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INFLUENCE OF FARM YARD MANURE AND INORGANIC NITROGEN USE ON GROWTH AND YIELD OF KALE (*Brassica oleracea* var. *acephala)*

Fozia Qureshi*, Javaid Ahmad Wani and Uzma Bashir

Division of Soil Science, S.K. University of Agricultural Science and Technology of Kashmir, Shalimar, Srinagar - 191 121, Jammu & Kashmir (India)
*e-mail: *foziasoil@gmail.com*

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ABSTRACT

An experiment was carried out in two consecutive *rabi* (winter) seasons of 2010 and 2011 on a silty clay loam soil to study the influence of four levels of farm yard manure {FYM} viz., 0, 15, 30 and 45 t ha^{-1} and four levels of inorganic nitrogen viz., 0, 45, 90 and 135 kg ha^{-1} on growth, yield attributes and quality of kale (*Brassica oleracea* L. var. *acephala*). Application of 45 t FYM ha^{-1} significantly increased growth and yield attributing characters of kale viz., plant height, plant spread, number of leaves, leaf yield plant^{-1}, whole plant weight and leaf yield. Nitrogen @ 135 kg ha^{-1} significantly increased all growth and yield parameters. The use of FYM @ 30 t ha^{-1} in combination with 90 kg N ha^{-1} increased the growth and yield attributing characters of kale. The highest nitrogen uptake, nitrogen and protein content was recorded in kale under the treatment receiving 45 t FYM ha^{-1} in combination with 135 kg N ha^{-1}. Kale crop receiving 30 t FYM along with 90 kg N ha^{-1} seemed to be the best combination in getting maximum growth and yield under temperate conditions of Kashmir.

Key words: FYM, growth, kale, inorganic nitrogen, interaction effect, yield attributes

INTRODUCTION

Kale (*Brassica oleracea* L. var. *acephala)* is one of the important green leafy vegetable, belonging to the family *Brassicaceae* (Korus and Lisiewska, 2011). Kale is a low-calorie leafy vegetable which contains high concentration of dietary fibre, glutamine and plant phytochemicals like polyphenol, flavonoids and carotenes (Ahmad and Beigh, 2009; Fadigas *et al*., 2010). It also contains vitamins (mainly vitamin C, E and K) and nutrients like calcium, magnesium, iron, zinc and manganese. Daily consumption of leafy vegetables lowers the risk of cancer and heart diseases, prevents tiredness, helps keeping well condition and prevents senescence (Kolton and Baran, 2008). In India, the crop is commercially grown in Jammu & Kashmir, Assam and Himachal Pradesh. In Jammu & Kashmir, it is a popular vegetable crop grown in almost all kitchen gardens as well as on commercial scale.

The application of fertilizers not only affects the yield but also the nutritional qualities of produce. The nutritional quality induced by different fertilizers is related to the chemical constituents of the fertilizers and, of these, nitrogen plays a dominant role. Nitrogen deficiency is a limiting factor for plant growth. But the excessive use of nitrogen fertilizers although guarantees good yield but simultaneously increases the risk of nitrate accumulation, since accumulation of nitrate in plants occurs when the nitrate uptake exceeds its reduction and assimilation. Nutritional and physiological factors play vital role in the accumulation of nitrate in plants. Nitrogen fertilization has been identified as major factors that influence the nitrate content in vegetables. Nitrogen application significantly increases growth components viz., plant height, number of leaves, etc.; and thereby enhances the broccoli yield (Ouda and Mohadeem, 2008). Organic manure plays a direct role in plant growth as a source of all necessary

macro- and micro-nutrients in available form during mineralization and improves physical and physiological properties of soil. FYM use reportedly increased vegetative growth, yield and quality of broccoli (Abu-El Magd *et al.*, 2006; Kandil *et al.*, 2008). A combination of FYM and inorganic nitrogen affects the quality of kale to the maximum extent (Naik and Gupta, 2010). Wani (2006) reported integrated use of organic manure and inorganic nitrogen as a better option for improving growth and yield attributing characters in cauliflower. Hence, the present study was aimed to assess the effect of FYM and inorganic nitrogen on growth, yield attributes and quality of kale under temperate conditions of Kashmir.

MATERIALS AND METHODS

Field experiment was carried out at the Experimental Farm of SKUAST-Kashmir, Shalimar, Srinagar (J&K) which lies between 340°.8/ N latitude and 74°.83 / E longitude at an altitude of 1587 m amsl. The experimental site had silty clay loam soil with pH 6.97, organic carbon 0.90% and available N, P and K 232.50, 19.25 and 212.20 kg ha^{-1}, respectively. The treatments comprized of four levels of farm yard manure (FYM) viz., 0.15, 30 and 45 t FYM ha^{-1} and four levels of inorganic nitrogen viz., 0, 45, 90 and 135 kg ha^{-1}. The experiment, conducted in two consecutive *rabi* (winter) seasons of 2010 and 2011, was laid out in a complete randomized block design with each treatment replicated three times. The crop was transplanted on 19th September, 2010 and 3rd September, 2011 and harvested on 9th December, 2010 and 21st November, 2011, respectively.

The FYM was prepared from animal and farm wastes in open pits at the university farm. It contained 0.47% N, 0.27% P and 0.43% K and was applied as per the treatment 15 days prior to plant transplantation. Full dose of P and K was applied uniformly to the plots and half dose of N to each plot as per treatment. The remaining dose of N was applied 30 days after plant transplantation. The plant spacing was maintained at 15 cm x 30 cm. The plants were harvested on 9th December, 2010 and 21st November, 2011. The growth parameters viz., plant height and number of leaves $plant^{-1}$ was recorded from five randomly tagged plants in each treatment. Plant spread of five randomly selected plants was measured from north to south and east to west directions with the help of meter scale and the average plant spread worked out. Yield parameters viz., leaf weight $plant^{-1}$, whole plant weight (excluding roots) and leaf yield were recorded. The nitrogen content in kale was determined by micro-Kjeldhal's method (Jackson, 1973) and protein content worked out by multiplying it with a factor of 6.25 (Tai and Young, 1974). Uptake of nitrogen was computed by multiplying total nutrient concentrations with corresponding crop yield. The experimental data were analyzed statistically by using analysis of variance technique (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth parameters

The application of increased levels of FYM to kale significantly enhanced plant height, plant spread and number of leaves over control (Table 1). Highest plant height, plant spread and number of leaves $plant^{-1}$ were recorded in treatment 45 t FYM ha^{-1} as compared to other treatments. Significant increase was noticed in all the growth attributes in kale when FYM was applied. It appears that growth may have been accelerated by the assimilation of more nutrients made available through FYM. These results are in line with Sharma and Dayal (2005). Plant height, plant spread and number of leaves showed significant and consistent improvement with increase in inorganic nitrogen levels from 0 to 135 kg ha^{-1} (Table 1). The inorganic nitrogen application significantly increased plant height, plant spread and number of leaves. It may be attributed to the positive effect of nitrogen on leaf production that led to the progressive increase in height. These results are in agreement with Gulser (2005). Significant interaction was observed between FYM and inorganic nitrogen with maximum growth in treatment combination $F_{45}N_{135}$ in both the years 2010 and 2011, followed by $F_{45}N_{90,}$ $F_{30}N_{135}$ and $F_{30}N_{90.}$ Integration

of FYM and inorganic nitrogen exhibited an increase in growth related attributes of kale, probably due to the balanced C/N ratio, better organic matter build up, efficient microbial activity, better root proliferation, abundant supply and availability of soil nutrients, more translocation of nutrients to aerial parts for protoplasmic proteins and synthesis of other compounds (Wani, 2006). The results are in conformity with Ghuge *et al*. (2007) and Maurya *et al*. (2008).

Table 1: Effect of FYM and inorganic nitrogen on plant height, plant spread and number of leaves plant^{-1} of kale during the two cropping seasons

Treatments	Plant height (cm)		Plant spread (cm)		No of leaves plant^{-1}	
	2010	2011	2010	2011	2010	2011
FYM levels						
F_0	41.03	42.09	48.65	49.02	11.38	11.22
F_{15}	43.98	44.40	50.82	52.06	12.42	12.53
F_{30}	45.98	46.93	53.57	54.51	13.34	13.50
F_{45}	47.30	48.02	55.13	56.19	13.78	13.96
$CD_{0.05}$	0.57	0.63	0.80	0.85	0.43	0.44
Inorganic N levels						
N_0	37.79	38.15	41.99	42.89	9.71	9.76
N_{45}	43.85	44.84	51.88	52.69	12.59	12.73
N_{90}	47.41	48.26	56.27	57.20	13.95	13.99
N_{135}	49.25	50.19	58.03	58.98	14.67	14.73
$CD_{0.05}$	0.57	0.63	0.80	0.85	0.43	0.44
Interaction effect						
F_0N_0	35.23	35.01	40.02	38.92	9.05	8.98
F_0N_{45}	39.45	40.78	47.95	48.38	10.58	10.32
F_0N_{90}	43.00	44.87	51.87	52.64	12.21	12.12
F_0N_{135}	46.44	47.70	54.75	56.12	13.66	13.47
$F_{15}N_0$	37.39	37.87	41.10	42.84	9.56	9.58
$F_{15}N_{45}$	43.73	44.44	50.27	51.82	12.65	12.94
$F_{15}N_{90}$	46.21	46.02	54.87	55.96	13.52	13.52
$F_{15}N_{135}$	48.60	49.25	57.03	57.60	13.93	14.08
$F_{30}N_0$	38.01	39.05	42.87	43.94	9.91	9.90
$F_{30}N_{45}$	45.09	46.12	52.57	53.57	13.23	13.63
$F_{30}N_{90}$	49.98	50.76	58.87	59.96	14.95	15.05
$F_{30}N_{135}$	50.85	51.78	59.98	60.96	15.28	15.42
F_{45} N_0	40.54	40.65	43.95	45.87	10.31	10.58
F_{45} N_{45}	47.12	48.03	56.73	56.98	13.90	14.04
$F_{45}N_{90}$	50.43	51.40	59.46	60.64	15.11	15.28
$F_{45}N_{135}$	51.11	52.01	60.37	61.25	15.80	15.93
$CD_{0.05}$	1.15	1.27	1.60	1.72	0.84	0.89

Yield parameters

Leaf weight plant^{-1}, whole plant weight and leaf yield of kale during 2010 and 2011 recorded significant and consistent increase with increase in FYM levels from 0 to 45 t ha^{-1} (Table 2). Increase in leaf yield due to FYM may be due to its beneficial effects on soil and plant by making sufficient amounts of nutrients available to the plant throughout the growth period resulting in better uptake, plant vigour and superior yield attributes (Shivakumar and Ahlawat, 2008). Application of inorganic nitrogen significantly increased the leaf weight plant^{-1}, whole plant weight and leaf yield upto 135 kg ha^{-1} (Table 2). Since nitrogen is an essential constituent of plant tissue and is involved in cell division and cell elongation, its beneficial effect on growth characters viz., plant height, plant spread and number of leaves appears to have contributed to the higher yield. These observations corroborate with the findings

of Boteva (2009). Significantly higher leaf weight plant^{-1}, whole plant weight and leaf yield of kale was recorded in treatment combination $F_{45}N_{135}$ which differed significantly with all the other treatments (Table 2) but was at par with $F_{45}N_{90}$, $F_{30}N_{135}$ and $F_{30}N_{90}$. This could be due to the balanced C/N ratio, more organic matter build up, enhanced microbial activity, improvement in soil properties, better root proliferation, availability and accelerated transport and higher concentration of plant nutrients. All these might have accelerated metabolic activities leading to better photosynthesis and efficient translocation of photosynthates from sink to sources, resulting in improvement in leaf yield and its related attributes. The results are in line with the findings of Kropisz (1992), Felczynski (2004) and Ouda and Mohadeen (2008).

Table 2: Effect of FYM and inorganic nitrogen on leaf weight, weight of whole plant and leaf yield of kale during the two cropping seasons

Treatments	Leaf yield (g plant^{-1})		Weight of whole plant (g)		Leaf yield (q ha^{-1})	
	2010	2011	2010	2011	2010	2011
FYM levels						
F_0	216.69	215.90	260.35	259.63	433.38	431.81
F_{15}	242.70	245.64	290.64	294.77	486.14	491.29
F_{30}	260.66	266.39	314.59	321.19	522.67	532.77
F_{45}	277.26	281.23	332.00	341.24	552.42	562.46
$CD_{0.05}$	6.30	6.40	8.41	8.80	12.56	13.01
Inorganic N levels						
N_0	189.59	188.15	221.28	221.09	379.19	376.30
N_{45}	245.56	247.95	293.88	298.14	490.37	495.50
N_{90}	274.77	278.21	332.43	338.94	548.18	556.42
N_{135}	287.38	294.86	350.48	358.66	576.86	589.72
$CD_{0.05}$	6.30	6.40	8.41	8.80	12.56	13.01
Interaction effect						
F_0N_0	162.50	159.50	182.69	178.21	325.00	319.00
F_0N_{45}	198.63	194.04	241.47	239.04	397.25	388.07
F_0N_{90}	236.83	238.80	288.23	291.45	473.65	477.59
F_0N_{135}	268.80	271.29	329.01	329.83	537.60	542.57
$F_{15}N_0$	177.38	174.51	207.72	206.58	354.75	349.01
$F_{15}N_{45}$	247.95	253.53	295.49	302.09	495.89	507.05
$F_{15}N_{90}$	268.40	268.17	323.83	324.04	536.80	536.33
$F_{15}N_{135}$	277.06	192.06	335.54	346.38	557.12	572.76
$F_{30}N_0$	194.38	264.17	229.38	229.49	388.75	384.11
$F_{30}N_{45}$	257.11	299.66	308.10	314.29	514.22	528.34
$F_{30}N_{90}$	292.06	309.66	355.08	365.09	584.12	599.32
$F_{30}N_{135}$	299.08	309.667	365.79	375.89	603.57	619.32
F_{45} N_0	224.13	226.54	265.34	270.07	448.25	453.08
F_{45} N_{45}	278.56	280.06	330.48	337.15	554.12	560.12
$F_{45}N_{90}$	310.79	306.22	362.58	375.20	598.15	612.44
$F_{45}N_{135}$	304.58	312.11	371.58	382.54	609.15	624.21
$CD_{0.05}$	12.61	12.81	16.80	17.62	25.12	26.05

Quality parameters

A perusal of data (Table 3) revealed that application of graded doses of FYM to kale significantly enhanced the nitrogen content and uptake over control. Application of 45 t FYM ha^{-1} increased the nitrogen content and uptake of kale to the tune of 12.20 and 84.29% in the year 2010 and 16.09 and 103.59% in the year 2011 over control. This increase might be due to the enhanced microbial population of N fixing microorganisms due to available organic carbon as well as mineralization of

organic nitrogen. FYM also provides absorption, which resulted in higher nutrient content of kale. This was supported by the findings of Brar *et al*. (2001). Application of inorganic nitrogen significantly increased the nitrogen content and uptake of kale upto 135 kg ha^{-1} over no inorganic nitrogen application. This apparent effect of nitrogen in increasing the nitrogen content and uptake might be attributed to the positive effect of chemical fertilizers on cell division, increased root hairs and root elongation of plant through which it may explore wider area for nutrient absorption leading to the higher nutrient concentration in plant. The increased nitrogen uptake with nitrogen fertilization might be attributed to the increase in symbiotic nitrogen fixation and higher availability of nutrient to the crop (Devi *et al.,* 1999). Interaction effect of FYM and inorganic nitrogen on nitrogen content and uptake was significant during both the years. Application of 45 t FYM along with 135 kg N ha^{-1} gave significantly higher nitrogen content and uptake over control. The magnitude of increase in this case was 45.31 and 184.64% and 50.76 and 220.68 % in 2010 and 2011. It may be inferred that when organics are applied along with inorganic fertilizers to soil, complex nitrogenous compounds slowly break down and make steady nitrogen supply throughout the growth period of crop, which might have attributed to more availability and its subsequent uptake by the crop (Liu and Li, 2003).

Table 3: Effect of FYM and inorganic nitrogen on nitrogen content, nitrogen uptake and crude protein content of kale during the two cropping seasons

Treatments	Nitrogen content (%)		Nitrogen uptake (kg ha^{-1})		Crude protein (%)	
	2010	2011	2010	2010	2010	2011
FYM levels						
F_0	2.155	2.205	106.77	110.89	13.47	13.78
F_{15}	2.010	2.337	139.76	152.33	13.97	14.61
F_{30}	2.325	2.430	167.48	184.39	14.53	15.19
F_{45}	2.418	2.560	196.77	225.77	15.11	16.00
$CD_{0.05}$	0.004	0.006	3.12	4.02	0.25	0.30
Inorganic N levels						
N_0	1.995	2.050	114.19	119.46	12.47	12.81
N_{45}	2.183	2.297	145.52	160.44	13.64	14.36
N_{90}	2.363	2.474	164.90	184.50	14.77	15.46
N_{135}	2.593	2.712	186.18	208.98	16.20	16.95
$CD_{0.05}$	0.004	0.006	3.12	4.02	0.25	0.25
Interaction effect						
F_0N_0	1.920	1.950	82.99	85.84	12.00	12.19
F_0N_{45}	2.070	2.128	97.11	99.01	12.94	13.30
F_0N_{90}	2.250	2.278	115.20	118.26	14.06	14.24
F_0N_{135}	2.380	2.465	131.79	140.43	14.88	15.41
$F_{15}N_0$	1.960	2.010	100.19	104.74	12.25	12.56
$F_{15}N_{45}$	2.150	2.260	138.60	150.12	13.44	14.13
$F_{15}N_{90}$	2.300	2.437	151.12	168.35	14.38	15.23
$F_{15}N_{135}$	2.530	2.642	169.14	186.13	15.81	16.51
$F_{30}N_0$	2.010	2.080	121.35	123.52	12.56	13.00
$F_{30}N_{45}$	2.210	2.320	157.74	174.55	13.81	14.50
$F_{30}N_{90}$	2.410	2.520	183.29	205.4	15.06	15.75
$F_{30}N_{135}$	2.670	2.800	207.57	234.1	16.69	17.50
F_{45} N_0	2.090	2.160	152.24	163.73	13.06	13.50
F_{45} N_{45}	2.300	2.480	188.62	218.09	14.38	15.50
$F_{45}N_{90}$	2.490	2.660	210.00	245.99	15.56	16.63
$F_{45}N_{135}$	2.790	2.940	236.23	275.28	17.44	18.38
$CD_{0.05}$	0.008	0.012	6.25	8.05	0.51	0.62

The protein content increased significantly with increase in the levels of FYM with highest protein content observed with the application of 45 t FYM ha^{-1} i.e., 15.11 and 16.00% and lowest in control i.e., 13.47 and 13.78% during both the years (Table 3). Increased protein content could be assigned to the supplementation of soil reservoirs on mineralization of organic nitrogen and phosphorus of FYM as well as enhanced microbial activity of ammonifiers and phosphate solubilizes bacteria in soil due to organic carbon which might have increased root growth resulting in increased N and P contents and hence protein content (Singh *et al*., 2000). Protein content was significantly influenced by the application of inorganic nitrogen. The maximum protein content was recorded in treatment 135 kg N ha^{-1} which was 29.91% and 32.31% higher than control during both the years. The increase in protein content due to higher application of nitrogen results in the formation of more amino acid. The increase in protein content with nitrogen fertilization is in line with those of Mullins *et al*. (1998) and Mahmud *et al*. (2003). Protein content in kale increased significantly with application of FYM and inorganic nitrogen. Maximum increase of 17.44 and 18.38% in protein content was obtained when 45 t FYM and 135 kg N ha^{-1} was applied in combination. Increase in protein content may be attributed to the increase in nitrogen content and also to the role of phosphorus in energy storage and transfer in form of ADP to ATP which are essential for protein synthesis. Jain *et al*. (1995) also reported significant and positive impact of FYM on protein synthesis.

Conclusion: In the present study the individual and combined application of FYM and inorganic nitrogen showed significant effect on growth, yield and quality of kale. The leaf yield recorded in treatment combination 45 t FYM + 135 kg N ha^{-1} was superior to all other treatment combinations but was at par with $F_{45}N_{90}$, $F_{30}N_{135}$ and $F_{30}N_{90}$. Hence, it may be concluded that the treatment combination of 30 t FYM and 90 kg N ha^{-1} gives maximum growth and yield of kale. However, maximum nutrient content and protein are in treatment $F_{45}N_{135}$.

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