ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 4 (3): 225-229, 2005
ISSN 1812-5379

Effect of Plant Density and Nitrogen Application on the Growth, Yield and Quality of Radish (*Raphanus sativus* L.)

M. El-Desuki, S.R. Salman, M.A. El-Nemr and A.M.R. Abdel-Mawgoud
Department of Vegetable Research, National Research Center, Cairo, Egypt

Abstract: A field trial was carried out in 2002 and 2003 growth seasons on radish (*Raphanus sativus* L.) cultivar White Icicle to investigate the interactive effect of different plant densities and N fertiliser rates on yield and quality attributes. Plants were spaced at two (10 and 20 cm) inter-row and two (5 or 10 cm) intra-row distances (plants thinned when leaves were 5-8 cm tall) and received N fertiliser (ammonium sulfat) at rates of 40, 60 and 80 kg fed^{-1}. One-half of the N dose was applied before sowing while the remaining N was applied as a top-dressing 15 days after sowing. The roots were harvested 35 days after sowing. Data are tabulated on yield, DM, N content in leaves and root TSS. Yield, root TSS and dry matter content recorded the highest values with the highest rate of N application. Decreasing plant density significantly reduced the total yield but markedly enhanced root quality. It was concluded that the reduction in yield due to lower plant density can be compensated by the higher prices of high quality roots.

Key words: Radish, *Raphanus sativus* L., cultivar White Icicle, plant density, nitrogen, yield, quality

INTRODUCTION

Radish is a cool-season, fast-maturing, easy-to-grow vegetable. The effect of density on the growth and yield has been discussed in literature[1,2]. Increasing plant spacings, increased yield per plant; however, the highest yield ha^{-1} was obtained at the closest plant spacing[1]. Inter-row spacings did not affect root and shoot yield, as well as the root/shoot yield ratio of radish[3]. On the other hand, the larger intra-row spacing increased root yield and reduced total shoot yield, resulting in a higher root/shoot ratio, compared with the low intra-row spacing[3]. Yield per plant decreased by 2.3% when plant density increased by 33%[4]. Moreover, root length and average root weight decreased with increasing plant density. On the contrary, root length increased as plant denisty increased[5]. The latter added that root quality parameters i.e. root diameter, fresh weight, dry weight, leaf area ratio, net assimilation rate, reducing sugar, non-reducing sugar and total sugar content of the radish roots decreased as plant density increased.

Effect of plant spacing on growth parameters may be due to competition of plants for available nutrients such as nitrogen. Therefore different N application rates must be tested with different plant spacing. Vegetative growth i.e plant height; number of primary, secondary and tertiary branches/plant and diameter of the main shoot was positively affected due to increasing N application rate up to 150 kg N ha^{-1}[6]. Increasing N application also increased significantly leaf length, root length, root diameter and root weight[2,7]. Moreover, increasing NPK rate for radish had marked increases in leaf area, Leaf Area Index (LAI), Leaf Area Duration (LAD) and root yield[8]. The yield increase was mainly due to increases in root weight and length and diameter of the roots.

The effect of N on radish yield has been studied earlier[9-14]. They found that the highest yield was obtained with the highest N rate. Root quality in terms of root TSS content was highest at the highest N rates while root ascorbic acid content was highest at the lowest N[15].

A significant increase in root N content in relation to N application has been reported[11,16]. More recently, nitrogen accumulation was found to be more in leaves than in roots and was highest in roots with the highest N application[17,18].

Different interactions between plant density and N application were reported. While the optimum yield was obtained with the plants spaced 5 cm apart, in rows 10 cm apart, combined with applications of N at rate of 45 kg ha^{-1}[19], maximum plant height and root yield were obtained with N at 200 kg ha^{-1} and 10 cm spacing, followed by 200 kg N ha^{-1} and 15 cm spacing[20].

The aim of this study is to investigate the interactive effect of plant density and N application rate on root yield and quality of radish crop.

MATERIALS AND METHODS

Two field experiments were conducted on radish (*Raphanus sativus* L.) during the last week of November of 2002 and 2003 at the Experimental Station

Corresponding Author: Dr. M. El-Desuki, Department of Vegetable Research, National Research Center, Cairo, Egypt
Tel: +202 336 8493

Table 1: Soil analysis of experimental plots in the farm of NRC

	Mechanical analysis (%)							OM%	
Depth of soil	Coarse sand	Fine sand	Silt	Clay	Texture	pH	EC (dS m^{-1})	$CaCo_3$%	(meq L^{-1})
0-40 cm	2.82	21.14	27.5	48.3	Clay	7.7	2.36	1.65	1.86

	Cations			Anions (meq L^{-1})		
	Total N	Available P	Available K			
Depth of soil	mg/100 g soil			CO_3^-	CL^-	SO_4^-
0-40 cm	151.82	4.82	0.58	5.13	1.65	95.4

of National Research Center in Shalkan, Qalubia Governorat, Egypt. The physical and chemical analysis of the soil is shown in Table 1.

Seeds were sown in the soil at 0.5 cm deep. After emergence, plants were thinned according to the experimental treatments when plant leaves were 5-8 cm tall.

Inter-row spacing treatments were 10 and 20 cm; Intera-row spacing treatments 5 and 10 cm and Nitrogen treatments (as ammonium sulfat) 40, 60 and 80 kg N/fed.

The treatments were arranged in split-split plot design with three replicates where inter-row spacing is the main plot, in-row spacing as the sub-plot and the N application rate as the sub-sub-plot. Experimental plot was 3.0x3.0 m for each plot. Standard agricultural practices for radish production other than experimental treatments were carried out according to the recommendation of the ministry of agriculture in Egypt.

Root yield was hand-harvested 35 days after planting. The plants (roots and leaves) were harvested and packed in cartons in the field.

Plant height, number of leaves, fresh and dry weights of plant, dry matter content of the leaves and total root yield of each plot were measured at harvest. Root quality i.e., root length (cm), root diameter (cm), root fresh and dry weights (g/root), TSS and dry matter content were also determined. Yield was calculated as ton fed^{-1} (feddan =4200 m^2).

Chemical constituents: The leaves and roots were washed in tap water containing a small amount of detergent. After excess water was allowed to drain away, they were placed in paper towels to remove additional moisture and oven dried at 70°C. The dry samples of leaves were grounded and then 0.2 g of each was digested and then used for N determination. Total nitrogen was determined as percentage using microkjeldahl apparatus[21].

Data of the experiment were subjected to statistical Analysis of Variance (ANOVA)[22].

RESULTS

Effect of nitrogen on plant height was significant and positive. The response was higher when N application increased from 40 to 60 kg compared to the increment from 60 to 80 kg N. Plant spacing both inter and intra- row had a positive effect on plant height (Table 2). The interaction showed the same positive effect on plant height. The highest effect was recorded with plant spacing of 10 cm between row and plants (Table 3).

The individual effect of nitrogen on number of leaves was not significantly different. Meanwhile, plant inter and intra-row spacings showed a significant positive effects on number of leaves per plant (Table 2). The effect of interaction was not significant for all treatments (Table 3).

Leaf fresh weight per plant was significantly affected by nitrogen treatments. In the same time, both inter and intra-row spacing showed the positive effect on this parameter (Table 2). The interaction showed significant positive effects on fresh weight of leaves compared to control. The highest effects were observed for all combinations under 20 cm inter-row spacing (Table 3).

The same trend of N effect was observed in leaf dry weight per plant. The same observed positive trends of inter and intra-row spacing were also noted on leaf dry weight (Table 2). Also the interaction was exactly comparable to that observed on leaf fresh weight (Table 3).

Leaf dry matter content was positively affected by all treatments either their individual effects or by their interactions (Table 2). The interaction effect was the clearest in the combination treatments under 20 cm intra-row spacing (Table 3).

Root yield was positively related to the rate of nitrogen application and the differences were significant at 5% level. However, both inter and intra-row spacing had
a significant negative effect on total root yield production (kg/fed) (Table 2). The interaction showed that only the highest two nitrogen treatments under the lowest inter and intra-row spacing showed the highest recorded root

Table 2: Individual effects of inter, intra-row spacings and N fertilization rates on different growth, yield and quality aspects of radish crop

	Vegetative growth						Root quality						
Treatments (cm)	Plant heights cm	Leaf No.	Fresh leaf weight (g/plant)	Dry leaf weight (g/plant)	Leaf dry matter (%)	Total Yield (t/fed)	Avg. root length (cm) (cm)	Avg. root diameter (cm)	Avg.F. root weight (g/fruit)	Avg.D. root weight (g/fruit)	Dry matter (%)	TSS (%)	Total nitrogen (%)
1st season													
10	29.57	7.54	38.30	2.90	7.57	11.96	17.11	1.70	23.24	1.77	7.56	5.15	3.52
20	32.27	10.37	56.04	4.87	8.69	8.85	13.91	2.65	32.35	2.66	8.20	6.59	4.57
LSD 5%	2.20	0.59	1.10	0.98	0.52	1.45	0.75	0.67	7.08	0.63	0.32	0.31	0.52
2nd season													
10	25.06	6.43	33.42	2.42	7.26	10.55	14.60	1.40	19.35	1.47	7.53	4.77	3.13
20	26.98	8.98	49.23	4.12	2.29	7.77	11.59	2.30	27.33	2.20	7.99	6.06	4.05
LSD 5%	1.67	1.06	0.97	0.45	0.51	0.63	2.51	0.45	0.10	0.09	0.23	0.28	0.46
1st season													
5	30.14	8.32	42.00	3.33	7.94	12.24	16.59	1.84	24.35	1.88	7.66	5.50	3.74
10	31.70	9.59	52.34	4.43	8.47	8.57	14.43	2.51	31.25	2.55	8.10	6.25	4.35
LSD 5%	1.35	0.34	3.60	0.63	0.29	1.85	2.09	0.53	6.23	0.53	0.26	0.20	0.31
2nd season													
5	25.34	7.14	36.54	2.77	7.56	10.89	14.12	1.55	20.11	1.52	7.54	5.09	3.32
10	26.70	8.27	46.11	3.77	7.99	7.43	12.08	2.15	26.57	2.14	7.99	5.74	3.87
LSD 5%	1.10	0.28	3.25	0.54	0.32	0.56	1.32	0.35	0.45	0.21	0.24	0.38	0.27
1st season													
40	28.82	8.18	44.01	3.49	7.93	9.86	14.65	1.99	26.85	1.96	7.32	5.63	3.66
60	31.50	9.03	47.56	3.86	8.11	10.34	15.53	2.17	28.03	2.16	7.68	5.89	4.09
80	32.44	9.66	49.94	4.31	8.62	11.02	16.35	2.36	28.50	2.52	8.72	6.09	4.39
LSD 5%	0.83	0.44	0.81	0.07	0.06	0.13	0.13	0.03	0.18	0.05	0.14	0.19	0.06
2nd season													
40	24.43	7.18	38.46	2.94	7.59	8.52	12.28	1.80	22.99	1.67	7.29	5.24	3.28
60	26.18	7.72	41.92	3.28	7.70	9.29	13.20	1.82	23.35	1.81	7.71	5.47	3.65
80	27.45	8.23	43.60	3.59	8.02	9.67	13.81	1.92	23.68	2.01	8.29	5.53	3.85
LSD 5%	0.59	0.31	0.68	0.21	0.07	0.27	0.52	0.07	0.12	0.06	0.13	0.14	0.05

Table 3: Interactive effects of inter and intra-row spacings with different N fertilization rates on different growth, yield and quality aspects of radish crop

		Vegetative growth						Root quality						
Inter/Intra spacing (cm)	Nitrogen rate (kg N.fd)	Plant heights cm	Leaf No.	Fresh leaf weight (g/plant)	Dry leaf weight (g/plant)	Leaf dry matter (%)	Total Yield (t/fed)	Avg. root length (cm) (cm)	Avg. root diameter (cm)	Avg.F. root weight (g/fruit)	Avg.D. root weight (g/fruit)	Dry matter (%)	TSS (%)	Total nitrogen (%)
1st season														
10/5	40	24.33	6.52	30.77	2.30	7.48	12.43	17.97	1.36	20.18	1.36	6.75	4.49	2.89
	60	31.17	7.10	36.70	2.71	7.39	14.35	18.55	1.60	20.80	1.48	7.10	4.73	3.02
	80	31.40	7.81	38.44	2.99	7.78	15.54	20.11	1.70	20.91	1.61	7.72	4.79	3.68
10/10	40	27.89	6.91	39.91	2.85	7.15	9.71	14.80	1.73	25.15	1.74	6.92	5.29	3.61
	60	30.08	8.15	41.35	3.12	7.54	9.73	15.02	1.82	25.91	1.99	7.66	5.66	3.91
	80	32.53	8.77	42.64	3.44	8.06	10.00	16.23	1.97	26.50	2.44	9.20	5.97	4.01
20/5	40	30.23	8.82	47.35	3.76	7.94	10.10	12.97	1.97	27.86	2.14	7.69	6.09	3.88
	60	31.29	9.53	48.46	3.96	8.18	10.24	14.87	2.04	28.05	2.32	8.26	6.32	4.35
	80	32.41	10.15	50.28	4.28	8.51	10.79	15.07	2.35	28.28	2.39	8.45	6.56	4.60
20/10	40	32.83	10.46	58.03	5.05	8.71	7.21	12.87	2.88	34.21	2.59	7.58	6.65	4.25
	60	33.44	11.35	63.72	5.64	8.84	7.05	13.68	3.22	37.37	2.88	7.70	6.86	5.08
	80	33.41	11.91	68.41	6.51	9.52	7.73	14.01	3.43	38.33	3.65	9.53	7.06	5.26
LSD 5%		1.66	NS	1.62	15.00	0.12	0.27	0.26	0.06	0.37	0.10	0.28	NS	0.13
2nd Season														
10/5	40	20.80	5.67	26.67	2.06	7.71	10.52	15.53	1.30	16.90	1.33	7.87	4.25	2.60
	60	26.25	6.00	32.49	2.26	6.96	13.06	16.21	1.25	17.50	1.23	7.03	4.38	2.80
	80	27.00	6.50	33.25	2.38	7.16	13.83	17.20	1.25	16.95	1.15	6.78	4.40	3.20
10/10	40	23.80	6.07	34.88	2.38	6.81	8.44	12.33	1.50	21.10	1.45	6.87	4.90	3.20
	60	24.82	7.00	36.17	2.68	7.41	8.66	12.52	1.47	21.65	1.71	7.90	5.30	3.40
	80	27.67	7.33	37.08	2.78	7.50	8.80	13.80	1.60	22.00	1.92	8.73	5.40	3.60
20/5	40	25.47	7.67	41.23	3.13	7.60	9.15	10.25	1.80	24.05	1.73	7.19	5.70	3.40
	60	25.80	8.00	42.14	3.33	7.90	9.35	12.67	1.77	22.54	1.82	8.07	5.85	3.90
	80	26.73	9.00	43.43	3.48	8.02	9.42	12.83	1.90	22.73	1.88	8.27	5.95	4.00
20/10	40	27.63	9.30	51.04	4.21	8.25	5.98	11.00	2.60	29.90	2.16	7.22	6.10	3.90
	60	27.87	9.87	56.86	4.86	8.55	6.10	11.40	2.80	31.70	2.48	7.82	6.35	4.50
	80	28.40	10.07	60.64	5.71	9.41	6.61	11.40	2.93	33.05	3.10	9.38	6.38	4.60
LSD 5%		1.19	NS	1.35	0.42	0.14	0.54	NS	0.03	0.23	NS	0.27	NS	0.10

yield compared to control (Table 3). All other treatment combinations were significantly lower than control with the lowest yield recorded in treatments under the highest inter and intra-row spacing (Table 3).

Root quality: Individual effects of nitrogen, inter and intra-row spacing treatments resulted in significant positive differences in root length (Table 2). The interactive effects were significantly different under all treatment combinations with the longest root length recorded under the highest plant spacing and N rate (Table 3).

Nitrogen treatments affected root diameter significantly. Similarly, both inter and intra-row spacing increased root diameter significantly (Table 2). The interaction of treatments showed positive effects on root diameter with the highest effect observed with the highest plant spacing and N rate (Table 3).

The same trend observed on root diameter was also recorded on average root fresh weight.

Average root dry weight responded positively and significantly to individual nitrogen and inter and intra-row spacing treatments (Table 2). Average root dry weight increased significantly in response to the interactive effects of all treatments (Table 3).

Individual effects of the treatments on dry matter content of the roots showed that there were positive and significant relationships between that parameter and all individual experimental factors (Table 2). However, the interactive effects did not show a clear trend on that parameter (Table 3).

Nitrogen treatments affected Total Soluble Solids (TSS) slightly but significantly positive. Plant inter and intra-row spacing also increased significantly TSS with the clearest effect observed by inter-row spacing (Table 2). TSS showed a positive response to all interactive effects of treatments however these differences were not significant (Table 3).

Mineral content: As expected, all individual treatments increased total nitrogen content in the leaves. Differences in N content were significant compared to control (Table 2). The interactive effects were very clear and positive. The highest N content in the leaves were recorded in treatments with the highest two N rates under the highest plant spacing (Table 3).

DISCUSSION

Radish yield is greatly affected by plant density and nitrogen application. The observed positive effects in this study of increasing plant spacing and nitrogen dose on vegetative growth had been reported previously[2,6,7]. Positive effects of increasing N application rate on vegetative growth was reported earlier[9-14,20]. They found that root length, root diameter and root weight all increased significantly as N fertiliser application rate increased. The highest N rate was superior with respect to growth in terms of number of leaves/plant and leaf length[2,6,7]. Increasing number of leaves and plant height observed in this study may result in a higher leaf area hence, increasing assimilation rate resulting in higher growth. This explanation can be supported by the findings of Sirkar *et al.*[5] who found that root diameter, fresh weight, dry weight, leaf area ratio, net assimilation rate, reducing sugar, non-reducing sugar and total sugar content of the radish roots decreased as plant density increased which may be due to competition for nutrients including nitrogen. The same explanation can be used for yield increment in response to increasing plant density and nitrogen application. Increment in total yield production due to increasing plant density may be brought about by the higher ground cover by leaf area which resulted in higher light interception hence higher assimilate production. The positive effect of different plant spacing and increasing nitrogen dose on yield had been reported by Lee and Leong[1] who mentioned that the highest yield ha^{-1} was obtained at the closest plant spacing. However, individual root weight was found to be decreased with increasing plant density[4].

Concerning the interaction between plant spacing and increasing nitrogen dose, the obtained results of this study agree with Pervez *et al.*[20] who reported that increasing N to 200 kg ha^{-1} and increasing spacing from 5 to 10 cm led to maximum plant height while, the maximum root length was obtained with 200 kg N ha^{-1} + 5 cm spacing.

Root quality in termes of TSS was positively affected by nitrogen application and the same results was reported in the litreture[15,19]. This increment may be brought about by more assimilates produced by the higher number of leaves recorded in this study as well as the larger observed roots which means higher absorbing surface area. Similarly N content in the leaves increased as N application increased. Nitrogen accumulation in radish leaves was found to increase with increasing N application rate[17].

It could be concluded that lowering plant density increases radish root quality in terms of average root weight and dry matter content. In addition increasing N dose application can enhance these effects. Although these practices (low plant density) may result in lower root yield per area, the increment in root quality (which means higher price) may compensate for this reduction.

REFERENCES

1. Lee, S.K. and P.C. Leong, 1981. Plant density and fertiliser studies on the Chinese radish *Raphanus sativus* L. (Longipinnatus group). Singapore J. Primary Indu., 9: 63-73.
2. Bhople, S.R., S.G. Bharad, V.N. Dod and S.V. Gholap, 1998. Effect of nitrogen and phosphorus on growth and yield of radish (*Raphanus sativus* L.) cv. Pusa Chetki. Orissa J. Hortic., 26: 34-36.
3. Minami, K., A. Cardoso, F. Costa and F.R. Duarte, 1998. Effect of spacing on radish yield. Bragantia., 57: 169-173.
4. Liu, Z.T., G.P. Li and Y.P. Pan, 1998. Effect of height and density of ridges on yield and quality of radish. Jiangsu Agric. Sci., 1: 52-53.
5. Sirkar, B., A. Saha and T.K. Bose, 1998. Effect of plant density on growth and yield of radish. J. Interacademicia., 2: 17-20.
6. Sharma, S.K. and G. Lal, 1991. Effect of nitrogen fertilization, plant spacing and steckling size on certain morphological characters and seed yield in radish (*Raphanus sativus* L.). Vegetable Sci., 18: 82-87.
7. Hussain, I., I. Haq, M. Sajid and A. Rehman, 1997. Effect of nitrogen alone and in combination with constant doses of phosphorus and potassium on yield of radish. Sarhad J. Agric., 13: 39-43.
8. Parthasarathi, A., K.S. Krishnappa, M.C. Gowda, N.S. Reddy and M. Anjanappa, 1999. Growth and yield of certain radish varieties to varying levels of fertility. Karnataka J. Agric. Sci., 12: 1-4.
9. Ghanti, P., G. Sounda and S. Ghatak, 1989. Effect of levels of nitrogen and soil moisture regimes on growth and yield of radish. Environ. Ecol., 7: 957-959.
10. Srinivas, K. and L.B. Naik, 1990. Growth and yield of radish (*Raphanus sativus* L.) in relation to nitrogen and potash fertilization. Indian J. Hortic., 47: 114-119.
11. Singh, V.B., P.L. Kar and T. Tatung, 1995. Effect of nitrogen and phosphorus on growth, yield and nutrient uptake of radish cv. Meghalaya selection. Adv. Hortic. For., 4: 127-132.
12. Gill, S.S., B.S. Gill, S.P.S. Brar and B. Singh, 1996. Nitrogen and phosphorus requirement of radish seed crop. Seed Res., 23: 47-49.
13. Jadhao, B.J., L.V. Kulwal and K.G. Mahakal, 1999. Effect of nitrogen, phosphorus and potassium on growth and seed yield of radish (*Raphanus sativus* L.). Vegetable Sci., 26: 95-96.
14. Prabhakara, B.S. and P.R. Ramachander, 1999. Response surfaces of radish for NPK fertilization. South Ind. Hortic., 47: 240-241.
15. Joshi, P.C. and N.S. Patil, 1988. Effect of plant density, nitrogen and phosphorus on TSS and ascorbic acid content of radish *Raphanus sativus* (L.). South Ind. Hortic., 36: 331-332.
16. Djurovka, M., V. Markovic, Z. Ilin, S. Jevtic (Eds.) and B. Lazic, 1997. The effect of nitrogen fertiliser on the dry matter content and mineral elements in radish. Acta Hortic., pp: 462.
17. Parthasarathi, and K.S. Krishnappa, 2000. Accumulation of primary nutrients in radish varieties as influenced by varying fertility levels. Current Res. Univ. Agric. Sci., Bangalore., 29: 1-2.
18. Gonge, V.S., M.S. Bhole, D.T. Deshmukh, A. D.Warade and V.S. Kale, 2003. Effect of plant density and nitrogen levels on seed yield and quality of radish (*Raphanus sativus* L.) var. Pusa Chetki. Orissa J. Hortic., 31: 82-84.
19. Joshi, P.C. and N.S. Patil, 1992. Note on effect of plant denisty, nitrogen and phosphorus on yield of radish. Ind. J. Hortic., 49: 265-266.
20. Pervez, M.A., C.M. Ayub, B.A. Saleem, N.A. Virk and N. Mahmood, 2004. Effect of nitrogen levels and spacing on growth and yield of radish (*Raphanus sativus* L.). Intl. J. Agric. Biol., 6: 504-506.
21. Black, C.A., 1965. Methods of Soil Analysis. Part 2 Am. Soc. Agron., INC., Publisher, Madison, Wisconsin, USA.
22. Snedicor, G.W. and W.G. Cochran, 1980. Statistical Method. 7th Edn. Iowa State University Press. Am. Iowa, USA., pp: 507.