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Field Performance of Three Rapeseed Genotypes (*Brassica napus* L.) Under Different Levels of Plant Density in Nineveh Governorate

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Abstract:

Two field experiments were conducted for rapeseed crop *(Brassica napus L.)* during two winter successive seasons 2018-2019, 2019-2020 at AL-Hamdanea location which is far Mosul city about (30km). Each experiment was conducted according to factorial experiment in randomized completely block design with three replications. Its included three plant population (111.110, 166.666 and 333.332 plants. hectar^{-1}) with three genotypes of rapeseed crop (Talayeh, Okapi and Rainbow).

The results could be summarized as:

The plant population of 111.110 plants. hectar^{-1} gave the highest mean for characters stem diameter, number of primary branches, number of silique/ plant, leaf area, number of seed per silique, weight of thousand seed, and oil, protein percentage in 2018-2019, 2019-2020 seasons, While the plant population of 333.332 plants. hectar^{-1} gave a high mean for plant height in both growing seasons.

The genotypes differed significantly in all the related characteristics, the Okapi genotype come over the other genotypes in plant height, stem diameter, number of branches/plant, leaf area, number of silique/plant, number of seed/silique, 1000 seeds weight (g.) seed yield (ton.ha^{-1}), oil, protein percentage of seeds and oil, protein yield (ton.ha^{-1}) in both growing seasons. The interaction between plant population and genotypes was significant in plant height in both growing seasons.

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الأداء الحقلي لثلاثة تراكيب وراثية من السلجم (*Brassica napus* L.) تحت مستويات مختلفة من الكثافة النباتية في محافظة نينوى

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ملخص البحث:

اجريت تجربتين حقليتين لمحصول السلجم (*Brassica napus L.*) لموسمي الشتاء المتعاقبين من العامين 2018–2019 و2019–2020 في موقع الحمدانية الذي يبعد حوالي (30كم) عن مدينة الموصل.

نفذت كل من التجربتين وفق نظام التجارب العاملية بتصميم القطاعات العشوائية الكاملة بثلاثة مكررات. تضمنت كل تجربة ثلاثة كثافات نباتية (111.110، 166.666 و333.332 نبات/هكتار) وثلاثة تراكيب وراثية من محصول السلجم (تاليه، عقابي ورينبو).
وتم التوصل إلى النتائج الآتية:

أعطت الكثافة النباتية الأولى (111.110 نبات/هكتار) أعلى معدل لصفات قطر الساق، عدد الأفرع/نبات، عدد الخردلات/نبات، المساحة الورقية ، عدد البذور/خردله ، وزن الألف بذرة/غم، ونسبة الزيت والبروتين للموسمين 2018–2019 و2019–2020، في حين أعطت الكثافة النباتية الثالثة (333.332 نبات/هكتار) أعلى معدل لصفة ارتفاع النبات في كلا موسمي الزراعة.

اختلفت الأصناف معنوياً في الصفات المدروسة جميعها، إذ تفوق التركيب الوراثي عقابي في صفات: ارتفاع النبات/سم،قطر الساق، عدد الأفرع/نبات، المساحة الورقية، عدد الخردلات/نبات، عدد البذور/خردله، وزن الألف بذرة/غم، حاصل البذور الكلي والزيت والبروتين (طن /هكتار) ونسبتي الزيت والبروتين في كلا موسمي الزراعة.

كان التداخل بين الكثافة النباتية والتراكيب الوراثية معنوياً لصفة ارتفاع النبات في كلا موسمي الزراعة.

Introduction:

In general, Iraq has a suitable climate for many oilseeds crops. This is not completely true in Mosul with low temperatures and short growing season, where the oilseed crops usually perform poorly except sunflower and rapeseed. Rapeseed (*Brassica napus L.*) is a new and promising oilseed crop for this region, its seed high oil content ranging from 45-60 percent (AL-Doori and Hasan, 2010). In oilseed rape, plant population varies considerably worldwide, depending on the environment, production system and genotype (Ozer, 2003). Previous studies have shown that plant population is an important factor affecting rapeseed yield. Plant population in rapeseed governs the components of yield, and thus the yield of individual plants. A uniform distribution of plants per area unit is a prerequisite for yield stability (Diepenbrock 2000 and Ozer, 2003). Under Mosul city conditions, AL-Doori and Hasan (2010) investigated the effects of different row spacing (30 - 60 cm) in rapeseed, they concluded that number of silique per plant, seed weights and dry matter per plant, weight of thousand seed and oil yield increases as row spacing increased. Leach *et al*. (1999), also reported that plants grown at high population had fewer siliques bearing branches per plant but produced more branches, and that with an increase in population, weight of thousand seed increased. The same researchers also observed that there was no effect of population on seed oil content. Rapeseed has generally slight or inconsistent seed yield responses to various row spacing. Therefore, optimum densities for each crop and each environment should be determined by local research. The present study was undertaken to assess the effect of plant population on growth, yield and quality of three rapeseed genotypes *(Brassica napus L.).*

Materials and Methods:

Two filed experiments were carried out during two winter successive seasons 2018-2019, 2019-2020 at AL-Hamdanea location which is far Mosul city about (30km) to investigate the effect of three levels of plant population (111.110, 166.666 and 333.332 plants.hectar^{-1}) on the growth, yield and quality of three rapeseed genotypes (Talayeh, Okapi and Rainbow). AL- Hamdanea is located in the east region of Mosul city at Nineveh province. Climatically, the region placed in the semiarid temperature zone cold winter and hot summer. Average rainfall is about 375 mm that most rainfall concentrated between winter and spring. Each experiment included twenty seven experimental units comprising the combinations of three plant populations and three rapeseed genotypes with three replications.

Seeds of these genotypes were obtained from the industrial crops company, Baghdad. Each plot 18 m^2 (5*3.6), included six rows 60 cm apart and five meters long and the distance between hills were 15, 10 and 5 cm apart to attain a plant population of 111.110, 166.666 and 333.332 plants per $hectar^{-1}$, respectively. Super phosphate 60 $kg.ha^{-1}$ (45%P_2O_5) and 40 $kg.ha^{-1}$ potassium (48%K_2O) were applied to the soil during the sowing period, nitrogen fertilizers was applied in the form of urea 100 $kg.ha^{-1}$ (46%N) in two equal doses, immediately after thinning (two weeks from sowing) and 15 days later.

The experimental design was factorial experiment in a Randomized Completely Block Design with three replications according to Snedecor and Cochran, 1982. Then Duncan's multiple range test (Duncan, 1955) was used to compare among means (SAS, 2001). A representative soil sample (0-30 cm depth) was taken before planting, (table 5) to determine some physical, chemical and nutritional properties using the methods description by Black, 1965, Jackson, 1973, Page *et al*., 1982 and Tandon, 1999.

Sowing dates were on the first and second of November for 2018-2019, 2019-2020 seasons, respectively. After two weeks from sowing seedlings were thinned to one plant per hill according to populations needed. The plots were weeded twice, the first one after two weeks from sowing and the second after four weeks from sowing. The external two rows were left as border. Two of the remaining rows were devoted for estimating plant growth and some characteristics. Normal cultural practices of growing rapeseed were conducted in the usual manner followed by the farmers of the district.

The studied characters were:

Sample of ten plants except guarded plants each was taken from each treatment, then the following data were record: plant height (cm): The height of the main stem from ground level to the tip of the plant, stem diameter (cm): measured by using a vernier (caliper) at the third node, number of branches/plant: was determined by counting the number of primary reproductive branches and leaf area (cm^2.plant).

At harvest, (when the color of seed coat presented in the lower zone of the terminal raceme was darkish at 142, 145, 144 and 143, 142, 141 days after sowing for each genotypes Talayeh, Okapi and Rainbow to both seasons 2018-2019, 2019-2020, respectively), ten plants except guarded plants were taken randomly from the two inner rows of each experimental plot, then the following data were measured; number of siliques per plant. Meanwhile, ten siliques were picked at random from these ten plants, and then the following characters were determined: Number of seeds per silique. The ten selected plants, mentioned above, were cut, put in an envelope and dried naturally in the lab. Their seeds were added to their respective seeds of the ten siliques in the small bags and weighed. Then weight of thousand seed (g) was estimated by counting thousand seeds at random from each plot and weighed using a sensitive balance. Oil seed content was determined using Soxhlet method (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).

Results and Discussion:

1- Effect of plant population:

In the two growing seasons, the attributes of rapeseed exhibited significant differences for the different plant population except seed yield, oil and protein yield in the two growing seasons. Data reported in table (1) indicate the effect of plant population on rapeseed attributes i.e. plant height, stem diameter, number of primary branches, leaf area (cm^2.plant), number of silique per plant, weight of 1000 seed (g) and oil, protein percentage in two seasons.

The low plant population (111.110 plants. $hectar^{-1}$) had a larger stem diameter (2.8011, 2.73444cm), higher number of primary branches (13.3611, 13.1067), number of silique per plant (190.819, 189.597), leaf area (2570.67, 2430.89cm^2.plant), Number of seeds. $silique^{-1}$(13.4989, 13.2211), weight of 1000 seed (1.99556, 1.91889g) and oil (41.1578, 41.5200), protein (21.8933, 22.0744) percentage than the high plant population (333.332 plants. $hectar^{-1}$), these results are true in the two growing seasons, respectively (table 2). This is in line with Sovero, (1993); Starner *et al*., (1996); Raymer, (2002); Lessani and Mojtahedi, (2006); Soleymani *et al*., (2011); Zhang *et al*., (2012) who attributed this result to the better soil moisture availability, decreased plant competition and increased light penetration through plant canopy at a lower plant population. These results may be attributed to the competition between plants and between the different parts of the individual plant under high planting population. In the present study, planting population exerts significant effect on plant height. The plant height was positively response with increasing plant population up to 333.332 plants. $hectar^{-1}$, these results are true in the two growing seasons. Similar results were reported by Ali *et al*.,(1990); Misra and Rana, (1992); Chauhan *et al*., (1993); Roy *et al*., (1993); Siddiqui, (1999); Yousaf and Ahmad, (2002);

Alam, (2004); Vujaković *et al*., (2014) reported that high plant population (low row spacing) had significant effect on plant height. In contrast, Kuchtova and Vasak, (2004) found that high plant population had no significant effect on plant height. Also Fathi *et al*., (2002) showed that high plant population had decreased number of silique per plant and weight of thousand seed. Increasing plant population up to 333.332 plants. hectar^{-1} decreased oil and protein percentage at the two growing seasons. Sharma, (1992) and Al-Doori and Hasan, (2010) found that high row spacing had increased oil percentage.

2- Effect of rapeseed genotypes:

The significant variations in some growth characters, yield components and some related traits were presented in table (1). Data in table (3) revealed that Okapi genotype had taller (139.0800, 139.679cm) and thicker plant (2.7178, 2.79556cm), higher number of primary branches per plant (13.0333, 12.8567), leaf area (2477.02, 2366.58cm^2.plant) than those of Talayeh and Rainbow in both seasons 2018-2019, 2019-2020, respectively. The differences among the three genotypes in the plant height may be attributed to the general varietals differences in the number of internodes per plant (Singh and Kumar, 1990; Ozer, 2003; Sana *et al*., 2003; Biabani *et al*., 2008; Kargarzadeh *et al*., 2008). Moreover, the differences in leaf area among the three genotypes may be attributed to the differences in leaves per plant. In this concern, Al-Doori and Al-Dulaimy, (2011) and Vujaković *et al*., (2015) showed that taller genotypes had more leaves and leaf primordial than the others rapeseed genotypes. This might explain the consistent differences among the tested genotypes in all growth characters that were measured in this study. It can also note that the number of silique.plant^{-1}, number of seeds per silique (13.1478, 12.9122), weight of thousand seed (2.14111, 1.92333gm), yield and oil, protein yield (ton. hectar^{-1}) of Okapi genotype outweighed Talayeh and Rainbow in a descending order at both seasons, respectively. The superiority of Okapi genotype in the dry matter production may be attributed to having the tallest and thickest plants, and as well the highest area of photosynthetic leaves and this in turn increased the capacity of dry matter accumulation in the different plant parts. However, the differences in oil, protein percent of seeds may be attributed to genetic factors and their interaction with the prevailing environmental conditions. This increase in oil, protein yield (ton.ha^{-1}) from Okapi genotype may be due to their high seed yield. hectar^{-1} (table 3) rather than differences in seed oil content. Similar conclusion were reported by Singh and Kumar, (1990); Ozer, (2003); Sana *et al*., (2003); Biabani *et al*., (2008); Kargarzadeh *et al*., (2008); AL-Doori, (2011). In this report, AL-Doori and Al-Dulaimy, (2011) reported that Emma genotype had highest plant height, number of primary branches per plant than the Topas and Monty genotypes. The superiority of Okapi genotype in the most seed characters may be due to that Okapi genotype had better vegetative growth and hence photosynthetic area which led to more carbohydrates which was translocated from the leaves and stem to the seeds (Mengel and Kirkby, 1982).

3- The interaction effect between plant population and rapeseed genotypes:

Mean values of interaction between plant population and genotypes are presented in table (4). The interaction between the studying factors showed significant effects on plant height in both growing seasons (table 1). Okapi genotype reflected the greatest response to plant population at 333.332 plants. hectar^{-1} for plant height in both growing seasons, with this regard, Hassan and El-Hakeem (1996) and Soleymani *et al*., (2011) found that high plant population produced higher plant height. The interaction between the plant population and genotypes for the other investigated traits were not statistically significant in both seasons, therefore the data were not discus. The insignificant effect between plant population and genotypes on other characteristic showed that each of these two factors acted independently on these traits.

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Table -1-
Analysis of variance for some growth characters, yield and yield components and quality in 2018-2019 and 2019-2020 seasons.

S.O.V	D.f	M.S. for 2018-2019 season											
		Plant height (cm)	stem diameter (cm)	no. of primary branches. plant^{-1}	no. of silique. Plant^{-1}	leaf area (cm^2\plant)	number of seeds.silique^{-1}	weight of 1000 seed (g)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
Replications	2	264.858337	0.581911	5.24173704	879.14814	81220.593	4.71922593	0.62167778	0.4537601	12.2820	0.10225595	15.92558	0.0339813
P	2	1918.582**	1.571144**	10.935525**	2269.74**	1536166.2**	11.3568259**	0.465344**	0.07185 $^{n.s.}$	13.67**	0.00702 $^{n.s.}$	19.016**	0.00175 $^{n.s.}$
G	2	697.2608**	0.848533**	5.9712925**	1047.73**	323771.37**	4.62311481**	0.929477**	0.68244**	45.99**	0.170157**	40.610**	0.05977**
P × G	4	11.23439*	0.135611 $^{n.s.}$	0.240392 $^{n.s.}$	89.7234 $^{n.s.}$	11310.990 $^{n.s.}$	0.81598704 $^{n.s.}$	0.015555 $^{n.s.}$	0.02395 $^{n.s.}$	0.916 $^{n.s.}$	0.00393 $^{n.s.}$	0.372 $^{n.s.}$	0.00126 $^{n.s.}$
Error	16	3.226562	0.113461	1.1817037	39.85648	8819.259	0.42026759	0.0356361	0.0510724	0.7222	0.0111143	0.56460	0.0031219
Total	26												
S.O.V	D.f	M.S. for 2019-2020 season											
Replications	2	356.509259	0.30472593	2.87477037	898.25925	80829.778	2.75080370	0.20738148	1.5382032	8.96258	0.28459074	17.36351	0.0881139
P	2	1524.451**	0.926825**	12.242492**	1865.04**	957588.2**	11.3421592**	0.411125**	0.07681 $^{n.s.}$	25.72**	0.002577$^{n.s.}$	21.570**	0.00016 $^{n.s.}$
G	2	555.5480**	1.241348**	7.3529592**	1096.05**	309737.75**	4.97218148**	0.410859**	0.33257**	43.16**	0.099346**	26.959**	0.03376**
P × G	4	16.31110**	0.015048 $^{n.s.}$	0.269375 $^{n.s.}$	55.8379 $^{n.s.}$	2765.448 $^{n.s.}$	0.59250370 $^{n.s.}$	0.011209 $^{n.s.}$	0.00203 $^{n.s.}$	0.449 $^{n.s.}$	0.000489$^{n.s.}$	0.3947 $^{n.s.}$	0.00009 $^{n.s.}$
Error	16	30.738426	0.02749259	0.99370370	66.425926	21098.111	0.43700370	0.01113565	0.0261878	1.09146	0.00516567	0.295144	0.0014056
Total	26												

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

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

seasons	plant population (plants.ha^{-1})	Plant height (cm)	stem diameter (cm)	no. of primary branches. Plant^{-1}	no. of silique. Plant^{-1}	leaf area (cm^2\plant)	Number of seeds. silique^{-1}	weight of 1000 seed (g)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
2018-2019	111.110	117.176c	2.8011a	13.3611a	190.819a	2570.67a	13.4989a	1.99556a	0.9713	41.1578a	0.4062	21.8933a	0.21876
	166.666	126.335b	2.3733b	12.2367b	170.948b	2483.88a	12.2556b	1.78333b	1.1433	39.6933b	0.4617	20.3122b	0.23908
	333.332	145.768a	1.9656c	11.1567b	159.426c	1815.65b	11.2567c	1.54111c	1.0993	38.7078c	0.4289	18.9900c	0.21233
2019-2020	111.110	119.802c	2.73444a	13.1067a	189.597a	2430.89a	13.2211a	1.91889a	1.08632	41.5200a	0.45748	22.0744a	0.24613
	83333	128.113b	2.35333b	11.9033b	171.837b	2297.66a	12.0200b	1.65000b	1.15233	39.6922b	0.46269	20.2689b	0.23848
	166666	145.320a	2.09667c	10.7744c	161.092c	1811.21b	10.9778c	1.49667c	1.26878	38.1422c	0.48905	18.9933c	0.24558

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

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

seasons	genotypes	Plant height (cm)	stem diameter (cm)	no. of primary branches. Plant^{-1}	no. of silique. Plant^{-1}	leaf area (cm^2\plant)	Number of seeds. silique^{-1}	weight of 1000 seed (g)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
2018-2019	Talayeh	128.6122b	2.3044b	12.3133ab	174.491b	2295.38b	12.0756b	1.63222b	0.8757b	39.2444b	0.34436b	19.8000b	0.17463b
	Okapi	139.0800a	2.7178a	13.0333a	184.120a	2477.02a	13.1478a	2.14111a	1.3862a	42.3556a	0.59078a	22.7578a	0.31748a
	Rainbow	121.5889c	2.1178b	11.4078b	162.581c	2097.79c	11.7878b	1.54667b	0.9521b	37.9589c	0.36185b	18.6378c	0.17806b
2019-2020	Talayeh	129.279b	2.32667b	11.8767ab	172.047b	2177.60b	11.8089b	1.63667b	1.05743b	39.0400b	0.41318b	19.9000b	0.21339b
	Okapi	139.679a	2.79556a	12.8567a	186.120a	2366.58a	12.9122a	1.92333a	1.39111a	42.2500a	0.59096a	22.3833a	0.31387a
	Rainbow	124.278b	2.06222c	11.0511b	164.359b	1995.57c	11.4978b	1.50556c	1.05889b	38.0644b	0.40506b	19.0533c	0.20293b

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

Table -4-Effect of interaction between genotypes and plant population on some growth characters, yield and yield components and quality in 2018-2019 and 2019-2020 seasons respectively.

plant population (plants.ha^{-1})	genotypes	Plant height (cm)	stem diameter (cm)	no. of primary branches. Plant^{-1}	no. of silique. Plant^{-1}	leaf area (cm^2\plant)	number of seeds.silique^{-1}	weight of 1000 seed (g)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
2018-2019 season													
111.110	Talayeh	116.600e	2.7100	13.2033	188.077	2602.67	12.9400	1.8833	0.8513	40.2400	0.34428	21.4200	0.18546
	Okapi	126.963d	2.9800	14.4700	207.303	2803.33	14.8567	2.4133	1.1920	44.0133	0.52982	24.3967	0.29554
	Rainbow	107.967f	2.7133	12.4100	177.077	2306.00	12.7000	1.6900	0.8707	39.2200	0.34456	19.8633	0.17530
166.666	Talayeh	124.087d	2.4400	12.4167	174.967	2506.70	12.1000	1.6733	0.8690	38.8300	0.33811	19.3267	0.16915
	Okapi	137.453c	2.6200	12.9833	180.210	2626.20	13.1333	2.0967	1.5593	41.9133	0.66268	22.6967	0.35760
	Rainbow	117.467e	2.0600	11.3100	157.667	2318.73	11.5333	1.5800	1.0017	38.3367	0.38455	18.9133	0.19049
333.332	Talayeh	145.150b	1.7633	11.3200	160.430	1776.77	11.1867	1.3400	0.9067	38.6633	0.35070	18.6533	0.16929
	Okapi	152.823a	2.5533	11.6467	164.847	2001.53	11.4533	1.9133	1.4073	41.1400	0.57984	21.1800	0.29929
	Rainbow	139.333c	1.5800	10.5033	153.000	1668.65	11.1300	1.3700	0.9840	36.3200	0.35644	17.1367	0.16840
2019-2020 season													
111.110	Talayeh	118.600ef	2.7100	13.0500	184.743	2412.7	12.5733	1.86333	1.0046	40.9600	0.41509	21.5867	0.22165
	Okapi	129.640cd	3.0467	14.2600	206.970	2634.0	14.3233	2.21333	1.3020	43.8467	0.57361	23.8400	0.31477
	Rainbow	111.167f	2.4467	12.0100	177.077	2246.0	12.7667	1.68000	0.9523	39.7533	0.38374	20.7967	0.20195
166.666	Talayeh	126.087de	2.2467	11.9367	170.967	2333.4	12.1333	1.64000	1.0300	38.7300	0.39899	19.3267	0.20266
	Okapi	137.920bc	2.7867	12.8967	182.543	2454.2	12.9267	1.83000	1.3653	41.9467	0.57961	22.3633	0.30887
	Rainbow	120.333def	2.0267	10.8767	162.000	2105.4	11.0000	1.48000	1.0617	38.4000	0.40945	19.1167	0.20392
333.332	Talayeh	143.150ab	2.0233	10.6433	160.430	1786.8	10.7200	1.40667	1.1377	37.4300	0.42547	18.7867	0.21588
	Okapi	151.477a	2.5533	11.4133	168.847	2011.5	11.4867	1.72667	1.5060	40.9567	0.61967	20.9467	0.31796
	Rainbow	141.333b	1.7133	10.2667	154.000	1635.3	10.7267	1.35667	1.1627	36.0400	0.42201	17.2467	0.20291

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

Table -5-
The physical and chemical characters of soil filed experiments in both seasons.

seasons	2018-2019	2019-2020
physical characters		
Sand (%)	27.00	22.00
Silt (%)	33.00	35.00
Clay (%)	40.00	43.00
Texture	Clay Loom	Clay Loom
Chemical characters		
O.M. ($g.kg^{-1}$)	10.23	11.54
Available N (ppm)	46.72	40.17
Available P (ppm)	10.12	12.66
Available K (ppm)	162.00	144.00
Total $CaCo_3$ ($g.kg^{-1}$)	8.44	9.22
pH	7.40	7.20
E.C. mmhos/cm	0.86	0.62

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