

RESPONSE OF SOME STRAWBERRY CULTIVARS TO NITROGEN FERTIGATION

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ABSTRACT: The present study was carried out during two successive seasons; i.e., 1999 /2000 and 2000/2001 to investigate the response of three new strawberry (*Fragaria x ananassa* Duch) cvs; i.e., Camarosa, Sweet Charlie and Rosalinda to three nitrogen fertigation levels; i.e, 100, 150 and 200 kg/feddan. This work was done at south Tahreer, Behera Governorate using the plasticulture system.

Results reflected significant differences among the three cvs. in crown number, leaf number and leaf area / plant at different sampling dates. Moreover, dry matter (DM) in the second season and carbohydrates, in the 1st season, showed a significant difference among the cvs, and the highest values of crown number, leaf number and leaf area / plant were scored by Camarosa and Sweet Charlie cvs, respectively. Comarosa cv, in general, had also the highest values of leaf DM, carbohydrates (%) and C/N ratio. The results showed also significant differences among the cvs in fruit weight, fruit number / plot, early and total yield / plot and total yield / feddan.

DM and carbohydrates were, generally, increased with increasing N-level and vice versa with C/N ratio. N level at 200 kg/fed. gave the highest crown No. and leaf No. /plant. On the other hand, N fertilizer had no significant effect on total yield / plot or per feddan and its components, whereas it had a significant effect on the early yield and its components. The best N-levels for average fruit wt., fruit No./plant and for total early yield was 100, 150 and 100 kg N/fed., respectively. N- level at 100 kg / fed. was convenient for cv Camarosa to obtain a maximum total yield, 150 kg for the first early period and 100 kg for the second early period. The best N-level for cvs Sweet Charlie and Rosalinda was 200 and 100 kg N/ fed., respectively for both early and total yields.

INTRODUCTION

Strawberry production in Egypt as annual culture system on raised-polyethylene mulched beds, low tunnels and drip irrigation has been the standard production system for export since 1993. However, Albrechts *et al.* (1991) reported that fertilizer application to strawberry through drip irrigation system resulted in a significant fruiting response. Moreover, new strawberry cultivars introduced to growers in (1996) by Agricultural Technology Utilization and Transfer Project Ministry of Agriculture. The new cultivars are Camarosa, Sweet Charlie and Rosalinda.

Camarosa *cv* produced fruits larger than those of Rosalinda and Sweet Charlie *cvs* as reported by Chandler and Legard (1997) and Chandler *et al.* (1997,2000). Other workers reported the effect of different rates of N on vegetative growth and dry matter of strawberry plant (Mamichev and Lyashenko, 1989; Maegawa and Minegishi, 1991; Neuweiler *et al.*, 1996; Archbold and Mackown, 1997; Miner *et al.*, 1997; Neuweiler *et al.*, 1997).

Strawberry yield was affected by N fertilizer at different rates when added through the drip irrigation system. Early and total

yield of many strawberry cultivars varied in their response according to the used N rates (from 50 to 250 kgN/ha) as illustrated by Cannell *et al.* (1961), Voth *et al.* (1961,1967), Albrechts and Chandler (1993) and Hochmuth *et al.* (1996).

The main objective of this research was to determine the optimum N requirements for three new strawberry cultivars grown under drip irrigation and N fertigation to obtain high early as well as total yields.

MATERIALS AND METHODS

The present study was conducted during the two successive seasons (1999-2000 and 2000-2001) using three strawberry cultivars; i.e, Comarosa, Sweet, Chartlie and Rosalinda. This work was done at south Tahreer, El-Behera Governorate, using the plasticulture system(drip irrigation, soil mulch and low tunnels).

Soil preparation took place in July every season by rotatillage the soil twice. Soil samples were taken from 50cm soil surface to measure EC, pH, cations and anions concentrations before planting (Table 1). Basic fertilizers were broadcasted before taillage. The kinds and amounts of fertilizers added per feddan were:

Table 1. Mechanical and chemical analysis of soil.

	Mechanical analysis	Chemical analysis meq/L			
		Anions		Cations	
Course sand	56.69%	HCO ₃	2.63	Ca ⁺⁺	4.2
Fine sand	29.81%	Cl	2.02	Mg ⁺⁺	1.8
Silt	11.40%	So ₄	4.31	Na ⁺	2.38
Clay	2.10%			K	0.57
Soil texture	Sandy				
EC (mmho/cm)	0.9				
pH	8.3				
SP	22.5				
CaCO ₃	7.60%				

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1. Farm yard manure (FYM); 40m³
2. Calcium superphosphate (15.5% P₂O₅); 200kg,
3. Sulphur at the rate of 250 kg,
4. Potassium sulphate (48% K₂O); 100 kg, and
5. Magnesium sulphate at 50 kg.

Raised beds were 120cm width, 40cm height and designed to have two lines of drip irrigation, each with discharge 4L/h per dripper. Soil was fumigated by methyl bromide at 70gm/m³ soil. Fresh transplants were soaked in fungicide solution for 20 minutes, then planted on raised beds in four rows, at 30 cm between rows and 30 cm between plants in a row.

Plot area was 3.6m² with 40 plants, each. Planting was done on 15th September in the two seasons.

Experimental layout was split – plot design with three replications. The cultivars were represented in the main plots and the nitrogen levels; i.e., 100, 150 and 200 kg N/feddan were assigned at random in the sub-plots.

Nitrogen fertilizer levels were applied through drip irrigation system. The source of nitrogen was ammonium sulphate (20.6%N), ammonium nitrate (33%N) and calcium nitrate (15.5%N). The nitrogen application levels from each source were scheduled as follow:

1. 50% was applied during the vegetative growth stage,
2. 30% was applied during the flowering stage, and
3. 20% was applied during the fruiting stage.

Phosphorus (P_2O_5) and potassium (K_2O) fertilizers were applied via the drip irrigation system at 60 and 250kg/ feddan, respectively. The residual soil P and K which were applied prior as a basic fertilization were taken into account.

Recorded Data

a. Vegetative growth:

Four samples were taken randomly from every plot, i.e., on 1st Nov., 15th Dec., 1st Feb. and 15th March, each sample consisted of five nondestructive plants, to measure the following plant growth traits.

1. Number of leaves per plant,
2. Total leaf area per plant; by multiplying the number of leaves per plant by the average of leaf area, which was measured by planimeter after drawing the leave each plant.
3. Number of crowns per plant,

b. Plant chemical analysis:

1. Plant dry matter in December sampling date (gm).
2. C/N ratio in leaf dry matter; total nitrogen was determined according to Evenhuis (1976); while carbohydrates was determined according to Dubois *et al* (1956).
3. P and K %, in leaf dry matter, were determined according to Murphy and Riley (1962) and

Brown and Lilliland (1946), respectively.

C. Fruit yield:

Strawberry fruits were picked twice a week when 75% red colour was appeared. Berries were counted and weighed at each harvest to determine the following:

1. Total early yield (kg / plot) and its components; from November up to the end of February,
2. Early yield (kg / plot) and its components, at the first period (From Nov. up to the end of December),
3. Early yield (kg / plot) and its components at the second period (From January up to the end of February).
4. Total yield (kg/plot) and (tons / feddan) were obtained from all harvests during the fruiting period.

Statistical analysis:

The recorded data were statistically analysed for each season. Analysis of variance and L.S.D. were done according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

The effects of N-fertilization on strawberry cultivars; i.e., Camarosa, Sweet Charlie and Rosalinda in two growing seasons will be presented under the following topics.

1. Plant Growth Traits

1.1 Crown number /plant

Results in Table 2 show significant differences among the studied cultivars in crown number/plant at all sampling dates; i.e., November 1st, December 15th, February 1st and March 15th in the two growing seasons (1999/2000 and 2000/2001). Camarosa cv scored the highest significant number of crowns followed by cvs Sweet Charlie and Rosalinda. Nevertheless, the difference between cvs Sweet Charlie and Rosalinda was not significant in the 2nd season at mid-December, 1st February, and at mid-March, and it was so between cvs Camarosa and Sweet Charlie. On the other hand, N-fertilization had insignificant effect on crown number, except that in the 1st season at mid of both December and March sampling dates. Nitrogen fertilizer at 200 kg N gave the highest crown number, which was significantly higher than that of the other two fertilizer levels, especially at the aforementioned two sampling dates.

Regarding to cultivar x nitrogen effects (Table 2), such interaction had significant effect on crown number in the two growing seasons. Using LSD¹ to compare the interaction values, it was observed that cv Camarosa x 150

or 200 kgN gave the highest crown number of all the cases, followed insignificantly by Sweet Charlie x 200 in the 2nd season on February 1st or 150 in the 1st season at mid-March. However, the highest significant value was obtained with Sweet Charlie x 200 kgN in the first season on March 15th sampling date. By using LSD² to compare the effect of nitrogen on each cultivar, generally 200kgN gave more crown number per plant than the other N-levels for each cultivar, but it was insignificant between those levels (150 and 100 kgN) when compared under the same cultivar. These results are in harmony with those reported by Albregts *et al.* (1991) and Miner *et al.* (1997).

1.2 Leaf number /plant

Concerning the main effects of cultivars and nitrogen (Table 3), results reflect significant differences among the studied cultivars for leaf number /plant. On November 1st in the two seasons, cv Sweet Charlie had the highest significant value followed insignificantly by cv Camarosa, but in the other sampling dates in the two seasons, cv Camarosa gave the highest significant leaf number /plant compared with other two cultivars. Rosalinda cv, in general, had the lowest number of leaves /plant. For nitrogen effect (Table

Table 2. Effect of cultivars, nitrogen and their interactions on crown number/ strawberry plant at different samples dates

Treatments	Samples Dates							
	Nov. 1st		Dec. 15 th		Feb. 1st		March 15 th	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
	Effect of cultivar							
Camarosa	2.54	2.33	3.69	4.04	4.31	4.87	5.53	5.27
Sweet Charlie	1.91	1.87	3.00	2.73	2.62	2.98	5.70	3.49
Rosalinda	1.37	1.41	2.24	2.12	2.93	2.60	4.22	3.13
LSD 0.05	0.25 **	0.41 **	0.72 *	0.92 *	0.64 *	0.83 *	1.17 *	1.44 *
	Effect of nitrogen							
100 (kgN)	1.87	1.76	2.76	2.89	3.44	3.47	4.77	3.93
150 ((kgN)	1.89	2.00	2.84	3.04	3.53	3.44	5.11	4.09
200 (kgN)	2.05	1.85	3.33	2.97	3.89	3.53	5.58	3.87
LSD 0.05	NS	NS	0.40 *	NS	NS	NS	0.33 *	NS
	Effect of cultivar x nitrogen interaction							
Camarosa								
100 (kgN)	2.33	2.40	3.27	4.27	4.07	5.07	5.26	5.40
150 ((kgN)	2.68	2.27	3.46	3.87	4.27	4.47	5.36	5.07
200 (kgN)	2.60	2.33	4.33	4.00	4.60	5.07	5.94	5.33
Sweet Charlie								
100 (kgN)	1.80	1.53	2.60	2.67	3.47	3.13	5.18	3.20
150 ((kgN)	1.93	2.20	3.20	2.73	3.53	2.93	5.80	3.73
200 (kgN)	2.00	1.87	3.20	2.80	3.89	5.07	6.13	3.53
Rosalinda								
100 (kgN)	1.07	1.33	2.40	1.73	3.07	2.47	3.83	3.20
150 ((kgN)	1.56	1.53	1.87	2.53	2.53	2.73	4.17	3.47
200 (kgN)	1.80	1.35	2.47	2.10	3.20	2.60	4.67	2.73
LSD(1) 0.05	0.76 *	0.53 *	0.65 *	1.46 *	0.78 *	1.06 *	0.59 *	0.90 *
LSD(2) 0.05	0.86	0.62	0.89	1.49	0.91	1.19	1.25	1.60

NS, *, **, insignificant, significant at 0.05, and significant at 0.01, respectively.

1, 2 :LSD for comparing interaction values, for comparing nitrogen effect under the same cultivar, respectively.

Table 3. Effect of cultivars, nitrogen and their interactions on leaf number /strawberry plant at different samples dates

Treatments	Samples Dates							
	Nov.1st		Dec.15 th		Feb.1st		March15 th	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
	Effect of cultivar							
Camarosa	9.80	11.09	20.61	22.44	22.30	32.00	18.49	28.07
Sweet Charlie	10.38	11.29	17.11	16.07	11.42	18.20	11.26	12.84
Rosalinda	8.22	8.42	13.42	11.31	9.42	17.49	11.12	9.91
LSD 0.05	1.07 *	0.60 *	2.06 **	2.62 **	6.32 **	5.57 *	2.83 *	6.12 *
	Effect of nitrogen							
100 (kgN)	9.09	10.02	15.80	16.40	15.02	23.24	11.39	17.44
150 ((kgN)	9.22	10.60	16.01	17.53	13.46	24.09	13.97	16.44
200 (kgN)	10.09	10.18	19.33	15.89	14.67	20.36	16.89	16.93
LSD 0.05	0.71 *	NS	2.98 *	NS	NS	3.40 *	3.53 *	NS
	Effect of cultivar x nitrogen interaction							
Camarosa								
100 (kgN)	9.47	10.80	18.87	23.73	25.47	29.40	13.00	27.47
150 ((kgN)	9.92	11.47	19.49	21.27	19.30	35.87	17.67	24.67
200 (kgN)	10.00	11.00	23.47	22.33	22.47	30.73	24.73	32.07
Sweet Charlie								
100 (kgN)	10.07	11.13	14.93	14.93	9.20	20.33	9.07	13.53
150 ((kgN)	9.87	11.40	16.93	17.13	12.33	18.67	12.67	14.47
200 (kgN)	11.20	11.33	19.47	16.13	12.73	15.60	16.27	10.53
Rosalinda								
100 (kgN)	7.74	8.13	13.60	10.53	10.40	10.00	12.11	11.33
150 ((kgN)	7.86	8.93	11.60	14.20	8.73	17.73	11.58	10.20
200 (kgN)	9.05	8.20	15.07	9.20	9.13	14.73	9.67	8.20
LSD(1) 0.05	1.24 *	2.54 *	5.16 *	4.78 *	4.96	5.85 *	6.11 *	5.40 *
LSD(2) 0.05	1.47	2.15	4.68	4.67	746.00	7.29	5.99	7.51

NS,*,** ; insignificant , significant at 0.05 , and significant at 0.01, respectively.

1,2 ;LSD for comparing interaction values , for comparing nitrogen effect under the same cultivar ,respectively.

3), it had significant effect at four cases out of eight, which had significant advantage (more leaves) for 200 kg N in the 1st season on November 1st, at mid-December and at mid-March, and for 150 kgN in the 2nd season on February 1st sampling dates.

Regarding to the interaction of cultivar x nitrogen (Table 3), results show the highest significant leaf number with Sweet Charlie x 200 kgN and with Camarosa x 150, 200, 100, 100, 150 and 200 kgN, respectively with the presented sampling dates in the table. Nevertheless, there were insignificant differences between N-levels under the same cultivar, except that, for cv Rosalinda x 150 kgN at mid-December in the 2nd season and for cv Camarosa x 200 kgN at mid-March, in the first season which had highly significant values of leaf number / plant. Similar results were found in other trials with 15 strawberry cultivars, where high rates of N produced excessive leaf formation (Neuweiler *et al.* 1996).

1.3 Leaf area /plant

Main effects of cultivars and nitrogen on leaf area (Table 4) show significant differences among the studied cultivars, at the four sampling, dates in the two growing seasons. The cultivars; Camarosa and Sweet Charlie had

plant leaf area significantly higher than that for cv Rosalinda at the 1st sampling date in the two seasons, with insignificant difference between the former two cultivars. In the other sampling dates (Dec., Feb. and March), Camarosa, generally had the highest values of leaf area followed by Sweet Charlie and Rosalinda. Nitrogen, in this respect, had significant effect in the 1st season at all sampling dates, and the significant advantage was for 200 kgN. In the 2nd season, on the other hand, nitrogen had insignificant effect on plant leaf area, except that at the mid-March sampling date, at which 150 kgN leaf area was significantly higher and insignificantly than those for 200 and 100 kgN/ feddan, respectively.

Regarding to the cultivar x nitrogen interaction (Table 4), data show significant interaction effect on plant leaf area at all sampling dates in the two seasons, except that in November and December in the 2nd and in the 1st seasons, respectively. Camarosa cv x 200 kg N gave, mostly, the highest values of leaf area, except that for Sweet Charlie x 200 kg N on 1st November, in the 1st season, and Camarosa x 100 kg in mid-December, in the 2nd season. The lowest leaf area was, generally,

Table 4. Effect of cultivars, nitrogen and their interaction on leaf area / strawberry plant(cm²), at different samples dates

Treatments	Samples Dates							
	Nov.1st		Dec.15 th		Feb.1st		March15 th	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of cultivar								
Camarsosa	968.66	1398.81	2041.74	2205.20	1286.90	1745.20	574.53	936.80
Sweet Charlie	991.23	1130.94	1504.55	1405.50	586.10	803.90	304.33	367.50
Rosalinda	684.71	496.46	1245.88	472.60	488.80	558.40	257.83	250.40
LSD 0.05	209.07 *	275.89 *	244.28 **	728.93 *	344.80 *	331.95	198.00 *	360.21 *
Effect of nitrogen								
100 (kgN)	757.77	1040.10	1374.80	1379.70	646.75	1044.20	207.19	498.90
150 (kgN)	842.36	982.90	1481.10	1552.00	723.89	1071.90	368.64	605.23
200(kgN)	1044.50	1003.20	1936.20	1421.60	991.26	991.30	560.87	450.90
LSD 0.05	81.13 *	NS	312.80 *	NS	167.90 *	NS	181.26 *	149.26 *
Effect of cultivar x nitrogen interaction								
Camarsosa								
100 (kgN)	853.06	1454.86	1727.42	2461.31	1160.62 *	1515.78	257.70	904.05
150 (kgN)	962.27	13.05.26	1888.68	2368.29	1119.93	1920.93	522.83	932.04
200(kgN)	1090.66 *	1436.31	2509.12	1785.85	1580.23	1799.61	943.05	974.41
Sweet Charlie								
100 (kgN)	840.34	1200.58	1247.03	1106.39	401.80	858.18	157.58	356.35
150 (kgN)	920.11	1070.16	1478.98	1599.97	572.51	847.42	299.14	525.17
200(kgN)	1213.24	1122.08	1787.63	1530.12	784.05	743.03	456.28	220.94
Rosalinda								
100 (kgN)	579.91	464.80	1149.94	517.38	377.84	791.50	206.28	235.30
150 (kgN)	644.70	573.38	1075.77	707.65	479.15	452.18	283.94	358.49
200(kgN)	829.53 *	451.20	1511.93	948.68	609.51	431.39	283.28	157.34
LSD(1) 0.05	140.60 *	NS	NS	1142.34 *	290.95 *	565.51 *	314.13 *	258.67 *
LSD(2) 0.05	237.03	NS	NS	1174.46	416.28	559.64	321.89	414.47

NS,*,** ; insignificant , significant at 0.05 , and significant at 0.01, respectively.

1,2 ;LSD for comparing interaction values , for comparing nitrogen effect under the same cultivar ,respectively.

obtained with *cv* Rosalinda x 100 kgN.

By comparing the nitrogen effect under the same cultivar, results reflected that, the three cultivars x 200 kgN on November, 1st in the 1st season, gave higher leaf area compared with other N-levels under the same cultivar. Nevertheless, Camarosa x 100 kgN and Sweet Charlie x 150 in mid-December in the 2nd season, and Camarosa x 200 at February and March, in the 1st season, gave the highest leaf areas. However, in the rest cases, there were no significant differences among N levels under the same cultivar.

These results were similar to those obtained by Mamichev and Lyashenko (1989), Maegawa and Minegishi (1991) and Neuweiler *et al.* (1997).

2. Plant chemical analysis

2.1 Plant dry matter, carbohydrate and C/N ratio

a. The main effects of cultivars and nitrogen. Results in Table 5 reflect insignificant differences among the studied three cultivars, concerning plant dry matter, in the 1st season; carbohydrates, in the 2nd season; and C/N ratio, in the two seasons. While, dry matter in the 2nd season and carbohydrate (%) in the 1st season reflected a significant difference among the

cultivars. In this respect, Camarosa in general had the highest values of the studied three cultivars followed by *cvs* Sweet Charlie and Rosalinda, with insignificance between Camarosa and Sweet Charlie in the three traits. Nitrogen, on the other hand, gave significant effect on the studied three traits, except those for carbohydrates and C/N ratio in the 2nd season. Dry matter per plant and carbohydrates content were, generally, increased with the increase in N-level, but C/N ratio was decreased with the increase in N-level. Similar results were reported by Neuweiler *et al.* (1997) who found that N applications increased leaf dry matter accumulation.

Concerning the cultivar x nitrogen interaction effect, results in Table 5 show that, such interaction had significant effect on dry matter in the 2nd season, and on both carbohydrates and C/N ratio in the 1st season. The highest value of dry matter was obtained by *cv* Camarosa x 200 kg N, of carbohydrate was obtained by *cv* Camarosa x 150 kgN and *cv* Sweet Charlie x 200 kgN, and of C/N ratio was obtained with *cv* Camarosa x 200 kgN. By comparing N-levels under the same cultivar, data reveal that N-level had insignificant effect on

Table 5. Effect of cultivars, nitrogen and their interactions on dry matter, Carbohydrates and C/N ratio of strawberry plant

Treatments	December Sampling Date %					
	Plant dry matter		Carbohydrates		C/N ratio	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of cultivar						
Camarosa	42.59	57.92	31.38	29.69	13.46	12.85
Sweet Charlie	37.99	43.02	31.45	26.81	11.64	11.20
Rosalinda	29.85	25.93	28.64	25.53	11.44	10.92
LSD 0.05	NS	25.77*	1.49*	NS	NS	NS
Effect of nitrogen						
100 (kgN)	28.49	36.55	28.44	26.84	13.13	12.29
150 (kgN)	40.06	39.69	31.78	28.19	12.52	11.61
200(kgN)	41.88	50.51	31.24	27.00	10.95	11.08
LSD 0.05	12.00*	13.67*	1.82*	NS	1.65*	NS
Effect of cultivar x nitrogen interaction						
Camarosa						
100 (kgN)	31.61	51.48	29.75	30.97	15.46*	14.16
150 (kgN)	46.15	54.36	34.23*	30.66	13.95	12.58
200(kgN)	50.02	67.93	30.15	27.44	10.46	11.80
Sweet Charlie						
100 (kgN)	23.75	32.23	29.54	26.15	11.49	11.60
150 (kgN)	32.33	38.31	30.97	28.33	12.36	11.14
200(kgN)	33.46	58.51	33.82*	25.96	11.08	10.87
Rosalinda						
100 (kgN)	30.11	25.93	26.03	23.41	12.45	11.10
150 (kgN)	41.68	26.41	30.16	25.60	11.25	11.10
200(kgN)	42.17	25.08	29.75	27.59	10.82	10.58
LSD(1) 0.05	NS	28.88	2.87	NS	2.87*	NS
LSD(2) 0.05	NS	34.64	2.96	NS	3.29	NS

NS, * ; insignificant , significant at 0.05 , respectively.

1,2 :LSD for comparing interaction values , for comparing nitrogen effect under the same cultivar ,respectively.

dry matter; Camarosa x 150 kgN, Sweet Charlie x 200 kgN and Rosalinda x 150 kg N gave highest values of carbohydrate compared with other N- levels under the same cultivar. For C/N ratio, the highest significant value was obtained only with Camarosa x 100 kgN in the first season, but for other cultivars there were insignificant differences among N-levels. Similar results were reported by Archbold and Mackown 1997 and Neuweiler *et al.* (1997).

2.2 NPK contents in strawberry plants

Results in Table 6 revealed insignificant difference among the studied three cultivars and among the three N-levels, concerning plant NPK, in the two seasons. However, nitrogen in the first season reflected significant effect on N% of the plants and the highest N% was obtained with fertilization with 200 kgN / feddan. These results are in agreement with those reported by Archbold and Mackown (1997) and Nestby (1998).

Moreover, the interaction of cultivar x nitrogen had also insignificant effect on NPK content, except that for P%, in the first season, which was significant. Phosphorous percent in the 1st season reflected its highest percent with Camarosa x 150 kgN or when

compared under the same cultivar. Meanwhile, for other two cultivars, insignificant P% was observed under Sweet Charlie and Rosalinda cvs separately.

3. Yield and Its Components

3.1 Main effect of the cultivars and nitrogen

Regarding to the differences among the cultivars (Table 7), obtained results showed significant differences among the three cultivars in fruit weight, fruit number /plot and total yield per plot and/feddan in the two growing seasons, except that in fruit number / plot in the 2nd season.

The highest average fruit weight was shown by cv Camarosa with insignificant difference with cv Sweet Charlie in the first season, but cv Rosalinda had significant lowest fruit weight, in the two seasons. For fruit number, cvs Camarosa and Rosalinda produced more number of fruits than cv Sweet Charlie. Moreover, cv Camarosa gave the highest yield per plot and per feddan compared with cvs Sweet Charlie and Rosalinda, with insignificance between the later two cultivars.

Chandler *et al.* (2000) reported that cv Camarosa produced large fruits and the total yield was significantly more than Sweet Charlie. These findings confirm the obtained results.

Table 6. Effect of cultivars, nitrogen and their interactions on N, P and K % of strawberry leaves dry matter

Treatments	December Sampling Dates					
	N%		P%		K%	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
	Effect of cultivar					
Camarosa	2.46	2.32	0.40	0.26	2.51	2.28
Sweet Charlie	2.73	2.40	0.38	0.41	2.28	2.42
Rosalinda	2.55	2.37	0.39	0.31	2.24	2.39
LSD 0.05	NS	NS	NS	NS	NS	NS
	Effect of nitrogen					
100 (kgN)	2.33	2.26	0.41	0.23	2.51	2.37
150 (kgN)	2.58	2.36	0.41	0.44	2.28	2.59
200(kgN)	2.77	2.51	0.36	0.30	2.24	2.13
LSD 0.05	0.30*	NS	NS	NS	NS	NS
	Effect of cultivar x nitrogen interaction					
Camarosa						
100 (kgN)	2.00	2.26	0.44	0.21	2.26	2.30
150 (kgN)	2.49	2.20	0.54	0.24	2.66	2.70
200(kgN)	2.71	2.60	0.33	0.32	1.84	1.86
Sweet Charlie						
100 (kgN)	2.57	2.26	0.40	0.22	2.73	2.51
150 (kgN)	2.77	2.54	0.40	0.68	2.04	2.43
200(kgN)	2.86	2.40	0.38	0.33	2.42	2.31
Rosalinda						
100 (kgN)	2.42	2.27	0.41	0.26	2.54	2.31
150 (kgN)	2.48	2.33	0.40	0.40	2.14	2.65
200(kgN)	2.74	2.52	0.40	0.26	2.46	2.22
LSD(1) 0.05	NS	NS	0.06*	NS	NS	NS
LSD(2) 0.05	NS	NS	0.08	NS	NS	NS

NS,* : insignificant , significant at 0.05 , respectively.

1,2 ;LSD for comparing interaction values , for comparing nitrogen effect under the same cultivar , respectively.

Table 7. Effect of cultivars, nitrogen and their interactions on strawberry fruit weight, total fruit number/plot, total yield/plot (kg) and total yield (tons/ fed.)

Treatments	Yield and Its Components							
	Fruit weight		Fruit number/plot		Yield /plot (kg)		Yield/fed. (Ton)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
	Effect of cultivar							
Camarosa	10.94	12.03	2093.20	2044.30	22.90	24.59	26.72	28.687
Sweet Charlie	10.65	9.58	1528.90	1829.00	16.28	17.52	18.99	20.428
Rosalinda	7.69	8.92	2145.90	2029.80	16.50	18.11	19.25	21.116
LSD 0.05	1.26	1.39	303.79*	NS	3.11	4.57	3.63	5.329
	Effect of nitrogen							
100 (kgN)	10.19	10.50	1933.80	2134.00	19.71	22.41	22.99	26.13
150 (kgN)	9.49	9.90	2004.40	2107.70	19.02	20.87	22.19	24.35
200(kgN)	9.62	10.14	1829.80	1661.40	17.60	16.85	20.53	19.65
LSD 0.05	NS	NS	NS	NS	NS	NS	NS	NS
	Effect of cultivar x nitrogen interaction							
Camarosa								
100 (kgN)	11.25	12.37	2201.70	2175.30	24.77	26.91	28.90	31.377
150 (kgN)	10.51	11.56	2189.00	2224.50	23.00	25.75	26.82	29.989
200(kgN)	11.05	12.15	1898.00	1733.30	20.97	21.06	24.45	24.556
Sweet Charlie								
100 (kgN)	10.75	9.65	1315.70	1737.70	14.10	16.77	16.45	19.554
150 (kgN)	10.82	9.75	1725.70	1935.00	18.67	18.86	21.77	21.991
200(kgN)	10.41	9.37	1545.30	1814.30	16.09	16.99	18.76	19.810
Rosalinda								
100 (kgN)	8.60	9.50	2284.00	2489.00	19.64	23.67	22.90	27.564
150 (kgN)	7.00	8.40	2098.70	2163.70	14.69	18.17	17.14	21.186
200(kgN)	7.40	8.88	2055.00	1436.70	15.20	12.76	17.73	14.878
LSD(1) 0.05	NS	1.90*	404.21*	NS	3.72	NS	4.34	NS
LSD(2) 0.05	NS	2.07	449.20	NS	4.32	NS	5.04	NS

NS, * ; insignificant , significant at 0.05 , respectively.

1,2 ;LSD for comparing interaction values , for comparing nitrogen effect under the same cultivar ,respectively.

On the other hand, nitrogen fertilizer did not reflect any significant effect on yield and its components (Table 7). Although the nitrogen had no significant effect, 100 or 150 kgN / feddan gave yields higher than that for 200 kgN. These results are in line with those of Albergts and Chandler (1993) who found that N application of about 200 lb/acre had no significant effect on strawberry yield. In other work, Hochmuth *et al.* (1996) applied N at rates of 50, 100, 150, 200 and 250 kg N/ha through drip irrigation and found that total yield increased with increasing N fertilization level from 50 up to 150 KgN/ha.

3.2 Effect of cultivar x nitrogen interaction

Cultivar x nitrogen interaction treatments had significant effect on strawberry yield and its components, except that on average fruit weight in the 1st season and fruit number and yield in the 2nd season which were insignificant (Table 7). The highest and the lowest values of fruit size were obtained by Camarosa x any N-level and by Rosalinda x 150 KgN, respectively. For fruit number, it was at the highest value with Rosalinda x 100 KgN and Camarosa x 100 KgN, with insignificance at 150 KgN for both the cultivars, but the lowest one was observed for Sweet

Charlie x 100 KgN. The highest total yield was obtained by Camarosa x 100 or 150 KgN, but the lowest yield value was with Sweet Charlie x 100 KgN/feddan.

Since the cultivars showed different responses to nitrogen fertilizer, it is fruitful to highlight on the effect of nitrogen on the same cultivar, using convenient LSD2 (Table 7). Nitrogen level had no effect on fruit size of the same cultivar. Fruit number, on the other hand, for *cv* Camarosa was higher with 100 or 150 kgN and for *cv* Sweet Charlie was with 150 kgN, but *cv* Rosalinda was not affected by N-level. Moreover, total yield for *cv* Camarosa was at the highest value with 100 kgN, although the three levels did not create a significant difference, for *cv* Sweet Charlie it was highest with 150 kgN, and for *cv* Rosalinda it was maximum with 100 kgN.

In California, most strawberry cultivars responded to N between 112 and 170 kg N/ha. Although, there was a response to more N as reported by Cannell *et al.* (1961) and Voth *et al.* (1961, 1967).

4. Early Yield and Its Components

4.1 Main effect of the cultivars and nitrogen

Results in Table 8 show significant differences among the

Table 8. Average effect of cultivars and nitrogen on strawberry fruit weight, total early fruit number/plot and total early yield /plot (kg)

Treatments	First season (1999/2000)			Second season (2000/2001)		
	Fruit weight (gm)	Fruit NO./plot	Early yield (Kg/plot)	Fruit weight (gm)	Fruit NO./plot	Early yield (Kg/plot)
Effect of cultivar						
Camarosa	13.41	408.80	5.48	14.14	350.00	4.95
Sweet Charlie	13.34	833.00	11.11	12.13	896.80	10.88
Rosalinda	9.20	1054.00	9.70	11.28	859.00	9.70
LSD 0.05	2.27	135.40	2.03	2.38	121.50	2.28
Effect of nitrogen						
100 (kgN)/fed.	12.27	698.30	8.57	15.37	599.60	9.22
150 (kgN)/fed.	10.69	855.80	9.15	11.30	799.60	9.05
200(kgN)/fed.	11.55	741.70	8.57	10.26	707.40	7.26
LSD 0.05	1.29	114.10	NS	1.39	87.40	1.32

NS, insignificant at the 0.05 level of probability.

studied cultivars and also among N- levels, except that for early yield /plot in the 1st season.

Camarosa, in the two seasons, showed the highest average early fruit weight, followed insignificantly by cv Sweet Charlie, but cv Rosalinda had significant lower fruit size, when compared with cv Camarosa in the two growing seasons. Rosalinda, on the other hand, produced significantly more fruit number /plot compared with the other two cultivars, but not significant with that for Sweet Charlie in the 2nd season. Sweet Charlie, in this respect, gave significant higher fruit number than cv Camarosa. The highest early yield was obtained by cvs Sweet Charlie and Rosalinda, with insignificance between them; but cv Camarosa, although it was considered to be more productive than the other two cultivars (Table 8), was the poorest one in that trait. Similar results were reported by Chandler *et al.* (1997, 2000).

Regarding to the effect of N-level (Table 8), nitrogen also had a significant effect on early yield and its components in the two growing seasons, except that for early yield /plot in the 1st season. Fruit weight in the two seasons was significantly higher with 100 kg N and than both 150 and 200

kgN/fed. with insignificance difference between the later two N- levels. Fruit number /plant was higher with 150 kgN, than with 200 and 100 kg N. This result indicates that the best N-level for fruit number /plant was 150 kgN, since it decreased it after (200 kgN) and before (100kgN). For total early yield, it was highest with 100 kgN or 150 kgN. It is interesting to note that N-level did not affect the total yield, as previously shown, but had considerable effect on early yield. Therefore, this result is important, since the present work, somehow, aimed and dealing with early yield.

Effect of cultivar x nitrogen interaction

The results of this portion have concerned with the effect of N-level on each cultivar separately to deduce the optimum N-level for each cultivar to achieve a considerable early yield. Camarosa cv was known to have the highest total yield (Table 9), but unfortunately had low early yield, which is very important target for local market and for exportation. Therefore, the present results will be discussed in two- ways, the first concerns the total early yield and the second concerns the two periods of early yield as suggested in this study.

Table 9. Effect of cultivars, nitrogen and their interactions on strawberry fruit weight, total early fruit number /plot and total early yield /plot (kg),

Treatments	First season (1999/2000)				Second season (2000/2001)			
	100 (kg/N)	150 (kg/N)	200 (kg/N)	LSD 0.05	100 (kg/N)	150 (kg/N)	200 (kg/N)	LSD 0.05
For Camarosa cultivar								
Fruit weight	14.29	11.83	14.72	NS	15.73	12.02	15.82	1.85
Early fruit No.	361.70	503.30	361.30	124.20	307.70	456.00	286.30	123.80
Early yield/plot(kg)	5.17	5.94	5.32	NS	4.84	5.48	4.53	0.95
Early yield/fed.(Ton)	6.03	6.93	6.22	NS	5.46	6.40	5.28	1.11
For Sweet Charlie cultivar								
Fruit weight	13.61	13.89	12.59	NS	12.48	12.56	11.47	NS
Early fruit No.	693.70	885.30	920.00	124.20	829.00	868.80	993.00	123.30
Early yield/plot(kg)	9.44	12.30	11.59	1.22	10.35	10.91	11.38	0.95
Early yield/fed.(Ton)	11.02	14.35	13.52	1.42	12.08	12.73	13.27	1.11
For Rosalinda cultivar								
Fruit weight	10.67	7.81	9.32	NS	12.64	10.03	11.28	1.85
Early fruit No.	1039.70	1178.70	943.70	124.20	985.70	1074.30	519.30	123.30
Early yield/plot(kg)	11.09	9.21	8.80	1.22	12.46	10.78	5.89	0.95
Early yield/fed.(Ton)	12.94	10.75	10.27	1.42	14.54	12.58	6.84	1.11

NS, insignificant at the 0.05 level of probability

4.2.1 Total early yield

Results in Table 8 show that average early fruit weight for cvs Camarosa and Rosalinda was not significantly affected by N-level in the 1st season, but it was affected by N-level in the 2nd one. Of both cultivars, fruit size favoured 100 kgN with insignificant difference between 100 and 200 kgN feddan. On the other hand, fruit size of Sweet Charlie was not affected by N-levels. Fruit number of the three cultivars was significantly affected by N-level in the growing seasons. In this respect, cvs Camarosa and Rosalinda gave the highest significant fruit number with 150 kgN, but Sweet Charlie favoured 200 kgN. For early yield /plot, a significant effect of N-level on early yield of the three cultivars was detected, except cv Camarosa in the 1st season. The best N-level for cv Camarosa was observed with 150 kgN, for cv Sweet Charlie was 200 kg N and for Rosalinda was 100 kg N/feddan, to get maximum early yield of each.

4.2.2 Early yield in the two early periods

The two early periods, as suggested before, were at the end of December and at the end of February.

For cv Camarosa (Table 10), results suggested that fruit size was significantly affected by N-level in

the two early periods in the two seasons and being the highest with 100 or 200 kg N /feddan. Fruit number /plot was significantly affected by N-level at the first early period, but not at the 2nd early period. However, it recorded the highest values with 150 kgN and 100 kg N in the 1st and 2nd early periods, respectively. Similar trend was also observed for early yield at the two periods. These results suggested that cv Camarosa would be fertilized with 150 kg N to get high early yield in the 1st early period and needs low input (100 kg N or less) at the 2nd early period.

For cv Sweet Charlie (Table 10), fruit weight was affected by N-level in the 2nd early period in the two growing seasons, and being highest with 100 or 150 kg N /feddan. Fruit number favoured 200 kg N in the two periods, although it was not affected by N-level in the 1st early period in the first season only. Regarding to early yield, the results show that high early yield at the two periods was achieved with 150 or 200 kg N/feddan, although it did not reach the level of significance in the second season.

For cv Rosalinda (Table 10), the results illustrate that, in the two early periods, fruit size favoured, mostly, 100 kgN / feddan. Fruit

Table 10. Effect of cultivars, nitrogen and their interactions on strawberry fruit weight, early fruit number/plot and early yield/plot (kg)

Treatments		First season (1999/2000)			LSD 0.05	Second season (2000/2001)			LSD 0.05
		100 (kg/N)	150 (kg/N)	200 (kg/N)		100 (kg/N)	150 (kg/N)	200 (kg/N)	
For Camarosa cultivar									
Fruit weight	1	13.72	10.92	13.52	1.24	15.06	10.53	14.85	1.36
	2	14.84	13.44	15.86	1.31	16.36	14.84	16.73	1.39
Early fruit No.	1	175.70	327.00	175.30	50.40	150.00	299.00	138.70	40.20
	2	186.00	176.00	186.00	NS	157.70	157.00	147.60	NS
Early yield/plot (kg)	1	2.41	3.57	2.37	1.09	2.26	3.15	2.06	1.06
	2	2.76	2.95	2.95	NS	2.58	2.33	2.47	NS
For Sweet Charlie cultivar									
Fruit weight	1	14.02	14.41	14.06	NS	12.70	12.87	12.06	NS
	2	13.24	13.47	11.48	1.31	12.29	12.31	10.47	1.39
Early fruit No.	1	327.30	399.00	396.70	NS	386.30	393.00	445.00	40.20
	2	366.30	486.30	523.30	55.90	332.70	475.30	548.00	50.50
Early yield/plot (kg)	1	4.59	5.75	5.58	1.09	4.91	5.06	5.61	NS
	2	4.85	6.55	6.01	1.19	5.44	5.85	5.79	NS
For Rosalinda cultivar									
Fruit weight	1	10.59	6.19	9.36	1.24	12.72	18.52	11.36	1.36
	2	10.73	9.56	9.29	NS	12.57	7.60	7.80	1.39
Early fruit No.	1	482.30	612.00	488.30	50.40	487.30	239.70	288.70	40.20
	2	557.30	566.70	455.30	55.90	501.30	834.70	330.70	50.50
Early yield/plot (kg)	1	5.11	3.79	4.57	1.09	6.16	4.44	3.28	1.06
	2	5.98	5.42	4.23	1.19	6.30	6.34	2.58	1.32

NS, insignificant at the 0.05 level of probability

number, in the two periods, being higher with 100 kgN although it was higher with 150 kgN in the 2nd period in both seasons, but insignificant with 100kg in the 1st season only. Moreover, early yield in the first period was high with 100 kgN, and it was also with 100 and /or 150 kg N in the second period, since there was insignificant differences between both the N-levels in the two seasons. Hochmuth *et al.* (1996) reported that nitrogen fertilization over the range of 50 to 250 kgN /ha had no significant effect on early (November to January) strawberry yield. They also stated that March was the largest production month. In addition, they found that total yield increased with increasing N fertilization from 100–150kg N/ha.

From the present results it could be concluded that the three cultivars responded differently to N- levels. These different responses might be due to the heredity differences among cultivars. It is also suggested that, to achieve high yield from each cultivar, 100 kgN being convenient for cv Camarosa and / also, it is suggested that the cultivar needs low inputs (100 kg N) or less, since the inputs beyond this level reduced its total yield. For early yield, 150 kg N proved to be the

appropriate one for the 1st early period and 100 kgN for the 2nd early period and was similar to that of total yield. Since this cultivar had vigorous plant growth, as shown from the sample taken at December, which affected the yield (early) in the 2nd early period. Therefore, in future, investigations on this cultivar would regulate its growth as well as its yield by using 150 kg N/ fed. to get high early yield by late of December and after that to use 100 kgN / fed. or less than that to increase the early yield in the 2nd period and total yield, which would be considered. For cvs Sweet Charlie and Rosalinda, results suggested that the best N-level for both the two cultivars was 200 and 100 kgN / feddan, respectively, for both early and total yield.

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استجابة بعض أصناف الفراولة للتسميد الأزوتي تحت نظام الري بالتنقيط

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أجريت هذه الدراسة خلال موسم زراعة (١٩٩٩/٢٠٠٠ و ٢٠٠٠/٢٠٠١) لدراسة استجابة ثلاثة أصناف جديدة من الفراولة وهى كما روزا، وسويت شارلى، وروز ندا، وثلاثة مستويات من التسميد الأزوتي تحت نظام الري بالتنقيط، وكانت مستويات الأزوت ١٠٠ و ١٥٠ و ٢٠٠ كجم ن للقدان. نفذ هذا العمل فى جنوب التحرير محافظة البحيرة باستخدام نظام الزراعة الحديثة بالبلاستيك.

أظهرت نتائج هذه الدراسة إختلافات معنوية بين الاصناف من حيث ، عدد التيجان ، وعدد الاوراق ، ومساحة أوراق النبات فى عينات مختلفة (نوفمبر وفبراير ومارس). كما أظهرت النتائج أيضاً إختلافات معنوية فى المادة الجافة فى الموسم الثانى و الكربوهيدرات فى الموسم الاول بين الاصناف ، ونقوى الصنف كماروزا على الصنفين الاخرين فى عدد التيجان وعدد الاوراق ومساحة أوراق النبات وأيضاً أظهر الصنف كماروزا أعلى القيم فى المادة الجافة ، والكربوهيدرات والنسبة بين الكربوهيدرات والأزوت (C/N) كذلك وجدت إختلافات معنوية بين الاصناف الثلاثة فى وزن الثمرة ، وعدد الثمار فى الوحدة التجريبية ، والمحصول المبكر، والمحصول الكلى للوحدة التجريبية ، والمحصول الكلى للقدان.

إزدادت المادة الجافة والكربوهيدرات بزيادة مستوى الأزوت . وعلى العكس من ذلك كانت نسبة الكربوهيدرات والأزوت (C/N) . أعطى مستوى الأزوت ٢٠٠ كجم /فدان أعلى قيمة لعدد كل من التيجان والأوراق للنبات وفى الاتجاه الاخر لم يكن للتسميد الأزوتي تأثيراً على المحصول الكلى، ومكونات المحصول للوحدة التجريبية وللقدان ، بينما كان تأثيره معنوياً على المحصول المبكر ومكوناته حيث أعطى التسميد الأزوتي بمعدل ١٠٠ و ١٥٠ و ١٠٠ كجم ن / فدان أعلى متوسط وزن للثمرة وعدد الثمار للنبات ، والمحصول المبكر على الترتيب وأظهرت النتائج أن مستوى الأزوت ١٠٠ كجم /فدان مناسب للصنف كماروزا لإنتاج أعلى محصول كلى و ١٥٠ كجم أزوت للقدان فى الفترة الاولى للمحصول المبكر و ١٠٠ كيلو جرام أزوت / فدان فى الفترة الثانية للمحصول المبكر ، وقد وجد أن أفضل مستوى من الأزوت للصنف سويت شارلى والصنف روز ندا ٢٠٠ كيلوجرام ، ١٠٠ كيلو جرام أزوت / فدان لكل من المحصول المبكر والمحصول الكلى على الترتيب.