IMPROVED GROWTH, SEED YIELD AND QUALITY OF FENNEL (*FOENICULUM VULGARE* MILL.) THROUGH SOIL APPLIED NITROGEN AND PHOSPHORUS

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ABSTRACT:- In Pakistan, fennel is conventionally grown without fertilizer. A field experiment, was conducted to study the effects of nitrogen and phosphorus fertilizer treatments (NP in ratio of 0:0, 30:0, 0:30, 30:15, 30:30, 60:30, 60:60, 90:45 and 90:90 kg ha^{-1}) on growth, seed yield and quality of fennel during 2011-2012. Fertilizer NP dose (90:45 kg ha^{-1}) increased plant height by 44%, number of leaves per plant by 76%, 1000 seed weight by 44%, biological yield by 50%, seed yield by 296%, harvest index by 162% and protein content by 6%. However, fertilizer NP (90:45 kg ha^{-1}) decreased oil content by 26%. Therefore, addition of NP fertilizer had the potential to increase fennel seed yield, but reduce oil content, under Faisalabad conditions.

Key Words: Foeniculum vulgare; Fertilizer, Nitrogen; Phosphorus; Growth; Seed Yield; Protein Content; Oil Content; Yield Components; Pakistan.

INTRODUCTION

Fennel (locally called 'saunf') belongs to family Umbelliferae. It is an annual plant that is cultivated for its economic, aromatic and medicinal value (Kandil, 2002). Fennel fruit had a sweet taste and spicy odour that may be used in soups, sauces, pickles, confectioneries, perfumery, cosmetics, scenting soaps, pharmaceutical and phytotherapy industries (Blumenthal et al., 2000). In Pakistan, farmers grow it on a small scale for medicinal purposes. Fennel seed contain numerous flavonoids with anti-oxidant capacity, rich source of dietary fiber, contain creosol and alpha-pinene, chemicals that help to loosen congestion, contain essential oil with digestive, carminative and anti-flatulent properties (Blumenthal et al., 2000). The average fennel yields are far less than in other fennel growing countries. Fennel crop in Pakistan is mostly grown without fertilizer application. Studies from other regions demonstrated that addition of Nitrogen (N) increases seed yield and oil contents (El-Wahab and Mohamed, 2007). Phosphorus (P) in combination with N improves the growth and seed yield and seed quality in fennel (Olle et al., 2010). Therefore, fertilizer (NP) applications may improve the growth, yield and quality of fennel seed in Pakistan.

The objectives of the study was to ascertain the effect of different NP levels on the growth, yield and oil

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contents of fennel and recommend NP doses under Faisalabad conditions.

MATERIALS AND METHOD

The experiment was conducted in 2011-12 at agronomic research area, University of Agriculture, Faisalabad, Pakistan (73.09°E longitude, 31.25°N latitude, altitude 183 m). Seed of fennel was obtained from the Directorate of Oilseeds, Ayub Agricultural Research Institute, Faisalabad, Pakistan. Before sowing the crop, soil samples were collected to a depth of 25 cm from the experimental area and analyzed for physico-chemical properties (Table 1). The crop was sown (seed @ 12 kg ha^{-1}) on November 30, 2011 in well prepared field maintaining 45 cm row distance and 20 cm plant distance. Plant to plant dis-tance was maintained by thinning. The experiment was laid out in RCBD with three replications. The NP (kg ha^{-1}) treatments were:

T_1 = 0:0 T_2 = 30:0
T_3 = 0:30 T_4 = 30:15
T_5 = 30:30 T_6 = 60:30
T_7 = 60:60 T_8 = 90:45
T_9 = 90:90

The nitrogen and phosphorus were applied as urea and single super phosphate (SSP), respectively. All P and half dose of N were applied at the time of sowing and remaining half N was applied with 2nd irrigation. Six irrigations each of 75 mm depth were applied during the growth period of crop. First at the completion of germination, second after 25 days of 1st irrigation, 3rd after 25 days of 2nd irrigation, 4th at the onset of flowering, 5th at late flowering stage and last irrigation was applied at the time of seed formation. Two hoeing were given to control the weeds (1st one month after sowing, and the 2nd after second irrigation). All other agronomic practices were kept standard and uniform for all the treatments. The crop was harvested on May 16, 2012. The data were recorded on plant density, plant height, number of leaves per plant, umbels per plant, seeds per umbel, 1000 seed weight, biological yield, seed yield, harvest index, protein content and oil content. Plant height was measured from soil to the tip of ten randomly selected plants. Number of leaves, number of umbels counted from ten randomly selected plants and means were calculated. Ten umbels were randomly selected from each plot, seeds were removed and counted. One thousand seeds of main, primary and secondary umbels were counted separately and weighed. The crop harvested at maturity from each plot was tied into small bundles which were weighed to plot yield and converted to hectare basis. All plots were harvested separately, threshed with wooden sticks to obtain seed yield.

Table 1. Pre-sowing physico-chemical analysis of soil

Parameter	Value
Physical analysis	
Sand (%)	53.00
Silt (%)	25.00
Clay (%)	22.00
Textural class	Sandy clay loam
Chemical analysis	
pH	7.81
EC (dSm^{-1})	0.73
Organic matter (%)	0.76
Total N (%)	0.04
Available phosphorous (ppm)	4.10
Available potassium (ppm)	118.00

Table 2. Meteorological data recorded during growing season (2011-2012)

Growing period	Temperature (°C)			Relative humidity (%)	Rainfall (mm)	Pan evaporation (mm day^{-1})
	Maximum	Minimum	Mean			
November, 2011	32	10.0	20.5	61.2	0.0	2.2
December, 2011	28	0.0	12.5	59.1	0.0	2.0
January, 2012	20	0.5	10.2	69.6	3.8	2.0
February, 2012	22	0.0	11.5	62.1	8.0	3.4
March, 2012	33	7.0	18.8	58.2	1.5	4.1
April, 2012	36	15.0	25.3	59.1	10.5	5.4
May, 2012	46	15.0	31.1	43.3	0.0	10.4

Source: Agricultural Meteorology Cell, University of Agriculture, Faisalabad

Harvest index was calculated by taking ratio of the seed yield to the biological yield and expressed in percentage. Crude protein contents were determined by Kjeldahl method (AOAC, 1990). Seed oil contents were determined by the Soxhlet Fat Extraction method (AOAC, 1990). Response values were analyzed as RCBD with 3 replications using GLM procedure of SAS (2008). When the treatment effect was significant at the 5% level, the multiple mean comparison treatments were completed and letter groupings generated using least significant difference (LSD) at the 5% level of significance. The validity of normal distribution and constant variance assumptions on the error terms was verified by examining the residuals (Steel et al., 1997). Weather data for experimental period were obtained (Table 2).

RESULTS AND DISCUSSION

Fertilizer (NP) had no effect on plant density at harvest (m^{-2}) but significantly affected plant height (Table 3). The non-significant effect of NP on plant density could be attributed to same seed rate having similar purity and germination percentage. Non-significant effect of nitrogen application on plant population of fennel has also been reported (Ayub et al., 2011; Zubair 2003). Plant height (cm) was 44% higher in the 90:45 NP than in the 0:0 NP treatment (Table 3). Fertilizer (NP) significantly affected number of leaves per plant (Table 3). Studies have reported increased plant height with addition of fertilizer particularly the nitrogen. However, higher nitrogen doses (> 120 kg ha^{-1}) could reduce the vegetative growth (Raj and Thakral, 2008; Mehta et al., 2011). Similar to the fertilizer effects on plant height, number of leaves per plant were 14.33 (an equivalent to 76% increase) higher in the 90:45 kg ha^{-1} NP treatment than control (Table 3).The increase in number of leaves per plant were in agreement of those reported by Zaki et al. (2011). Fertilizer NP significantly affected the number of umbels per plant. The maximum number of umbels per plant (16.0) were recorded in T_7 (90 kg N + 45 kg P ha^{-1}) and minimum value (8.9) was observed in control treatment (T_0). Studies reported increase in number of umbels per plant with addition of N fertilizer (Nakhaei et al.,

Table 3. Effect of nitrogen and phosphorus treatment on agronomic characters, yield, yield component, seed protein and seed oil contents of fennel grown at Faisalabad

NP levels (kg ha^{-1})	Plant density (m^{-2})	Plant height (cm)	Number of leaves plant^{-1}	Umbels plant^{-1}	Seeds umbel^{-1}	1000-seed weight (g)	Biological yield (t ha^{-1})	Seed yield (kg ha^{-1})	Harvest index (%)	Seed protein content (%)	Seed oil content (%)
0:00	20.0	106.9^{g}	08.13^{d}	08.90^{e}	390.6^{f}	7.13^{c}	1.59^{e}	131.9^{e}	8.28^{d}	12.91^{f}	12.50^{a}
30:00	20.8	118.3^{e}	08.67^{d}	09.57^{e}	409.3^{e}	7.20^{c}	1.79^{d}	143.3^{e}	7.99^{d}	13.14^{cd}	12.33^{a}
0:30	20.2	112.2^{f}	08.17^{d}	09.37^{e}	395.1^{ef}	7.20^{c}	1.61^{e}	134.2^{e}	8.32^{d}	13.01^{e}	12.00^{a}
30:15	21.3	131.9^{d}	10.90^{c}	11.33^{d}	428.2^{d}	7.53^{c}	1.84^{cd}	238.6^{d}	12.96^{c}	13.13^{d}	11.83^{a}
30:30	21.0	139.8^{c}	10.87^{c}	11.97^{d}	436.7^{d}	7.70^{c}	1.89^{c}	262.4^{d}	13.91^{c}	13.15^{cd}	11.83^{a}
60:30	21.5	140.4^{c}	12.20^{b}	13.63^{c}	463.4^{c}	8.40^{c}	2.08^{b}	356.9^{c}	17.17^{b}	13.20^{bcd}	10.67^{b}
60:60	21.7	147.5^{b}	12.87^{b}	14.43^{bc}	490.1^{b}	8.77^{b}	2.14^{b}	384.2^{b}	17.97^{b}	13.23^{bc}	10.67^{b}
90:45	21.8	154.3^{a}	14.33^{a}	16.00^{a}	525.5^{a}	10.20^{a}	2.39^{a}	517.4^{a}	21.69^{a}	13.68^{a}	9.17^{c}
90:90	21.7	151.9^{ab}	13.67^{a}	15.13^{b}	513.3^{a}	9.90^{a}	2.34^{a}	501.8^{a}	21.47^{a}	13.27^{b}	10.00^{bc}

Means followed by the same letters do not differ significantly at the 5% level.

2012; Salarazai et al., 2005). Similarly the number of seeds per umbel significantly affected NP application. The maximum number of seeds per umbel (525.47) and minimum seeds per umbel (390.6) were observed at NP levels of 90:45 and 0:0 kg ha^{-1}, respectively. Higher number of seeds per umbel could be attributed to balanced nutrition (Mehta et al., 2011).

Application of NP fertilizer significantly increased 1000-seed weight (Table 3).The fertilizer NP 90:45 kg ha^{-1} increased 1000-seed weight (g) by 44% compared with control. Similarly NP fertilizer (90:45 kg ha^{-1}) significantly increased biological yield (kg ha^{-1}), seed yield (kg ha^{-1}) and harvest index by 50%, 296%, and 162% relative to the control treatment, respectively. The increase in biological yield was mainly due to the increase in plant height and number of umbels per plant and seeds per umbel. Raj and Thakral (2008) found similar affect of system and P fertilizer. The harvest index trends were same and reported elsewhere (Cserni and Saas, 1994; Mehta et al., 2011).

Fertilizer (NP) had significant effects on seed protein and oil contents (%). Application of 90:45 kg ha^{-1} NP increased protein content by 6% compared to control (zero fertilizer). The oil contents ranged between 9.17% and 12.50%. The control treatment (T_0) had highest oil contents (12.50%) and T_8 (90 kg N + 45 kg P ha^{-1}) had the minimum oil contents (9.17%). Application of 90:45 kg ha^{-1} NP decreased oil content by 26% relative to control treatment. The increase in crude protein contents in response to nitrogen application could be attributed to increase in amino acids formation since nitrogen is an essential component of amino acids. Amin and Patel (2001) found that application of NP improved protein content in fennel. Generally, an inverse relationship exists between crude protein and oil contents. For example, Paschalina et al. (2006) found the decrease in oil contents of fennel by addition of NP fertilizer.

It is thus concluded that application of NP (90-45 kg ha^{-1}) increased number of leaves per plant by 76%, 1000 seed weight by 44%, biological yield by 50%, seed yield by 296% and protein content by 6%. Consequently, soil applied N-P fertilizers should be incorporated into fennel production technology under Faisalabad conditions.

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