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Full Length Research Paper

Effect of nitrogen application on growth, yield and oil contents of Fennel (*Foenoculum vulgare* Mill.)

Muhammed Ayub[1]*, Muhammad Naeem[2], Muhammad Ather Nadeem[1], Asif Tanveer[1], Muhammad Tahir[1] and Rehan Alam[1]

[1]Department of Agronomy, University of Agriculture Faisalabad, Pakistan.
[2]University College of Agriculture and Environmental Sciences, Islamia Universiry Bahawalpur, Pakistan.

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Fennel is used in pharmaceutical, preparation of various dishes, confectionaries and cosmetic products in Pakistan. Therefore, there is a dire need to know optimum nitrogen level for higher seed yield and oil contents of fennel. Field studies pertaining to the effects of different levels of nitrogen viz., 0, 30, 45, 60, 75, 90, 105 and 120 kg ha^{-1} on growth, seed yield and oil contents of fennel were carried out at the Agronomic Research Area, University of Agriculture, Faisalabad, during two consecutive years 2006 to 2007 and 2007 to 2008. Seed yield and yield components were influenced significantly by different levels of nitrogen application. The treatments of 90 kg N ha^{-1} produced higher seed yield but it was statistically similar to 105 and 120 kg N ha^{-1}. The increase in yield was mainly due to greater plant height, umbels per plant, seeds per umbel and 1000-seed weight. The nitrogen application at the rate of 90 kg ha^{-1} seems to be the economical dose for fennel under agro-climatic conditions of Faisalabad.

INTRODUCTION

Fennel is locally known as 'Saunf' belongs to the family Umbelliferae. Fennel is grown as a seed crop almost all over the world and has several medicinal uses. Its fruit is widely used in the preparation of various dishes like soups, sauces, pastries, confectioneries, pickles and meat dishes etc. The leaves, stalks and the tender shoots are also used as salads. Although the fennel crop is not grown on commercial scale in Pakistan, but on account of its medicinal value, the farmers almost all over Pakistan grow on small scale for their domestic use only. The yield obtained from small cultivation does not fulfill the country requirements. Pakistan imported 144.31 t of fennel seed worth Rs. 12.4 crore during the year 2004 to 2005 (Anonymous, 2006). So, there is a need to increase the production of fennel in the country in order to become self sufficient in this important commodity. The yield can be increased by bringing more area under cultivation or by increasing the yield on per unit basis. The horizontal expansion is not possible due to increasing population pressure. So, the only way is to increase yield on per unit area basis. Among the various factors which can increase yield on per unit area basis, the application of nitrogen fertilizer is considered to be the most important one (Chatzopoulou et al., 2006). Nitrogen application depends upon crop, cultivar, soil and fertility status of soil. As soils of Pakistan are deficient in nitrogen, so application of adequate amount of nitrogen is considered to be the most important under our conditions. The application of nitrogen not only increased seed yield but also improved oil contents (El-Wahab and Mohamed, 2007). According to Omidbaigi and Hornok (1992) and Abdullah et al. (1978) nitrogen application had a positive effect on plant height and seed yield of fennel. Munir (2005) and Mehfoz and Sharaf-Eldin (2006) obtained maximum seed yield when nitrogen was applied at the rate of 90 kg ha^{-1}. Similarly, Rai et al. (2002) also obtained the maximum seed yield when nitrogen and phosphorous were applied at the rate of 90 kg ha^{-1} each. Whereas, Cserni and Sass (1994) reported that 120 kg N ha^{-1} produced more seed yield, plant weight leaf area, plant height, number of umbels, seed per umbel and oil contents. Zubair (2003) observed highest growth and

*Corresponding author. E-mail: mayubuaf@hotmail.com.

Table 1. Effect of various levels of nitrogen on plant density, plant height, umbels plant^{-1}and seeds umbel^{-1}of fennel.

Nitrogen level (kg ha^{-1})	Plant density		Plant height (cm)		Umbels plant^{-1}		Seeds umbels^{-1}		1000-Seed weight (g)	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
0	23.76	26.63	152.73^{d}	106.50^{c}	21.60^{e}	20.40^{f}	552.26^{c}	548.56^{c}	11.00^{b}	10.70^{cd}
30	23.96	23.43	155.06^{cd}	105.70^{c}	23.96^{d}	21.96^{e}	561.00^{c}	552.03^{c}	11.13^{ab}	10.23^{d}
45	25.55	25.16	157.13^{cd}	107.93^{c}	25.37^{c}	23.40^{d}	575.10^{c}	558.80^{c}	11.97^{ab}	11.36^{bcd}
60	26.3	25.96	157.86^{cd}	112.53^{bc}	24.13^{c}	23.10^{de}	582.06^{bc}	573.10^{bc}	12.20^{ab}	11.50^{bc}
75	27.22	25.60	160.06^{bc}	119.83^{ab}	26.57^{b}	25.33^{c}	592.90^{bc}	580.43^{bc}	13.13^{a}	11.63^{abc}
90	27.73	27.90	168.40^{a}	124.43^{a}	28.00^{a}	28.06^{a}	648.00^{ab}	607.10^{ab}	12.50^{ab}	12.70^{a}
105	27.83	27.73	169.09^{a}	123.90^{a}	27.27^{ab}	26.66^{b}	640.30^{a}	642.93^{a}	12.37^{ab}	12.06^{ab}
120	28.92	28.30	166.00^{ab}	123.60^{a}	27.00^{ab}	26.56^{bc}	653.50^{a}	625.33^{a}	11.67^{ab}	12.26^{ab}
LSD	ns	ns	5.884	9.444	1.018	1.248	53.11	42.42	2.213	1.138

Any two means not sharing the same letter differ significantly at 0.05 level of probability (LSD).

yield parameters at 150 kg N ha^{-1}. Whereas, Damato et al. (1994) reported that nitrogen applied at the rate of 300 kg ha^{-1} increased 1000-seed weight and seed yield. So, there has been a great variation in the use of nitrogen for obtaining higher seed yield of fennel. The information in Pakistan about the use of nitrogen for fennel is almost lacking.

The present study was therefore planned to evaluate the effect of nitrogen on growth, yield, oil contents and profitability of fennel, under agro-climatic conditions of Faisalabad.

MATERIALS AND METHODS

A field experiment to study the effect of nitrogen levels of 0, 30, 45, 60, 75, 90, 105 and 120 kg ha^{-1} on growth, yield and oil contents of fennel was carried out at the Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan during two consecutive years 2006 to 2007 and 2007 to 2008. The field was previously under cultivation of forage sorghum. The crop was sown on well prepared field in 30 cm rows apart with the help of dibbler. The experiment was laid out in randomized complete block design having three replications measuring a net plot size of 1.8 × 6 m. The entire dose of phosphorus at the rate of 40 kg ha^{-1} was applied at sowing to all the plots, while, nitrogen was applied in two splits, that is, half at sowing and half with second irrigation. The sources used for nitrogen and phosphorous were urea and di-ammonium phosphate (DAP), respectively. The crop received four irrigations viz., first at the completion of germination, second 35 days after the first irrigation, third at the time of flowering and last irrigation was applied at seed formation. Two hoeing were given to the crop, that is, first one month after sowing and the second after second irrigation. Plant to plant distance was maintained by thinning.

For recording plant density, two rows of one meter length were randomly selected at three randomly selected places in each plot of each replication. Plants were counted and then were converted to per square meter. For individual plant observations like plant height and number of umbels plant^{-1}, ten plants were selected at random from each plot. Three samples of 1000-seeds each were selected at random from the seed lot of each plot for recording 1000-seed weight. For recording number of seeds per umbel, 5 umbels were selected at random from each plot. After threshing with hand, seeds were counted and their average number of seeds was determined. The oil contents of seed were determined by using Soxhlet extraction method. For economic analysis, net benefit and benefit cost ratio was calculated by using methodology described in CIMMYT (1998). All other agronomic practices were kept normal and uniform for all the treatments. The data collected was analyzed statistically using Fisher's analysis of variance technique and least significant difference test (LSD), at 5% probability level was employed to compare the differences among treatment means (Steel et al., 1997).

RESULTS

Plant density at harvest was not influenced significantly by nitrogen application (Table 1) and plant density remained between 23 to 29 plants m^{-2} in both the years.

Plant height was influenced significantly by the application of nitrogen in both the years (Table 1). In 2006 to 2007, the nitrogen applied at the rate of 120 kg N ha^{-1} resulted in the maximum plant height (169.09 cm), but it did not differ significantly from T6 (90 kg N ha^{-1}) and T_7 (105 N kg ha^{-1}). The treatment T_1 (0 kg N ha^{-1}), produced minimum plant height (152.73 cm). In 2007 to2008, the nitrogen applied at the rate of 90 kg ha^{-1} produced maximum plant height (124.43 cm), but it did not differ significantly from T_7 (105 kg N ha^{-1}) and T_8

Table 2. Effect of various levels of nitrogen on 1000-seed weight, biological yield, seed yield and economic analysis of fennel.

Nitrogen level (kg ha^{-1})	Biological yield (t ha^{-1})		Seed yield (t ha^{-1})		Oil content (%)		Economic analysis (BCR)			
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	Net income 2006-07	BCR 2007-08	Net income 2006-07	BCR 2007-08
0	1.613^{c}	1.557^{d}	186.70^{e}	148.33^{d}	2.66	2.64	4146	1.58	2900	1.55
30	1.900^{bc}	1.807^{c}	281.70^{de}	213.33^{c}	2.62	2.65	5710	1.59	6669	1.73
45	1.953^{bc}	1.890^{c}	363.30^{d}	242.66^{c}	2.59	2.61	8858	168	6629	1.75
60	2.693^{ab}	2.027^{c}	543.33^{c}	363.33^{b}	2.63	2.63	16819	2.06	1339	1.62
75	3.013^{a}	2.433^{b}	686.66^{b}	375.00^{b}	2.75	2.62	21789	2.12	14260	1.83
90	3.153^{a}	2.930^{a}	860.00^{a}	606.66^{a}	2.59	2.60	28100	2.19	22659	2.08
105	3.053^{a}	3.097^{a}	810.00^{a}	586.66^{a}	2.61	2.63	20640	1.73	18969	1.94
120	2.983^{a}	2.997^{a}	783.33^{a}	576.66^{a}	2.63	2.65	17179	1.57	16625	1.78
LSD	0.8325	0.2477	95.78	47.13	NS	NS	-	-	-	-

Any two means not sharing the same letter differ significantly at 0.05 level of probability (LSD).

(120 kg N ha^{-1}).

The number of umbels plant^{-1} was also affected significantly by different nitrogen levels. During both years, the nitrogen applied at the rate of 90 kg ha^{-1} produced maximum number of umbels plant^{-1} (Table 1), but in 2006 to 2007, those plots which received nitrogen at the rate of 90 kg ha^{-1} remained at par with T_7 (105 kg ha^{-1}) and T_8 (120 kg ha^{-1}). Whereas, in 2007 to 2008, the application of 90 kg N ha^{-1} produced significantly more number of umbels plant^{-1} than the remaining levels. The minimum number of umbels plant^{-1} was noted from plots receiving no nitrogen in both the years. Number of Seeds umbel^{-1} was affected significantly by various nitrogen levels during both years (Table 1). In 2006 to 2007 and 2007 to 2008, the maximum number of seeds umbel^{-1} were produced when nitrogen was applied at the rate of 120 and 105 kg ha^{-1}, respectively, but the differences among the nitrogen levels of 90, 105, and 120 kg ha^{-1} were not significant in both the years. The minimum number of seeds umbel^{-1} was recorded at 0 kg N ha^{-1}. The differences among nitrogen levels of 0, 30, 45, 60 and 75 kg ha^{-1} were not significant in both years. The number of seeds umbel^{-1}were more in 2006 to 2007 than during the year 2007 to 2008. Data regarding 1000-seed weight presented in Table 2 showed that nitrogen application significantly affected the 1000-seed weight in both years. In both years, the control (0 kg ha^{-1}) produced the lowest 1000-seed weight than all other treatments. In 2006 to 2007, the application of fertilizer at the rate of 75 kg ha^{-1} (T_5) produced the maximum 1000-seed weight (13.13 g) and it was statistically similar with all other treatments except control. In 2007 to 2008, maximum 1000-seed weight was obtained when nitrogen was applied at the rate of 90 kg ha^{-1}and it was statistically similar to treatments T_5, T_7 and T_8. The data presented in Table 2 revealed that there was a significant effect of nitrogen on biological yield of fennel in both the years. The minimum biological yield was recorded from plots where no nitrogen was applied. The maximum biological yield in 2006 to 2007 and 2007 to 2008 was observed at 90 and 105 kg N ha^{-1}, respectively. The differences between nitrogen levels of 90, 105, and 120 kg ha^{-1} were not significant in both he years. A slight reduction in yield was noted when nitrogen was applied at the rate of 120 kg ha^{-1} during both the years.

Seed yield influenced significantly by nitrogen application in both the years (Table 2). The seed yield increased with increased nitrogen level up to 90 kg ha^{-1} and then it started to decrease, but decrease could not reach a significant level in both years. The minimum seed yield was recorded where no nitrogen was applied. In the year 2007 to 2008, the control produced significantly the lowest yield than all other nitrogen levels, but during 2006 to 2007, the differences between control and 30 kg N ha^{-1} were not significant. Economic analysis presented in

(Table 2) indicated that the maximum net income and benefit cost ratio was obtained when nitrogen was applied at the rate of 90 kg ha^{-1} in both years. In the year 2006 to 2007, it was followed by T_5 (75 kg N ha^{-1}), whereas, during 2007 to 2008, this was followed by T_7 (105 kg N ha^{-1}). The minimum net return during both the years was recorded from those plots where no nitrogen was applied (control). Seed oil contents were not influenced significantly by nitrogen application. The oil contents ranged from 2.59 to 2.75% during 2006 to 2007 and 2.55 to 2.75% during 2007 to 2008.

DISCUSSION

Plant density was not significantly influenced by the application of nitrogen fertilizer. This might be due to the reason that the plant to plant and row to row distance was kept almost constant and same seed rate was used in all the treatments. Non-significant effect of fertilizer application on plant density of fennel has also been reported before by Zubair (2003).

Plant height was increased by increased nitrogen rate up to 105 kg ha^{-1} in 2006 to 2007 and 90 kg ha^{-1} in the year 2007 to 2008. The increase in plant height at each increased nitrogen level was not significant. The decrease in plant height at nitrogen levels of 120 kg ha^{-1} during 2006 to 2007 and 105 and 120 kg ha^{-1} during 2007 to 2008 might has been due to imbalanced nutrient status of the soil. Abdullah et al. (1978), Omidbaigi and Hornok (1992) and Patel et al. (2000) have also reported increase in the plant height with the application of nitrogen fertilizer.

The nitrogen application significantly increased number of umbels $plant^{-1}$ and number of seeds $umble^{-1}$ during both the years (Table 2). The increase in number of umbles $plant^{-1}$ and number of seeds $umble^{-1}$ by the application of nitrogen may be due to better root and shoot development, which in turn resulted in higher number of umbles $plant^{-1}$ and seeds $umble^{-1}$. These results are similar to those of Patel et al. (2000), Zubair (2003) and Munir (2005).

The effect of nitrogen application on 1000-seed weight was also significant in both the years. The results indicated that nitrogen application has influenced the physiological processes such as photosynthesis that ultimately resulted in fully filled seeds. Patel et al. (2000) and Munir (2005) have also reported an increase in 1000-seed weight with the application of nitrogen fertilizer.

All nitrogen levels produced significantly higher seed yield than the control (0 kg N ha^{-1}) in both years and this increase can be attributed to greater number of umbels $plant^{-1}$, seeds $umbel^{-1}$ and 1000-seed weight. Increase in fennel seed yield with nitrogen application has been observed by Khan et al. (1999), Zubair (2003), Munir (2005) and Mehfoz and Sharaf-Eldin (2006).

Nitrogen application significantly affected the biological yield in both years. The response to nitrogen application was not exactly similar in both the years. In the year 2006 to 2007 and 2007 to 2008, maximum biological yield was noted at nitrogen level of 105 and 90 kg ha^{-1}, respectively. At higher level than these, a slight reduction in biological yield was observed in both years. This decrease effect may be due to imbalanced nutrient status of the soil, and the reason of having maximum biological yield at different nitrogen levels may be due to variation in soil fertility and climatic conditions. The results are supported by the findings of Omidbaigi and Hornok (1992), Butain and Chung (1994) and Patel et al. (2000).

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