصل البذور الكلي في وحدة المساحة وحاصلي الزيت والبروتين.

كانت الاختلافات بين الصنفين المزروعين معنوية في الصفات المدروسة جميعها، عدا حاصل البروتين في الموسم 2008-2009 ومحتوى البذور من البروتين في الموسم-2010 2009.

كان أعلى حاصل من بذور الصنف مهران مرتبطاً بأعلى قطر للقرص الزهري وأعلى عدد من البذور في القرص الزهري. واستناداً لما جاء في هذه الدراسة، يمكن الاستنتاج بان الكثافة النباتية 66666 نبات/هكتار هي الأفضل لزراعة محصول زهرة الشمس، إذ اثبت الصنف مهران بأنه صنفاً واعداً للإنتاج التجاري مقارنة بالصنف سنبرد.

Introduction:

Sunflower (*Helianthus annuus L.*) is probably the most ancient oil seed crop known and used by human. Both Peru and Mexico have been proposed as centers of origin. The seed contains 40 to 50% semidrying oil and 20% to 25% protein (Mohamed *et al*.,1992 and Sangoi and Kruse, 1993). Basically, sunflower is a crop of the warm regions of the tropics and subtropics. It has high temperature and light requirements, and is sensitive to low temperatures. High population density has been used for improving seed yield under this type of farming system. Previous research indicated that sunflower cultivars are highly variable in their response to planting density (Getmanets *et al*., 1991). Numerous research studies for different climates have shown that plant density influences

the growth, seed yield and quality of sunflower (Harmati, 1992; Patil *et al*., 1992 and Oyinlola, 2007). Studies by Tenebe *et al*., (1996) showed that as plant density was increased head diameter, number of seeds per head and 1000 seed weight decreased while seed yield increased. Oyinlola, (2007) and Kene *et al*., (1992) also suggested that increased plant density resulted in a significant increase in seed yield. Similarly, Killi and Ozdemir (2001) reported that denser sowings (71.000 to 100.000 plant per ha^{-1}) resulted in higher (30%) yields in hybrid sunflower than lower plant densities (41.000 to 57.000 plant.ha^{-1}). Chavan *et al*., (1990) reported that as plant populations were increased, seed oil content increased. The current study attempted to evaluate the yield performance of two sunflower cultivars under three planting densities.

Materials and Methods:

A field experiment was conducted, during the spring of 2008-2009 and 2009-2010 seasons, at AL-Quba in the west north region of Mosul city at Nineveh region (latitude 36°19' north; longitude 43°90' east and altitude 220 meters above sea level). The climate of the locality is semiarid with hot summer and rainy cool winter. The rainy season extends from October to April with peak monthly rainfall in November (F.S.M.C., 2010). The mean annual rainfall is around 375 mm. The soil of the experimental site (table 1), was determined by using the methods description by Black (1965), Jackson (1973), Page *et al*., (1982) and Tandon (1999). The land experiment was irrigated and then plowed by using disc plow and harrowing.

Table -1-
The physical and chemical characters of soil filed experiments in both seasons.

Seasons	2008-2009	2009-2010
physical characters		
Sand (%)	66.00	62.00
Silt (%)	23.00	31.00
Clay (%)	11.00	7.00
Texture	Sandy Loom	Sandy Loom
chemical characters		
O.M. (mg.kg^{-1})	0.72	0.84
Available N (ppm)	30.44	31.86
Available P (ppm)	11.00	10.22
Available K (ppm)	166.00	164.00
Total $CaCo_3$ (mg.kg^{-1})	29.00	24.00
pH	7.20	7.60
E.C. mmhos/cm	0.92	0.72

Two sunflower cultivars; namely, Mehran and Sunbred were sown at four planting densities: 41666, 47619, 55555 and 66666 plants.ha^{-1}. The treatments were arranged by using the factorial experiments in randomized complete block

design with three replicates. Each plot consisted of 6 ridges, 4 m in length with 80, 70, 60 and 50 cm in width between ridges and the distance between hills was 30 cm apart to attain a plant density as above, respectively. Sowing was done manually on the shoulder of the ridge in first and mid of April in the first and second seasons respectively. The required plant densities were achieved by thinning the plants to one seedling per hole, after two weeks from sowing. Super phosphate 140 kg per hectar ($45\%P_2O_5$) and potassium ($48\%K_2O$) were applied (40 kg per hector) to the soil during the sowing period, nitrogen fertilizer, in the form of urea, was applied to all experimental plots at a rate of 80 kg N. hector, in two equal doses, half with sowing and the remaining half after thinning. The crop was irrigated twelve times during the season. Data were collected on some growth (plant height (cm), stem diameter, leaf area, and head diameter), yield components (number of seeds per head, weight of thousand seed, hulls, fertility, harvest index, biological yield), seed yield per plant and total seed yield per hectar^{-1}. In addition, oil content and oil yield (ton. hectar^{-1}) was also determined by the soxholet apparatus (A.O.A.C., 1980), and seed nitrogen concentration was measured by microkjeldahl method, then, protein percentage was calculated by multiplying the nitrogen percentage by the converting factor 6.25 (Agrawal *et al*., 1980). Statistical analysis was carried out using SAS statistical program (SAS, 2001), means were compared using Duncan's multiple range test at 1 and 5% probability level (Duncan, 1955).

Results and Discussion:

1- Plant density effect:

Results of statistical analysis showed that plant density significantly affected all studied characters in 2008-2009 and 2009-2010 seasons, except seed yield (gm.plant^{-1}) in only 2008-2009 season (tables 6,7). Stem diameter (2.8, 3.4 cm), leaf area (4172.06, 3660.7cm^2.plant), head diameter (23.40,23.72 cm), number of seeds.head^{-1} (1296.51, 1193.67), weight of thousand seed (72.61, 70.38 gm), hulls (52.53, 48.99%), fertility (82.84, 83.74%), harvest index (22.31, 23.01%), oil (42.27, 40.54%) and protein (14.56, 13.68%), were significantly increased as plant density decreased from 66666 to 41666 plant.ha^{-1} in the two growing seasons respectively (table 2). At low density, plants grew as isolated units for most of their early life and interfered less with each other than at higher densities 66666 plant.ha^{-1}. This might explain the highly significant effects of plant density on seed yield per plant and seed yield per unit area obtained in this study. For example, increasing plant density up to 66666 plant.ha^{-1} significantly decreased seed yield per plant (table 2). This was primarily due to the reduction in the both number of seeds.head^{-1} and weight of thousand seed at higher plant population. In two growing seasons, plant height (137.51, 135.18cm), total seed yield (3.78, 4.18 ton.ha^{-1}) and oil yield (1.34, 1.48 ton.ha^{-1}), protein yield (0.456, 0.470 ton.ha^{-1}) increased with increasing the plant density up to 66666 plant.ha^{-1}, then decreases towards decreased the plant

density. These results are true in the two growing seasons. Taller plants at high density may be due to inter plant competition for light and aerial resources. Similar results were obtained by Sedghi *et al*., (2008) who found maximum total seed yield, oil and protein yield in dense plant population. On the contrary, Tenebe *et al*., (1996) reported that oil and protein yield tends to decrease with increasing plant density. Increasing plant density increased the biological yield (gm.plant^{-1}), particularly during the vegetative phase (table 2). These results are in agreement with the previous findings reported by Tenebe *et al*., (1996). They showed that dry matter accumulation varied with population density, and the rate of increase was higher during the vegetative period. However, Killi and Ozdemir (2001) attributed the increase in biological yield production per unit of ground area may be due to the daily amount of photosynthetic ally active radiation which is intercepted the crop.

2- Cultivars effect:

Mehran cultivar had more plant height (129.63, 126.96cm), stem diameter (2.52, 3.09 cm), leaf area (3863.33, 3452.99 cm^2.plant^{-1}), head diameter (22.76, 22.51cm), number of seeds.head^{-1} (1220.5, 1126.4), weight of thousand seed (73.98, 74.05), hulls (51.17, 48.90), fertility (81.06, 80.31%), biological yield (330.84, 321.36 gm.plant^{-1}), seed yield (67.1, 66.9 gm.plant^{-1}), total seed yield (3.52, 3.54 ton.ha^{-1}), harvest index (20.45, 21.08%) than Sunbred cultivar in the first and second seasons, respectively (table 3). Differences in seed yield between sunflower cultivars are attributed to differences in morphological characters and yield components (Mohamed *et al*., 1992). In this respect, seeds of Mehran cultivar had more oil (40.21, 38.99%) and less protein (12.38, 12.37%) than those of Sunbred cultivar. Reports by Sangoi and Kruse, (1993); Villalobos *et al*., (1994); Ibrahim *et al*., (2003); Luan, (2006); Zehra *et al*., (2007); Al-Doori and Hasan, (2012) and Al-Doori and Al-Dulaimy, (2012) showed that there is considerable variability in oil and protein contents among sunflower cultivars.

3- Interaction effect between plant density and cultivars:

Mean values of interaction between plant density and cultivars are presented in tables (6,7). The interaction between the studying factors showed significant effects on plant height, no. of seeds per head and 1000 seed weight in only 2008-2009 season, biological yield (gm.plant^{-1}), seed yield (gm.plant^{-1}), total yield (ton.ha^{-1}) and oil yield (ton.ha^{-1}) in only 2009-2010 season (tables 4, 5). Mehran cultivar reflected the greatest response to plant density at 66666 plants.hectar^{-1} for seed yield (69.75 gm.plant^{-1}), total yield (4.65 ton per ha^{-1}) and oil yield (1.70 ton.ha^{-1}) in only 2009-2010 season, with this regard, Mariayesa *et al*., (2007) and Sedghi *et al*., (2008) found that high plant density produced higher oil yield. The interaction between the plant density and cultivars for the other investigated traits were not statistically significant in both

seasons, therefore the data were not discus. The insignificant effect between plant density and cultivars on other characteristic showed that each of these two factors acted independently on these traits.

Table -2- Effect of plant density on some growth characters, yield, yield components and quality in both seasons.

seasons	plant density (plants.ha^{-1})	plant height (cm)	stem diameter (cm)	leaf area (cm^2.plant)	head diameter (cm)	no. of seeds per head	1000 seed weight	hulls (%)	fertility (%)
2008-2009	41666	112.97d	2.82a	4172.06a	23.40a	1295.51a	72.61a	52.53a	82.84a
	47619	121.29c	2.48b	3935.64b	22.74a	1237.91b	69.76b	49.04b	80.59b
	55555	128.37b	2.22c	3482.41c	21.63b	1110.39c	66.16c	46.63c	76.62c
	66666	137.51a	1.93d	2796.79d	19.57c	966.68d	58.23d	43.94d	72.18d
2009-2010	41666	112.99c	3.43a	3660.70a	23.72a	1193.67a	70.38a	48.99a	83.74a
	47619	120.12b	3.09b	3406.50b	22.79b	1105.24b	67.46a	46.05b	80.19b
	55555	123.54b	2.65c	3115.70c	20.94c	1038.39c	64.07b	43.39c	77.16c
	66666	135.18a	2.30d	2712.60d	19.13d	951.52d	58.59c	41.30d	73.09d

seasons	plant density (plants .ha^{-1})	biological yield (gm.plant^{-1})	seed yield (gm.plant^{-1})	total yield (ton.ha^{-1})	harvest index (%)	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
2008-2009	41666	286.31b	63.92	2.66d	22.31a	42.27a	1.12d	14.56a	0.38b
	47619	318.19a	63.42	3.02c	19.95b	40.33b	1.22c	13.46b	0.40b
	55555	332.48a	60.78	3.37b	18.31c	37.13c	1.25b	12.93c	0.43ab
	66666	318.83a	56.82	3.78a	17.83c	35.29d	1.34a	12.11c	0.45a
2009-2010	41666	255.66d	58.64b	2.44d	23.01a	40.54a	0.99c	13.68a	0.33c
	47619	302.54c	63.35a	3.01c	21.02b	38.36b	1.160b	12.96ab	0.39b
	55555	324.44b	60.57a	3.36b	18.69c	36.93c	1.24b	12.00bc	0.40b
	66666	351.71a	62.77a	4.18a	17.81d	35.35d	1.48a	11.20c	0.47a

* The mean values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively in every seasons.

Table -3- Effect of cultivars on some growth characters, yield, yield components and quality in both seasons.

seasons	cultivars	plant height (cm)	stem diameter (cm)	leaf area (cm^2.plant)	head diameter (cm)	no. of seeds per head	1000 seed weight	hulls (%)	fertility (%)
2008-2009	Mehran	129.63a	2.52a	3863.33a	22.76a	1220.51a	73.98a	51.17a	81.06a
	Sunbred	120.44b	2.20b	3330.12b	20.91b	1084.73b	59.39b	44.90b	75.06b
2009-2010	Mehran	126.96a	3.09a	3452.99a	22.51a	1126.42a	74.05a	48.90a	80.31a
	Sunbred	118.95b	2.64b	2994.79b	20.78b	1017.98b	56.20b	40.97b	76.78b

seasons	cultivars	biological yield (gm.plant^{-1})	seed yield (gm.plant^{-1})	total yield (ton.ha^{-1})	harvest index (%)	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
2008-2009	Mehran	330.84a	67.10a	3.52a	20.45a	40.21a	1.40a	12.38a	0.43
	Sunbred	297.05b	55.37b	2.90b	18.75b	37.30b	1.07b	14.15b	0.40
2009-2010	Mehran	321.36a	66.92a	3.54a	21.08a	38.99a	1.37a	12.37	0.43a
	Sunbred	295.81b	55.74b	2.96b	19.19b	36.59b	1.07b	12.55	0.36b

* The mean values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively in every seasons.

Table -4- Effect of interaction between plant density and cultivars on some growth characters, yield, yield components and quality in 2008 - 2009 season.

plant density (plants.ha^{-1})	cultivars	plant height (cm)	stem diameter (cm)	leaf area (cm^2.plant)	head diameter (cm)	no. of seeds per head	1000 seed weight	hulls (%)	fertility (%)
41666	Mehran	116.61d	3.05	4465.50	24.29	1393.38a	81.82a	55.64	85.88
	Sunbred	109.33e	2.58	3878.62	22.51	1197.63c	63.40d	49.41	79.81
47619	Mehran	124.39c	2.61	4273.71	23.43	1313.59b	77.78b	52.09	83.23
	Sunbred	118.20d	2.36	3597.56	22.05	1162.23c	61.74de	46.00	77.95
55555	Mehran	132.38b	2.37	3748.99	22.68	1181.94c	73.13c	50.12	80.40
	Sunbred	124.37c	2.08	3215.82	20.58	1038.83d	59.19e	43.15	72.84
66666	Mehran	145.14a	2.07	2965.10	20.65	993.11de	63.21d	46.84	74.73
	Sunbred	129.88b	1.79	2628.47	18.49	940.25e	53.24f	41.05	69.64
plant density (plants.ha^{-1})	cultivars	biological yield (gm.plant^{-1})	seed yield (gm.plant^{-1})	total yield (ton.ha^{-1})	harvest index (%)	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
41666	Mehran	299.25	69.60	2.90	23.35	43.82	1.26	13.34	0.388
	Sunbred	273.36	58.24	2.42	21.28	40.72	0.987	15.79	0.385
47619	Mehran	335.10	69.37	3.30	20.76	41.73	1.379	12.53	0.413
	Sunbred	301.28	57.47	2.73	19.14	38.92	1.066	14.39	0.395
55555	Mehran	352.41	67.08	3.72	19.12	38.78	1.444	12.00	0.446
	Sunbred	312.55	54.48	3.02	17.51	35.47	1.074	13.86	0.420
66666	Mehran	336.62	62.35	4.15	18.59	36.50	1.518	11.67	0.484
	Sunbred	301.05	51.30	3.42	17.08	34.08	1.169	12.56	0.429

* The means values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively in every seasons.

Table -5- Effect of interaction between plant density and cultivars on some growth characters, yield, yield components and quality in 2009 - 2010 season.

plant density (plants.ha^{-1})	cultivars	plant height (cm)	stem diameter (cm)	leaf area (cm^2.plant)	head diameter (cm)	no. of seeds per head	1000 seed weight	hulls (%)	fertility (%)
41666	Mehran	115.61	3.74	3890.80	25.02	1265.05	79.82	53.51	85.35
	Sunbred	110.37	3.11	3430.60	22.41	1122.29	60.94	44.48	82.14
47619	Mehran	125.39	3.38	3683.70	23.50	1169.26	76.65	50.82	81.94
	Sunbred	114.86	2.79	3129.20	22.08	1041.23	58.27	41.29	78.45
55555	Mehran	126.04	2.84	3355.70	21.78	1094.27	73.35	46.86	79.64
	Sunbred	121.04	2.47	2875.80	20.09	982.50	54.79	39.93	74.67
66666	Mehran	140.81	2.40	2881.80	19.75	977.11	66.38	44.41	74.34
	Sunbred	129.55	2.20	2543.50	18.52	925.92	50.81	38.19	71.84
plant density (plants .ha^{-1})	cultivars	biological yield (gm.plant^{-1})	seed yield (gm.plant^{-1})	total yield (ton.ha^{-1})	harvest index (%)	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
41666	Mehran	282.88d	67.04ab	2.79d	23.86	41.42	1.16cd	13.24	0.371
	Sunbred	228.45e	50.24e	2.09e	22.17	39.66	0.83f	14.12	0.295
47619	Mehran	308.30bd	67.55ab	3.21c	22.05	39.80	1.28bc	12.83	0.413
	Sunbred	296.79cd	59.15cd	2.81d	20.00	36.92	1.03e	13.09	0.368
55555	Mehran	322.70bc	63.36bc	3.52b	19.63	38.18	1.34b	11.94	0.420
	Sunbred	326.19bc	57.78cd	3.21c	17.75	35.67	1.14de	12.06	0.385
66666	Mehran	371.58a	69.75a	4.65a	18.78	36.57	1.70a	11.47	0.534
	Sunbred	331.85b	55.80d	3.72b	16.85	34.12	1.26bd	10.94	0.407

* The mean values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively in every seasons.

Table -6- Analysis of variance F values for some growth characters, yield and yield components and quality in 2008 - 2009 season.

s.o.v	d.f.	plant height (cm)	stem diameter (cm)	leaf area (cm^2.plant)	head diameter (cm)	no. of seeds per head	1000 seed weight	hulls (%)	fertility (%)
Replications	2	63.291667	0.47933754	12346.875	7.60115000	11316.2917	16.687917	8.0454167	10.9892042
P	3	652.799126**	0.86067504**	2197696.76**	16.9007819**	128094.732**	232.78296**	79.753059**	131.838348**
C	1	506.093504**	0.62694338**	1705856.09**	20.6276041**	110605.030**	1277.64633**	236.191004**	215.940004**
P*C	3	25.470760*	0.01457337 n.s.	30978.839 n.s.	0.19090417 n.s.	5384.4196**	19.274460	0.3785486 n.s.	1.8866819 n.s.
Error	14	6.625000	0.01021087	10194.494	0.30057857	967.1012	2.348869	0.8982167	2.9584423
Total	23								

s.o.v	d.f.	biological yield ($gm.plant^{-1}$)	seed yield ($gm.plant^{-1}$)	total yield ($ton.ha^{-1}$)	harvest index (%)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
Replications	2	7700.11641	132.2251125	0.36665417	4.34751667	1.3962500	0.06263994	2.37791667	0.01109300
P	3	2298.36449**	63.2771375 n.s.	1.3943486**	24.5492277**	58.919927**	0.0478075**	6.3360375**	0.00573679*
C	1	6849.20951**	825.205537**	2.3002041**	17.3740166**	50.808600**	0.6486270**	18.6737041**	0.00389811 n.s.
P*C	3	51.28358 n.s.	0.6925375 n.s.	0.02218194 n.s.	0.09367222 n.s.	0.2228667 n.s.	0.00226083 n.s.	0.62613750 n.s.	0.00070803 n.s.
Error	14	310.54707	6.738884	0.01660655	0.6340881	0.8938690	0.00365342	0.99363095	0.00148409
Total	23								

*, ** Significant at the 0.05 and 0.01 probability levels, respectively. and n.s. not Significant.

Table -7- Analysis of variance F values for some growth characters, yield and yield components and quality in 2009 - 2010 season.

s.o.v	d.f.	plant height (cm)	stem diameter (cm)	leaf area (cm^2.plant)	head diameter (cm)	no. of seeds per head	1000 seed weight	hulls (%)	fertility (%)
Replications	2	465.133067	2.62751667	863128.292	1.99625000	21615.1250	3.545937	42.2108167	36.6530167
P	3	514.128249**	1.45582639**	994520.284**	24.8122486**	63111.102**	153.64938**	66.594348**	122.966738**
C	1	384.720338	1.20153750	1259720.096	18.04400417	70554.3172	1911.021067	376.9130042	75.1188167
P*C	3	16.806971 n.s.	0.06207083 n.s.	12060.367 n.s.	0.56248194 n.s.	2424.6018 n.s.	3.531411 n.s.	3.8630819 n.s.	1.6167611 n.s.
Error	14	17.616876	0.03908810	37484.054	0.4824405	2013.4107	7.175938	2.1423405	1.5298167
Total	23								
s.o.v	d.f.	biological yield ($gm.plant^{-1}$)	seed yield ($gm.plant^{-1}$)	total yield ($ton.ha^{-1}$)	harvest index (%)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
Replications	2	9444.26983	166.1887500	0.42140000	6.11108750	4.81637917	0.09869986	2.63760000	0.00862832
P	3	9897.14797**	27.9641375**	3.18516111**	33.0731819**	29.168550**	0.2500350**	7.0546152**	0.019178**
C	1	3915.78636**	750.289837**	2.053350**	21.4515041**	34.560000**	0.544374**	0.20720417 n.s.	0.0301234**
P*C	3	1038.19825*	39.1728375*	0.12105000**	0.03324861 n.s.	0.32751111 n.s.	0.01598889*	0.49941528 n.s.	0.00249066 n.s.
Error	14	258.43749	9.706779	0.02473333	0.5756780	0.7963315	0.00485849	0.74893333	0.00140107
Total	23								

*, ** Significant at the 0.05 and 0.01 probability levels, respectively. and n.s. not Significant.

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