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ORIGINAL ARTICLE

Growth and Yield of *Ocimum* as a Function of Nitrogen Fertilization

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ABSTRACT

A field trial according to factorial randomize block design was conducted to evaluate the effect of nitrogen on growth, herb and seed yield of three species of Ocimum *namely* O. sanctum*,* O. basilicum *and* O. amaricanum*. The objective of the experiment was to select the better species under local conditions which ultimately improve the production of the crop. The treatments consisted of three levels of nitrogen* viz*. 50, 100 and 150 kg N/ha. A control without nitrogen was also maintained for reference. A uniform basal dose of phosphorous and potassium fertilizers were given to the soil before transplanting at the rate of 20 kg P/ha and 30 kg K/ha respectively. The different parameters such as plant height, number of branches per plant, fresh and dry herb yield per plant were investigated at 50, 70 and 90 DAP; whereas the yield parameters like oil content in herb, seed and oil yield were measured at harvest (90 DAP). It is revealed from our results that 90 N kg/ha,* O. amaricanum *as well as its interaction were found best among all the tested treatments at all the sampling stages except for the oil content which gave the best result at 100 kg N/ha. Thus, the application of nitrogen at the rate of 150 kg N/ha under the local climatic condition could be recommended for maximising herb and oil yield.*

Key words: Ocimum*, Nitrogen fertilizer, Oil Content, Seed and Oil Yield*

INTRODUCTION

Most of the crude drugs which are used in medicinal preparations come from the state of their wild growth. Natural resources are going to deplete day by day due to excessive exploitation. Therefore, it becomes necessary to bring these plants under domestication to combat the required demand of resultant product. Since long time, there has been increasing demand for traditional drugs in the world market (Kumar *et al.* 2011). According to a report of WHO (2008), about 65-80% population of developing countries diverted towards traditional system of medication for their primary health care because of some ill effects produced by other system of medicine (Akhtar *et al.* 2014a; Swami *et al.* 2016). *Ocimum* (commonly known as Basil) belongs to the family Lamiaceae (Mint family) and is grown for herbs which are rich with numerous aromatic plant species used traditionally as a medicinal plant in the treatment of various ailment as well as in pharmaceuticals, perfumery and cosmetic industries (Simon *et al.* 1999, Javanmardi *et al.* 2002). Moreover, it also possesses various beneficial effects, e.g., antiseptic, carminative, antimicrobial and anti-oxidative as well as insect-repelling properties and toxic activities (Baranauskiene *et al.* 2003, Telci *et al.* 2006, Akhtar *et al.* 2014b).

Nutrition plays very crucial roles in overall growth and development of various crop plants under diverse agro-climatic conditions. Among different nutrients, nitrogen (N), phosphorus (P) and potassium (K) are required in somewhat larger quantities and, therefore, deserve a special attention (Noggle and Fritz, 1986, Salisbury and Ross, 1992). In the case of medicinal plants that synthesize essential oils, use of proper nutrients can increase oil yield and quality by enhancing the amount of biomass per unit land area, leaf area development and photosynthetic rate (Daneshian *et al.* 2009; Singh *et al.* 2016). Moreover, the essential oil content and its composition are also affected by plants genotypes, agro-climatic conditions, and agricultural practices (Ram *et al.* 2003, Swamy *et al.* 2016). Nitrogen is one of the important essential nutrients and is used by plants to build many organic compounds: amino acids, proteins, enzymes, and nucleic acids. Accordingly, N plays an important role in synthesis of the plant constituents through the action of different enzymes (Salisbury and Ross, 1992). As nitrogen is an integral part of chlorophyll molecule, it could be expected to exert positive effect in production of final biomass. Furthermore, it is well documented that nitrogen plays several important roles in metabolic and regulatory processes through enhancing the level of various phytohormones in leaves and root exudates in plants (Anderson 1974, Goldbach *et al.* 1975, Krauss 1978, Angelova and Georgieva 1983, Marschner 2002). Therefore, it's sufficient availability acts as a key factor towards wholesome improvement in agriculture production (Singh 2009). *Ocimum* being a cash crop, its demand is increasing day by day. Therefore, it becomes necessary to maintain the equilibrium between production and demand. The key objective of the present study was to examine the effects of nitrogen fertilizers in view to improve the production of *Ocimum* under the local climatic conditions of Shahjahanpur, U.P., India.

MATERIAL AND METHOD

A field experiments was conducted on the experimental farm of Gandhi Faiz-e-Aam College, Shahjahanpur. U.P. India in order to study the effect of three levels of nitrogen on the three species of *Ocimum* namely *Ocimum sanctum* (S_1), *Ocimum basilicum* (S_2) and *Ocimum amaricanum* (S_3). The aim of the experiment was to find out the best dose of nitrogen fertilization and better species adapted to the local conditions with regards to their growth and yield characteristics. Seeds were procured from Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow, U.P. India. Healthy seeds of uniform size were surface sterilized with 90% ethanol. After repeated washing with water and sterilization, the viability of seeds for germination was also tested by tetrazolium salts. The soil of the experiment was sandy loam with pH 7.9 to 8.01, electric conductivity 1.01 to 2.23 ds/m, available average nitrogen 82 to 320 kg/ha, phosphorous 1.4 to 18 kg/ha, potash 3.1 to 19 kg/ha. First ploughing of the field was done in the month of February for the maximum aeration and eradication of weeds. After that the field was irrigated and ploughed once more to maintain the uniform moisture content in the soil and to eradicate the weeds completely. Thereafter, nursery of 1 × 1 m was prepared by mixing soil, sand and compost in the ratio of 3:1:1. The seeds were sown in the rows at a distance of 5 cm. Proper care of seedlings were taken until they become 45 days old. Experimental plots of 5 sq m size were prepared separately for transplanting the 45 days seedlings. The seedlings were transplanted in the rows with the space of 30 × 30 cm in 2 × 2.5 sq m plots. Each treatment was replicated thrice and the seeds were sown by the usual behind the plough method. In this experiment nitrogen was applied in three levels at the rate of 50 (N_1) 100 (N_2) and 150 (N_3) kg /ha. A control (N_0) was also maintained without nitrogen for the reference. Nitrogen was applied in the form of urea in 3 split doses. The first 1/3 of nitrogen was applied one week after transplanting the seedlings. Remaining quantity of nitrogen was applied in two equal splits, after 30 and 45 days after transplanting (DAP). A uniform basal dose of P and K were also given prior to planting at rate of 20 kg P/ha and 30 kg K/ha in the form of super phosphate and muriate of potash respectively. The crop was irrigated immediately after transplanting for successful establishment of seedlings and the subsequent irrigations were given when required. Weeding was done when required during the entire course of growth of the plants. Growth attributes recorded at 50, 70 and 90 DAP *viz.*, plant height, number of branches, fresh and dry herb yield. To study the yield parameters like oil content, seed and oil yield, the plants were harvested at full blooming stage (90-95 DAP). Determination of oil content in fresh plant herbs was done only at 90 DAP by using Clevenger's apparatus (1928).

Statistical Analysis

The experimental data were analyzed by adapting analysis of variance (ANOVA) technique with respect to design of the experiment according to Gomez and Gomez (1984), where 'F' value was found to be significant at 5% level of probability. Critical difference (C.D.) was also calculated.

RESULTS AND DISCUSSION

Growth Parameters

This experiment was conducted to find out the effect of nitrogen fertilizers on vegetative characteristics and yield attributes of three species of *Ocimum*. In the present study, basal application of nitrogen proved significantly effective on various parameters studied. Among the applied doses of nitrogen, N_3 (150 kg N/ha) proved the best by causing maximum stimulation. It is evident from Table 1 that different doses of nitrogen at the rate of 50, 100 and 150 kg N/ha showed a gradual increase in plant height as compared to control at all the sampling stages. N_3 proved best and gave maximum plant height of 30.57, 57.32, 66.74 cm at 50, 70 and 90 DAP respectively which was followed by N_2 and N_1. All the treatments were significantly different from each other. The treatments N_3, N_2 and N_1 gave 99.74, 78.84 and 50.02%; 67.65, 50.68 and 29.13% and 77.70, 60.89 and 33.97% more plant height than control at 50, 70 and 90 DAP respectively. Regarding species tested, it was found that all the three species were significantly different from each other. Variety S_3 gave the maximum plant height i.e. 28.16 cm, 53.37 cm and 60.73 cm at 50, 70 and 90 DAP respectively which was followed by S_2 and the minimum value was recorded in S_1 and species S_3 showed an increase in the plant height of 46.89 percent, 31.81 percent 30.29 percent over S_1 at 50, 70 and 90 respectively. Interaction studied showed that $S_3 \times N_3$ gave the maximum value of plant height which was significantly higher from rest of the interactions at all the sampling stages. Moreover, the interaction $V_3 \times N_3$ was followed by $V_2 \times N_3$ and $V_3 \times N_2$ which were with each other at all the sampling stages. Rest of the interactions was found to be significantly different from each other. The shortest plants were obtained in the interaction $V_1 \times N_0$. Similar results were also reported by (Singh and Ramesh 2002, Badran and Safwat 2004 and Swaefy *et al.* 2007). As far as the number of branches is concerned, it is evident from the table 2 that all the treatments were at par with each other but significantly superior over control. The nitrogen application of N_3, N_2 and N_1 gave 90.10, 44.29 and 80.35 percent more branches over control at 50, 70 and 90 DAP respectively. Among the tested species, S_3 species gave an increase in the number of branches per plant over S_1 at all the sampling stages. The interaction between $S_3 \times N_3$ again proved the best followed $S_3 \times N_2$ and $S_3 \times N_1$ at all stages of sampling. The present observations are in very close conformity with findings of Priyasharan *et al.* (2001), Mohamed and Ahmed (2003) and Swafey *et al.* (2007), Azzaz *et al.* (2009). It is revealed from Table 3 that fresh herb yield increased significantly at all the sampling stages by nitrogen treatment over the control and among each other and again the treatment N_3 proved to be the best followed by N_2 and N_1. The treatment N_3 gave 123.74, 275.6 and 134.27% more fresh weight over the control at 50, 70 and 90 DAP respectively. As for as species are concerned, S_3 showed the best response and gave 149.63, 77.60, 47.31% more fresh herb yield than S_1 at 50, 70 and 90 DAP respectively. Interaction $S_3 \times N_3$ gave 27.06 g fresh herb yield which was significantly more from rest of the interactions. Interaction $S_1 \times N_0$ gave the poorest response in this regard. The stimulation effects of nitrogen on vegetative growth may be attributed to the well known facts that nitrogen is involved in many organic compounds of the plant. The enhancing effect of N-fertilization on plant growth may be due to its positive effects on activation of photosynthesis and metabolic processes of organic compounds in plants which, in turn, encourage plant vegetative growth. Increase in fresh herbage yield with various applications of nitrogen is well established (Agamy 2004, Hasan *et al.* 2007 and Mauyo *et al.* 2008).

Data in the table 4 indicated that the higher dose of nitrogen N_3 gave maximum dry yield of 4.18 g followed by N_2 and N_1. All the treatments were significantly different from each other. The treatment N_3 gave 127.20, 266.75 and 127.55% more dry herb yield over the control at 50, 70 and 90 DAP respectively. Similar findings were also reported by Zheljazkov *et al.* (2008). As for as species are concerned all three species differ from each other significantly with S_3 showed the best result which gave 76.59, 90.88 and 54.63% higher dry herb yield over S_1. The interaction effect of $S_3 \times N_3$ proved to be best and significantly different from rest of the interactions at all the sampling stages which gave 6.18, 14.38 and 16.88 g dry herb yield at 50, 70 and 90 DAP respectively. However, $S_1 \times N_0$ proved to be the poorest at all the sampling stages. Our data are in agreement with previous studies, which reported an enhancement of fresh or dried yield in *O. americanum*, *O. canum* and *O. basilicum,* under the influence of nitrogen fertilizers (Sarrou *et al.* 2016).

Among the various growth characteristics, dry weight has been the most important character as all the physiological activities ultimately exert its effect in the form of dry matter accumulation (Sajjad, 2016). Growth and development of plants are highly dependent on its genetic constitution and environment including nutrient management of the soil. Nitrogen is the major factor of all growth parameters and the yields of crop plants are directly proportional to the percentage of nitrogen present in their whole dry matter (Singh *et al.* 2016). It is present as a key constituent in a number of metabolites like amino acids, chlorophylls, co-enzymes, enzymes, proteins, purines and pyrimidines (Salisbury and Ross, 1992; Marschner, 2002). Moreover, nitrogen also activates the enhancement of cytokinin level which affects the extension of cell wall (Arnold *et al.* 2006). It is therefore, concluded that nitrogen was involved directly or indirectly in the enlargement and division of new cells and production of tissues which in turn were responsible for increase in growth characteristics. The present findings are in agreement with the findings of Badran and Safwat (2004), Haque *et al.* (2007a), Azzaz *et al.* (2009) and Frabboni *et al.* (2011).

Table 1: Effect of nitrogen on plant height (cm) of three species of *Ocimum*

	Days after Transplanting (DAP)														
	50					70					90				
Species	N_0	N_1	N_2	N_3	**Mean**	N_0	N_1	N_2	N_3	**Mean**	N_0	N_1	N_2	N_3	**Mean**
S_1	14.94	18.15	21.05	22.53	19.17	28.44	39.08	45.38	49.05	40.49	34.38	43.91	52.29	55.88	46.61
S_2	14.59	25.09	28.30	33.55	25.38	33.29	43.57	52.12	57.13	46.53	36.69	51.59	61.05	68.96	54.57
S_3	16.39	27.93	32.71	35.61	28.16	40.83	49.81	57.06	65.77	53.37	42.26	56.29	68.99	75.37	60.73
Mean	15.30	23.72	27.36	30.57		34.19	44.15	51.52	57.32		37.77	50.60	60.77	66.74	

CD (Critical Difference) at 5%			
CD for S	0.48	0.28	0.55
CD For N	0.56	0.32	0.63
CD for S × N	0.97	0.56	1.09

Table 2: Effect of nitrogen on number of branches per plant of three species of *Ocimum*

	Days after Transplanting (DAP)														
	50					70					90				
Species	N_0	N_1	N_2	N_3	**Mean**	N_0	N_1	N_2	N_3	**Mean**	N_0	N_1	N_2	N_3	**Mean**
S_1	3.01	3.83	4.10	3.83	3.69	5.67	6.33	7.67	7.00	6.67	7.00	9.67	12.33	13.00	10.50
S_2	2.31	5.14	5.19	5.74	4.59	8.33	9.67	10.33	9.00	9.33	8.00	11.33	14.33	14.67	12.08
S_3	3.19	6.01	5.74	6.56	5.38	9.33	13.33	13.33	17.67	13.42	14.00	16.33	19.67	24.67	18.67
Mean	2.83	4.99	5.01	5.38		7.78	9.78	10.44	11.22		9.67	12.44	15.44	17.44	

CD (Critical Difference) at 5%			
CD for S	0.47	0.53	0.79
CD For N	0.55	0.61	0.91
CD for S × N	0.95	1.06	1.58

Yield Parameters

The ultimate goal of all agronomical practices is to get the maximum productivity of the crop. Yield is the final manifestation of any agricultural practices. High yield of crop can be achieved only when a proper combination of species, nutrients and agronomic practices are adapted (Mohammed et.al 1987). In the present study increasing dose of nitrogen gradually enhanced seed and oil yield of all *Ocimum* species but the oil content registered a decline when highest dose of nitrogen (150 kg/ha) was applied. These results are consistent with the results reported by Yadav (1984) and El Gendy (2015). Considering the effect of nitrogen, it was found that all nitrogen treatments gave significantly different results. The treatment N_3 proved to be the best and produced maximum seed yield of 84.58 kg/ha, which was 59.49% higher than control (N_0). Species S_3 produced 80.36 kg/ha seed yield which was 22.33% higher than S_1 which is the poorest performer. Interaction results revealed that $S_3 \times N_3$ resulted into maximum seed yield of 90.34 kg/ha. The interactions $S_3 \times N_2$ and $S_3 \times N_1$ were at par while the rest interactions were statistically different from each other. The interaction $S_1 \times N_0$ gave the poorest result which produced 50.24 kg/ha seed yield only (table 5). A positive effect of nitrogen on seed yield was also reported by several Farm Scientists (Sharaf and Khattab 2004, Hasan *et al.* 2007 and Navid *et al.* 2009). As far as the oil content is concerned, the treatment N_2 proved to be best and produced maximum oil content which was at par with N_3. In case of species, S_3 produced maximum oil content of 16.74% which is an increase of 9.84% higher than S_1 which is the poorest performer. The interactions results showed that $S_3 \times N_3$ resulted in maximum oil content of 17.89% followed by $S_3 \times N_2$. The interaction $S_1 \times N_0$ proved to inferior among all interactions. Hasan *et al.* (2007) also reported that increasing dose of nitrogen increased the herb yield but showed a decline in the essential oil content of *Ocimum baslilicum*. Sawan *et al.* (2007) and Swaefy *et al.* (2007) also reported similar findings regarding oil content. The enhancement effect of nitrogen as basal dressing on essential oil content could be ascribed to the pivotal roles played by it in plants. Ram *et al.* (1995) stated that the enhancement in biomass yields per unit area, leaf area development and photosynthetic rate due to nitrogen applications resulted in increased oil content and yield in aromatic plants. Results of the present study are also supported by the findings of Singh *et al.* (2016). Many other workers have also reported the similar findings on various crops (Mohamed and Ahmed, 2003; Abdou and Mahmoud, 2003 and Badran and Safwat, 2004 and Shaalan, 2005). Like other yield parameters**,** oil yield was also significantly affected by fertilizer treatments, species response and their interactions (Table 5). Out of the various applications of nitrogen, N_3 being significantly different from other treatments gave maximum oil yield of 15.83 kg/ha. The treatments N_1, N_2 and N_3 gave an increase of 56.66, 80.28 and 82.64% higher oil yield over control (N_0) respectively. Considering the species response, S_3 proved to be the best which produced oil yield of 13.66 kg/ha which is 35.38% more than S_1. Interaction effect of $S_3 \times N_3$ yielded significantly higher oil yield than any interactions and produced 127.93% higher oil yield than $V_1 \times N_0$ which showed poorest result for this parameter. A positive role of nitrogen on oil yield was also reported by Singh and Ramesh (2002) and Omer *et al.* (2008). From the above results and discussions, it is clear that the highest dose of nitrogen proved best for most of the growth parameters. The photosynthates accumulated in vegetative parts (source) are finally translocated to seeds (sink) and hence, maximum seed yield was also obtained with same dose of nitrogen. Singh and Singh (1977) and Sajjad (2016) have found linear relationship between dry matter and seed yield of mustard.

Table 3: Effect of nitrogen on fresh herb yield per plant (gm) of three species of *Ocimum*

	Days after Transplanting (DAP)														
	50					70					90				
Species	**N_0**	**N_1**	**N_2**	**N_3**	**Mean**	**N_0**	**N_1**	**N_2**	**N_3**	**Mean**	**N_0**	**N_1**	**N_2**	**N_3**	**Mean**
S_1	6.07	7.64	8.60	10.26	8.14	9.55	17.76	22.10	27.67	19.27	19.02	25.26	33.16	40.70	29.55
S_2	6.74	9.40	11.24	17.53	11.23	11.33	21.06	33.28	45.59	27.81	21.91	30.49	37.54	52.42	35.59
S_3	11.69	19.34	23.20	27.06	20.32	15.20	25.86	45.25	53.49	34.20	26.60	36.34	46.86	64.31	43.53
Mean	8.17	12.13	14.35	18.28		12.03	21.56	33.54	42.25		22.53	30.69	39.19	52.48	

CD (Critical Difference) at 5%			
CD for S	0.30	0.35	0.22
CD For N	0.35	0.40	0.26
CD for S × N	0.59	0.70	0.44

Table 4: Effect of nitrogen on dry herb yield per plant (gm) of three species of *Ocimum*

	Days after Transplanting (DAP)														
	50					70					90				
Species	**N_0**	**N_1**	**N_2**	**N_3**	**Mean**	**N_0**	**N_1**	**N_2**	**N_3**	**Mean**	**N_0**	**N_1**	**N_2**	**N_3**	**Mean**
S_1	1.40	1.76	1.97	2.35	1.87	2.24	4.22	5.48	6.94	4.72	5.05	6.50	8.05	9.98	7.41
S_2	1.59	2.16	2.57	4.00	2.58	2.86	5.21	8.25	11.30	6.90	5.68	7.89	10.34	13.29	9.30
S_3	2.67	4.40	5.29	6.18	4.64	3.80	6.45	11.39	14.38	9.01	6.91	9.39	12.65	16.88	11.46
Mean	1.89	2.77	3.28	4.18		2.96	5.29	8.37	10.87		5.88	7.95	10.35	13.38	

CD (Critical Difference) at 5%			
CD for S	0.09	0.10	0.12
CD For N	0.10	0.11	0.14
CD for S × N	0.18	0.19	0.23

Table 5: Effect of nitrogen on seed yield, oil content and oil yield of three species of *Ocimum*

	Seed Yield					Oil Content					Oil Yield				
Species	N_0	N_1	N_2	N_3	**Mean**	N_0	N_1	N_2	N_3	**Mean**	N_0	N_1	N_2	N_3	**Mean**
S_1	50.24	60.71	74.52	77.29	65.69	14.12	15.45	15.56	15.81	15.24	7.09	9.38	11.65	12.23	10.09
S_2	53.66	73.06	85.91	86.12	74.69	14.88	16.10	16.42	15.77	15.79	7.98	11.76	14.10	13.58	11.86
S_3	55.20	87.15	88.75	90.34	80.36	14.34	17.05	17.67	17.89	16.74	7.92	14.86	15.68	16.16	13.66
Mean	53.03	73.64	83.06	84.58		14.45	16.20	16.55	16.49		7.66	12.00	13.81	13.99	

CD (Critical Difference) at 5%

	Seed Yield	Oil Content	Oil Yield
CD for S	0.95	0.05	0.15
CD For N	1.10	0.06	0.18
CD for S × N	1.90	0.11	0.31

CONCLUSION

It may be concluded from the present study that basal application of nitrogen ameliorated the overall performance of *Ocimum* crop. The results suggest that application 150 kg N/ha proved best for enhancing over all crop productivity. The increase in fresh herb yield induced by N application has positive effects on the commercial value of basil due to the increase in number of branching per plant. Considering the other parameters which directly linked to the economic results (seed and oil yield), we found that 150 kg N/ha and *Ocimum amaricana* ensure better growth and yield under local conditions, which ultimately beneficial for the farmers as well as the nation.

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