NITROGEN AND SOWING METHOD AFFECT RADISH GROWTH AND YIELD UNDER ARID ENVIRONMENTS OF PAKISTAN

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ABSTRACT: *The optimization of nitrogen (N) fertilizer application and planting method for root crops such as radish (Raphanus sativus L.) is the important for root yield. Therefore, the study was carried out to optimize N dose and sowing method under arid environment. A field experiment was conducted at College of Agriculture Dera Ghazi Khan. A radish cultivar Mino Early White was sown on February 3, 2009. Two sowing methods S_1 and S_2 (ridge and flat, respectively) were kept in main plots while five N rates N_1, N_2, N_3, N_4 and N_5 (0, 50, 100, 150 and 200 kg ha^{-1}, respectively) were subjected in sub plots. Therefore a split plot design was used having three replications. The results showed that between sowing method, in ridge sowing crop achieved the maximum growth and resulted in the highest yield. The application of 200 kg N ha^{-1} gave the maximum germination (71.3%), number of leaves per plant (14), leaves fresh and dry weight (168.8 g and 23.1g, respectively), root length (27.7 cm), root fresh and dry weight per plant (196.3 g 18.18 g, respectively) root yield (19.12 t ha^{-1}). Similarly, the maximum (75.6 kg root yield kg^{-1} N) and nitrogen use efficiency was achieved by application of 200 kg N ha^{-1}. The treatment N_4 gave the maximum ($ 1139 ha^{-1}) net benefit in economic analysis. Therefore, in the arid environment of Pakistan, ridge sowing with 150 kg N ha^{-1} gave the optimum production of radish tested in this experiment.*

Keywords: Economic analysis, nitrogen, radish, sowing methods.

INTRODUCTION

Radish is originated in China and Indo-Pak. Radish of the Niger variety was an imperative food in Egypt probably as early as 2700 B.C. In the tropics radish is grown from sea level to a height of at least 1800 m. In India it is grown as high as 2700 m in the Himalayas, while Var. oleifera has been found suitable for high mountain areas (2500- 3000 m) in the Yunan Province of China. Edible part of radish is root. Along with its culinary uses, radish has several medicinal importances. Radish is a rich source of minerals and vitamin A and C. Average composition of the edible portion has been reported as: energy 86.7 kJ100^{-1} g, water 93.5%, fiber 0.7%, and protein 1.05% [1].

World production of radish roots is estimated at 7 million tons per year, about 2% of the total world production of vegetables. Average yield per hectare in Punjab is 18.87 tones [2] compared to world's average yield 15-20 tones per hectare [3]. In Pakistan especially in Punjab province, it is grown on an area of 6061 ha with the total production of 113163 t, having average yield ha^{-1} 18.67 t [4].

Enhancement in crop yield is the ultimate objective in the horticultural research. The radish being cultivated in Pakistan is low in yield and quality, thus lowering production income. The best quality and high yield is dependent on appropriate cultural practices, adequate fertilizers, soil type, sowing method, irrigation etc. Nitrogen promotes the growth and yield of radish [5] with optimum application rates being about 100 kg N ha^{-1}. At higher rate of N, such as 200 kg N ha^{-1}, improved root size and yield, but high rate of N (particularly NO_3^-) caused accumulation of N in crop root [6, 7] which may be considered harmful for human consumption. It was observed that 50% of the N applied as fertilizer to plant may not be taken up by the plants and this can result in leaching of nitrate into underground water [8]. An excessive amount of N fertilizer may inhibit the growth and yield of radish [9]. Therefore, optimum N application to vegetable crops such as radish it may be both cost-effective and beneficial for the environment. So, proper application of N and sowing method are the most important for crop productivity, human health and soil environment.

Nitrogen is quite important plant nutrient for increasing plant growth more than any other nutrient. Numerous studies have been shown that the highest growth of plant was recorded with the highest rates of N [10]. However, optimum dose of N is essential to maximizing nitrogen use efficiency (NUE) in root crops [11]. The efficiency of any production system is finally evaluated on the basis of its economic revenues. Economic analysis is the simplest technique for determining the highest net benefit of treatments.

The planting methods greatly affect on the germination and growth of the plant. The flat bed result crust formation in heavy soil which affects germination. Ridges provide better environment for root growth and performance of cultural practice. Keeping in view the above factors the current study was *designed* with the objective to determine optimum dose of N for growth and yield of radish by using various sowing methods under arid environment.

MATERIALS AND METHODS

The proposed study was conducted during 2009, at Ghazi University, College of Agriculture, Dera Ghazi Khan. The experiment was laid out in randomized complete block design with split plot arrangement having three replications. Before the sowing of crop, soil samples were obtained from five different locations of the field with the help of an auger at the 0-15 cm and 15-30 cm depths. These samples were packed in a polyethylene bag, labeled and were analyzed in the laboratory. The soil physico properties were given in table 1. The table showed soil fertility decreased at depth of 15 – 30 cm. The weather summary (daily maximum and minimum

Table 1: Results of soil physico-chemical analysis of experimental site on dry weight basis

Determination	Quantity	
	0 – 15 cm	15 – 30 cm
Sand (%)	58	59
Silt (%)	25	24
Clay (%)	17	17
Organic matter	1.03	0.79
pH of the soil	7.80	7.65
Total N (%)	0.03	0.02
Available P (ppm)	6.9	5.05
Available K (ppm)	225	202

Table 2: Effect of irrigation regimes and nitrogen rates on yield and yield components
Means with in columns sharing different letters vary significantly at P ≤ 0.05

Treatment	Seed germi-nation (%)	Number of leaves plant^{-1}	Fresh weight of leaves plant^{-1} (g)	Dry weight of leaves plant^{-1} (g)	Root length plant^{-1} (cm)	Fresh weight of root plant^{-1} (g)	Dry weight of root plant^{-1} (g)	Root yield (t ha^{-1})	Nitrogen use efficiency
S_1	77.8 a	14 a	164.4 b	22.3 a	23.8 a	196.1 a	17.5 a	20.37 a	40.2
S_2	57.3 b	9 b	144.7 a	18.3 b	18.7 b	169.7 b	13.1 b	16.48 b	47.1
LSD 5%	4.1	1.4	10.2	2.8	1.1	21.3	2.9	1.8	37.4
Sign.	P< 0.01	P< 0.01	P< 0.05	P< 0.05	P< 0.01	P< 0.05	P< 0.05	P< 0.01	ns
N_1	61.2 c	7 c	139.7 e	16.3 d	15.8 e	168.5 d	10.7 d	16.42 b	--
N_2	64.5 b	10 b	147.7 d	18.0 c	18.0 d	175.6 c	13.6 c	17.85 ab	28.0 c
N_3	69.8 a	11 b	153.8 c	21.2 b	20.6 c	182.9 b	15.8 b	18.75 ab	46.1 bc
N_4	70.8 a	13 a	163.0 b	23.1 a	20.1 b	191.1 a	17.6 a	19.98 a	68.5 ab
N_5	71.3 a	14 a	168.8 a	22.9 a	27.7 a	196.3 a	18.8 a	19.12 a	75.6 a
LSD 5%	1.760	1.66	5.10	0.91	1.64	5.60	1.24	2.33	23.6
Sign.	P < 0.001	P<0.001	P <0.0001	P <0.0001	P<0.0001	P < 0.0001	P<0.0001	P<0.001	P <0.0001
I × N	P < 0.01	P > 0.05	P > 0.05	P > 0.05	P > 0.05	P > 0.05	P > 0.05	P > 0.05	P > 0.05
Linear	**	**	**	**	**	**	**	**	**
Quadratic	**	ns	ns	**	*	*	*	ns	*
Cubic	ns	ns	ns	**	ns	ns	ns	ns	ns

*, ** = Significant at 5% and 1%, respectively, ns = Non-significant
S_1 = Ridge sowing and S_2 = Flat sowing method
N_1 = 0, N_2 = 50, N_3 = 100, N_4 = 150 and N_5 = 200 kg ha^{-1}.

Table: 3. Economic analysis of different nitrogen application rates in radish

Detail	N_1	N_2	N_3	N_4	N_5	Remarks
Total grain yield	16.42	17.85	18.75	19.98	19.12	ton ha^{-1}
Adjusted yield	14.78	16.07	16.88	17.98	17.21	To bring at farmer's level
Gross income	1043	1134	1191	1269	1215	Price of 1 t root yield $ 70.59
Cost of N_1	0	—	—	—	—	Price of one bag urea (23 kg
Cost of N_2	—	43.5	—	—	—	– do –
Cost of N_3	—	—	87	—	—	– do –
Cost of N_4	—	—	—	130.5	—	– do –
Cost of N_5	—	—	—	—	174	– do –
Cost that vary	0	43.5	87	130.5	174	$ ha^{-1}
Net benefits	1043	1091	1104	1139	1041	$ ha^{-1}

All prices of input and output considered according to local market during 2009
N_1 = 0, N_2 = 50, N_3 = 100, N_4 = 150 and N_5 = 200 kg ha^{-1}

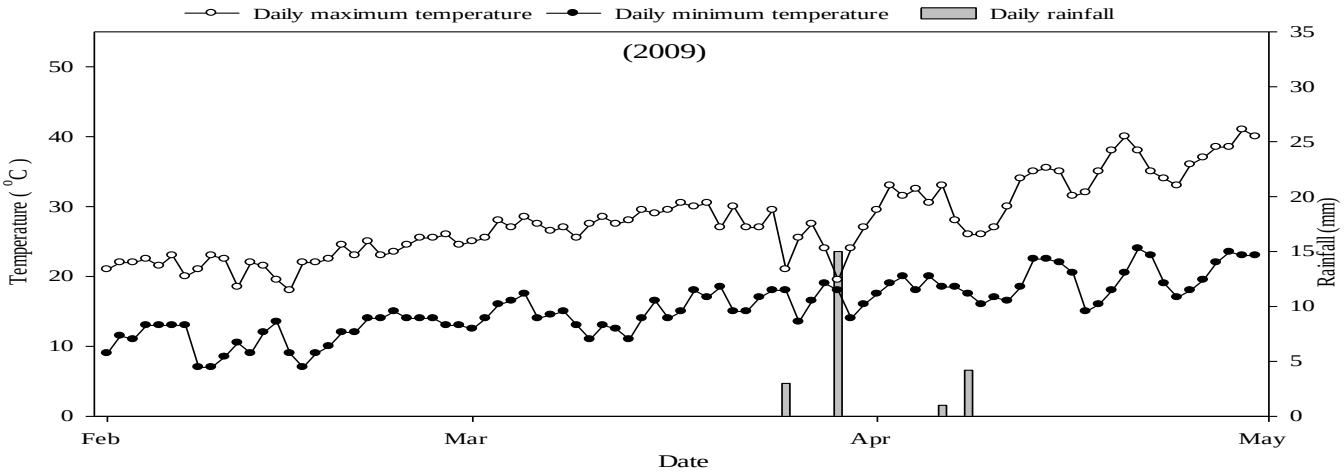

Fig. 1: Daily metrological data of experimental site during growing seasons in 2009

temperature and rainfall) of experimental site was shown in Fig. 1

Two sowing methods; ridge (S_1) and flat (S_2) were kept in main plots while five N rates; N_1, N_2, N_3, N_4 and N_5 (0, 50, 100, 150 and 200 kg ha^{-1}, respectively) were kept in sub plots. A radish cultivar Mino Early White was sown on February 3, 2009. The plot size was maintained 3 × 1.5 m. The fertilizer such as P_2O_5 and K_2O were applied equally in all treatments at the rate of 80 and 60 kg ha^{-1}, respectively during seed bed preparation. The N was applied according to treatments in three splits. First dose of N applied at the time of sowing, second with the second irrigation and third at the time of root development. All the agronomic practices were kept normal for all the treatments.

Near maturity period roots diameter were measured daily. Harvesting of crop took place when roots attained the maximum diameter and its value and did not increase within a 2-3 day period. Therefore, based on this principle, the crop was harvested at 81 days after sowing. Ten plants were selected randomly from each sub plot. The numbers of leaves, fresh and dry weight of leaves for the selected plants were measured and average was computed. Similarly, ratio diameter, length, fresh and dry weight were measured from the same selected plants. For dry weight the samples were oven dry up to constant weight at 70 ˚C. At the maturity 3 m area from each plot were harvested and root yield of each plot was converted into t ha^{-1}.

Nitrogen use efficiency of the crop was calculated for each N treatment with a standard procedure [12].

$$\mathrm{NUE} = \frac{(Y - Y^{*})}{F} \quad (1)$$

where Y is root yield (kg ha^{-1}) by applied N (kg) and Y˚ is root yield (kg ha^{-1}) without N, and F is the amount of N fertilizer (kg ha^{-1}) applied.

Economic analysis was conducted using input and output prices. Net benefit was calculated by standard formula [13]:

$$\text{Net benefit} = (\text{Gross income} - \text{Variable cost}) \quad (2)$$

Where gross income is the income without expenditures and variable cost is that differs in treatments.

The results were subjected to analysis of variance and means were compared at 5% probability by the least significant difference (LSD) test with aid of the SAS [14]. Response of variables to N rates was analyzed by using polynomial contrasts (linear, quadratic and cubic) within the analysis of variance structures.

RESULTS AND DISCUSSION

The sowing method significantly influenced germination of the crop (Table 2). The maximum (77.8%) seed germination occurred in ridge sowing it might be due to optimum moisture and presence of shallow soil for seed. Nitrogen rates significantly affected seed germination and effect of N was quadratic. The maximum (71.3%) seed germination occurred by application of treatment N_4 (200 kg N ha^{-1}) however, it was statistically similar with treatments N_2 and N_3 (100 and 150 kg N ha^{-1}, respectively) while the minimum was observed in treatment N_1 (0 kg N ha^{-1}, control). The results were supported by the finding of [15] who concluded that N fertilizer significantly influenced seed germination.

Number of leaves per plant was significantly affected by sowing method (Table 2). The maximum (14) number of leaves per plant was observed in ridge sowing. The nitrogen rates showed highly significant effect on number of leaves per plant. There was linear increased by application of N up to 200 kg N ha^{-1}. The maximum (14) number of leaves per plant was achieved in treatment N_5 and it was statistically similar with treatments N_4. Radishes need less N fertilizers to grow than many other vegetable. However, applying an appropriate quantity of N can increase germination and growth of the radish plant [16].

Fresh and dry weights of leaves were significantly affected by sowing method (Table 2). The maximum fresh and dry weights of leaves (164.4 g and 2.3 g, respectively) were achieved in ridge sowing. Nitrogen rates showed significant effect on fresh and dry weights and the effect of N was linear and cubic in fresh and dry weight, respectively. The maximum fresh weight of

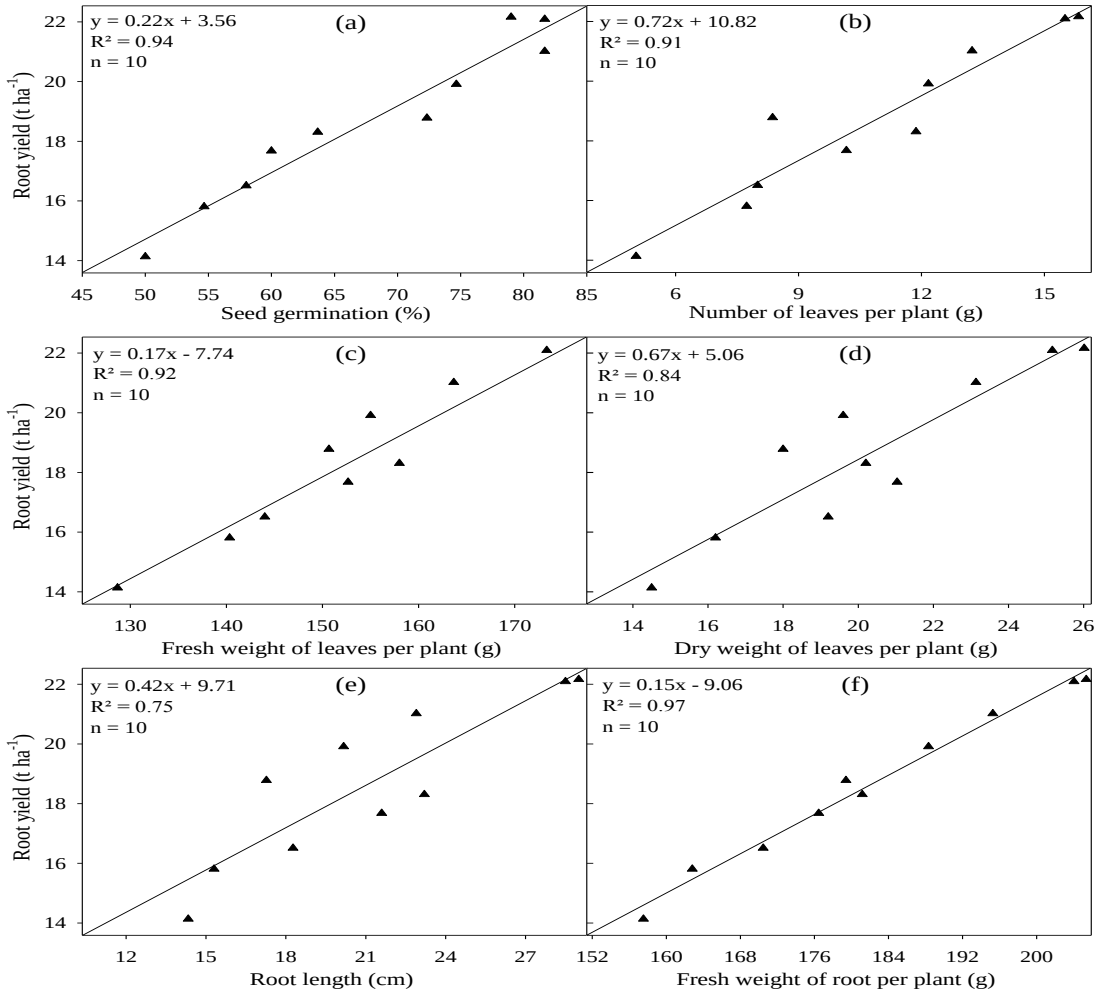

Fig. 2: Relationship of crop root yield with seed germination (a), number of leaves per plant (b), fresh weight of leaves per plant (c), dry weight of leaves per plant (d), root length (e) and fresh weight of root per plant during the study

leaves (168.8 g) was achieved in treatment N_5 while the maximum dry weights (23.1 g) was obtained in treatment N_4 however, it was statistically similar with treatment N_5. The results were supported by the finding of El-Desuki [17] who concluded leaves fresh and dry weights increased by increasing N rates in radish.

Sowing method showed highly significant effect on root length and fresh weight of root per plant (Table 2). The plant obtained the highest root length and root fresh weight per plant (38.8 cm and 196.1 g, respectively) in ridge sowing. The ridge sown radish roots were statistically longer resulted in early study that was conducted by Shri, [18]. Nitrogen rates applied significantly influenced root length and fresh weight of root per plant. The effect of N was quadratic in both variables. The maximum root length and fresh weight of root per plant (196.3 cm and 18.8 g, respectively) was achieved in treatment N_5 it was statistically similar with treatment N_4. The lowest root length and fresh weight of root per plant were resulted in control treatment (N_1). The results were supported by the finding of Pervez [19] who reported that root length of radish increased significantly by increasing N rate up to 200 kg ha^{-1}.

The data (Table 2) showed that root yield was significantly affected by sowing methods. The maximum (20.37 t ha^{-1}) root yield was achieved in ridge sowing. In ridge sowing method performance of all yield components was better than flat sowing method. Therefore, it was resulted the high root yield. The results were supported by the finding of Pandey and Joshua [20] who reported ridge sowing gave maximum radish root yield as compare other sowing method. The N rate showed highly significant effect on root yield. The effect of N was linear. Statistically maximum (19.98 t ha^{-1}) root yield was obtained by application of N up to 150 kg N ha^{-1} and beyond this level there was no significant increase observed in root yield. Similar trend was observed in seed germination, number of leaves per plant, dry weight of leaves per plant and fresh & dry weight of root. Moreover, positive and highly significant correlation of root yield was observed with seed germination (R^2 = 0.94 Fig 2a) number of leaves per plant (R^2 = 0.91 Fig 2b) fresh weight of leaves per plant (R^2 = 0.92 Fig 2c) dry weight of per plant (R^2 = 0.84 Fig 2d) root length (R^2 = 0.75 Fig 2e) and fresh weight of root per plant (R^2 = 0.97 Fig 2f). Most of researchers [6, 21, 22] reported that radish root yield responds positively to N up to 200 kg N ha^{-1}

however, some researcher [23] concluded 150 kg N ha^{-1} optimum dose for radish crop.

Sowing method and nitrogen rates significantly affected nitrogen use efficiency (NUE). Ridge sowing method was resulted maximum (47.1 kg root yield kg^{-1} N) NUE. Nitrogen rates showed highly significant effect on NUE. There was quadratic effect of N on NUE. The maximum (75.6 kg root yield kg^{-1} N) NUE was achieved in treatment N_5 and it was statistically at par with treatment N_4. The results were supported by the finding of [24] who reported that optimum fertilizer increased fertilizer use efficiency. Nitrogen rates affected net benefit of crop (Table 3). The net benefit increased by increasing N rates up to 150 kg N ha^{-1} (treatment N_4). Beyond this rate of N, reduction in the net benefit was observed. The highest net benefit ($1139 ha^{-1}) was achieved by treatment N_4.

CONCLUSION

Ridge sowing is the best method for high radish growth and yield. Nitrogen fertilizer increased the growth and yield of radish up to 150 kg ha^{-1}. The maximum net benefit ($1139 ha^{-1}) was achieved by application of nitrogen fertilizer input at the rate of 150 kg ha^{-1}. Our findings suggest that farmers of arid region should use ridge sowing method by applying nitrogen at the rate of 150 kg ha^{-1}.

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