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Effect of different sources of nitrogen on various physiological parameters and their correlation with yield of cabbage (*Brassica oleracea* var. capitata L.)

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Abstract

A field experiment to study the effect of organic and inorganic sources of nitrogen on various physiological parameters of cabbage was conducted at Horticulture Farm, SKN College of Agriculture, Jobner. Results showed that the number of leaves, leaf area, photosynthesis, transpiration, stomatal conductance and chlorophyll content increased significantly with the integrated application of nitrogen as compared to control. The highest values for these parameters were recorded with the application of nitrogen 50% through urea + 50% through vermicompost. The yield increased maximally and significantly when nitrogen was supplied as 50% through urea + 50% through vermicompost. It is concluded that the application of 50% nitrogen through urea + 50% nitrogen through vermicompost registered a significant higher values of physiological parameters in cabbage which was followed by 50% nitrogen through urea + 50 % nitrogen through poultry manure.

Introduction

Cabbage (*Brassica oleracea* var. capitata L.) is one of the most important member of genus Brassica grown in world. It is the native of Western Europe and Northern shore of Mediterranean region (Thompson and Kelly, 1957). In India, this crop was introduced during Mughal period. Basically, cabbage is a slow growing biennial crop of temperate region. However, its cultivation is equally successful in tropical and sub-tropical regions. It is the most common vegetable crop available during winter all over India. The area under cabbage cultivation in India is 0.25 million hectares with annual production of about 5.29 million tonnes. (Anon., 2008).

It is well documented that growth, yield and quality of plants are greatly influenced by a wide range of nutrients. Nitrogen is an essential macronutrient which has great significance in plant growth, development and metabolism. Its availability is directly associated with vigorous vegetative growth and deep green colour of plants. Nitrogen is a constituent of several macro and micro molecules including amino acids, proteins, vitamins and nucleic acid and is found to be associated with carbohydrates utilization and protein biosynthesis. The deficiency of nitrogen leads to chlorosis, poor vegetative growth, reduced yield and quality of leafy vegetables (Singh, 1989). Deficiency of these major nutrients is quite common in most of the Indian soils (Arakeri et al., 1956). The soil of our region is sandy with high pH, low water holding capacity and deficient in nitrogen content. Therefore, application of nitrogen is essential in these soils for proper plant growth and development.

It is a well known that nitrogen increases the growth and yield of most of the crops, particularly leafy vegetables including the cabbage. Application of nitrogen through inorganic fertilizers can enhance the growth and yield to considerable extent but the soil fertility and productivity can not be retained for a longer period. Therefore, it is important to supplement the urea with inorganic sources of nitrogen. In Indian conditions, it is more important owing to the availability of sufficient F.Y.M., vermicompost and poultry manure in mixed farming system. The FYM is rich source of organic matter and able to replenish most of the macronutrients being taken up by crop (Abdel-Nasser and Hussein, 2001). Poultry manure is a concentrated source of nitrogen and other nutrients. It is well documented that it is an excellent source of organic manures which increases uptake of several nutrients (Abusaleha 1992; Jose *et al.*, 1988). Vermicompost means a mixture of worm casting, organic materials, humus, living earthworms, their cocoons and other organisms. Earthworm reduces the C:N ratio, increases humic acid, cation exchange capacity and water soluble carbohydrates (Talashilkar *et al.,* 1999).

Thus, the manures not only provide plant nutrients but also improve the soil physical and chemical properties by providing binding effect to soil aggregates. They also improve the cation exchange capacity, water holding capacity, and phosphate availability, fertilizer use efficiency and microbial activity in the soil. A low nitrogen loss due to slow release of nutrients from these organic manures is an added advantage of the application of organic manures (Abusaleha and Shanmugavelu, 1988).

Pillai *et al.* (1985) has reported that the integration of chemical fertilizers with manures can better maintain soil fertility and sustain crop productivity. In vegetable production, role of organic manures is more important than other cereal crops. Therefore, it is hypothesized that the yield and quality of cabbage can be enhanced to a great extent by application of nitrogen through a combination of urea with different organic sources of nitrogen.

Keeping all these points in mind, an investigation was conducted to evaluate the effect of organic and inorganic sources of nitrogen on some physiological parameters and their correlation with yield of cabbage (*Brassica oleracea* var. capitata L.)

Materials and Methods

The experiment was conducted on Golden Acre variety of cabbage at Horticulture Research Farm, S.K.N. college of Agriculture, Jobner. The climate of this region is semi-arid characterized by aridity of the atmosphere and extremity of temperature both in summer (45.5C) and winter (-1C). The average rainfall of this area is 500 mm, most of which occurs during the period of July to mid September. The soils of experimental site was loamy sand (85.2% samd 9.2% silt and 5.4% clay), pH of 8.0, electrical conductivity of 1.20 dS^{-1}, available carbon 0.16% and available N, P_2O_5 and K_2O of 130, 15.20 and 140 kg ha^{-1}, respectively.

The experiment was laid out in a Randomized Block Design (RBD) with three replications. The randomization of treatments was done with the help of random number table (Fisher, 1950). The treatments comprised total 17 combinations including control. The seeds were first raised in nursery and then transplanted in field after 6 weeks. The distance between plant to plant as well as row to row was kept at 45 cm. Nitrogen was applied at the rate of 150 kg ha^{-1} as per zonal recommendation. For treatments, nitrogen was supplied through FYM, vermicompost, poultry manure and urea. A full dose of FYM, vermicompost, poultry manure were applied at the time of transplanting, while urea was applied in two split doses i.e. half at the time of sowing and remaining half dose 30 days after transplanting. Phosphorus and potash were applied as basal in all plots @ 80 kg ha^{-1} P_2O_5 and 75 kg ha^{-1} K_2O through SSP and KCl, respectively. Standard practies were employed for all other inputs and inter-culture operation.

Five plants were randomly selected in each plot and tagged. The following observations were recorded from these plants.

Leaf area per plants (cm^2)

Leaf area per plant was measured directly with help of leaf area meter (LICOR-3100, Lincoln, USA). The fully expanded green leaves were detatched from the plants and leaf area was determined immediately to avoid wilting of leaves.

Photosynthesis, transpiration and stomatal conductance

Photosynthesis was measured by infra red gas analyzer (CID-301, Vancouver, USA). Top most expanded leaf was enclosed in the assimilation chamber and the rate was monitored at which the CO_2 concentration changed over a definite time interval. The system automatically calculated the rate of photosynthesis on the basis of preloaded flow and leaf area. The leaf transpiration rate and stomatal conductance were also measured directly by infra red gas analyzer (CID 301, Vancouver, USA) on the same leaf as described for the photosynthetic rate. All these measurements were taken at 10.00-11.00 in triplicates.

Chlorophyll content in leaves

Chlorophyll content was determined using the method of Hiscox and Israelstom (1979) with slight modifications. 50 mg fresh leaf material was used for chlorophyll estimation. The material was taken in test tube to which 5.0 ml DMSO was added. These tubes were tightly capped and placed in an oven at 60C for 6 h. Finally, the tubes were thoroughly shaken and extracted solvent was decantated to read at 645 and 663 nm in spectrophotometer (Systronics, India). The amount of total chlorophyll was calculated as advocated by Arnon (1949).

Yield and Yield attributes

Data on growth, yield and quality attribute recorded were subjected to randomized block design (RBD) as advocated by Fisher (1950). Analyses of variance were calculated and critical difference (CD) at 5% level of significance was tested through 'F' test as given in tables and appendices.

Results and Discussion

Leaf area

Table 1 shows that the application of nitrogen through various sources either alone or in combination significantly increased the leaf area at harvest. Application of nitrogen 50% through urea + 50% through vermicompost (T_8) registered maximum leaf area (2010.6 cm^2) and proved significantly superior to rest of the treatments. However, application of nitrogen 50% through urea + 50% through poultry manure (T_{12}) did not exhibit significant difference with T_8 where the leaf area was 1876.5 cm^2. It was further noted that treatments T_8 and T_{12} enhanced the leaf area by 38.3 and 29.1 per cent, respectively over control.

It is apparent from the data (Table 2) that there was a significant effect of different doses of organic and inorganic sources of nitrogen in improving the rate of photosynthesis over control at all growth stages.

Observations recorded at 30 days after transplanting revealed that application of different organic manures either alone or in combination with urea brought about perceptible variation in rate of photosynthesis of cabbage at 30 days after transplanting. The maximum rate of photosynthesis (62.32 mol CO_2 m^{-1} s^{-1}) was recorded with the application of nitrogen 50% through urea + 50% through vermicompost (T_8) followed by application of nitrogen 50% through urea + 50% poultry manure (T_{12}) where the photosynthesis rate was 59.35 mol CO_2 m^{-1} s^{-1}. Both the treatments were highly significant over rest of the treatments. The treatment T_8 and T_{12} increased the photosynthesis to the tune of 58.65 and 51.09 percent, respectively over control.

Data recorded at the time of harvesting further indicated (Table 2) that photosynthesis rate at harvest was significantly increased by the application of different organic and inorganic sources of nitrogen either alone or in combination over control. Application of nitrogen 50% through urea + 50% through vermicompost (T_8) was recorded maximum rate of photosynthesis (73.56 mol CO_2 m^{-1} s^{-1}), whereas it was at par with application of nitrogen 50% through urea + 50% poultry manure (T_{12}). It was proved a significantly increase of 60.08 percent over control.

It is obvious from the data (Table 2) that the rate of transpiration shows the positive response to the application of organic and inorganic sources of nitrogen either alone or in combination at 30 days after transplanting as well as at harvest.

At 30 days after transplanting, the rate of transpiration significantly increased with the application of organic and inorganic sources of nitrogen either alone or in combination at this stage. The highest rate of transpiration (3.26 m mol H_2O $m^{-1}s^{-1}$) was recorded with the application of nitrogen 50% through urea + 50% through vermicompost (T_8) followed by application of nitrogen 50% through urea + 50% poultry manure (T_{12}). Further, it was also noticed that this treatment was significantly higher over rest of the treatments including control.

Data recorded at the time of harvesting (Table 2) revealed that application of organic and inorganic sources of nitrogen brought about significant variations in rate of transpiration at this stage. Among all the treatment combinations a maximum rate of transpiration i.e. 3.86 m mol H_2O $m^{-1}s^{-1}$ was recorded in the treatment T_8 (50% N through urea + 50% N through vermicompost) which was significantly higher over control as well as all the treatments except T_{12} (50% N through urea + 50% N through poultry manure), where the transpiration rate was 3.70 m mol H_2O $m^{-1}s^{-1}$. The treatment T_8 and T_{12} increased the transpiration rate to the order of 159.03 and 148.15 percent, respectively over control.

It is clear from the data (Table 2) that integrated application of nitrogen brought about significant variation in stomatal conductance over control at all growth stages.

At 30 days after transplanting application of nitrogen 50% through urea and 50% through vermicompost (T_8) registered maximum stomatal conductance (38.4 cm s^{-1}) followed by T_{12} (50% nitrogen through urea +50% through poultry manure), where the stomata conductance was 34.8 cm s^{-1}. Further, treatment T_8 was significantly higher than rest of the treatments including control.

It is explicit from the data (Table 2) recorded at the time of harvesting that application of organic and inorganic sources of nitrogen either alone or in combination has produced pronounced effect on stomatal conductance at this stage.

Among all the treatments, application of nitrogen 50% through urea and 50% through vermicompost (T_8) produced the maximum stomatal conductance (43.7 cm s^{-1}) which is significantly higher over rest of the treatments. However, the variations in stomatal conductance recorded in treatment T_8 and T_{12} were statistically identical. The increase in stomatal conductance by treatment T_8 and T_{12} were to the tune of 96.84 and 81.98 percent, respectively over control.

It is obvious from the data (Table 3) that the chlorophyll content in leaves showed a positive response to the application of organic and inorganic sources of nitrogen either alone or in combination at all growth stages.

Data recorded at 30 days after transplanting (Table 3) revealed that application of organic and inorganic sources of nitrogen either alone or in combinations significantly increased the chlorophyll content in leaves at this stage. Application of nitrogen 50% through urea and 50% through vermicompost (T_8) registered maximum chlorophyll content (0.687 mg g^{-1} f. w.) followed by application of nitrogen 50% nitrogen through urea + 50% through poultry manure (T_{12}), where the chlorophyll content was 0.661 mg g^{-1} f. w. This treatment was significantly higher over rest of the treatments including control (0.517 mg g^{-1} f. w.).

At harvest, application of organic and inorganic sources of nitrogen brought about significant variation in chlorophyll content in leaves (Table 3).

Among all the treatment combinations, maximum chlorophyll content 1.167 mg g^{-1} f. w. was recorded with the application of nitrogen 50% through urea and 50% through vermicompost (T_8) which was significantly higher over control as well as all other treatments except application of nitrogen 50% through urea + 50% through poultry manure (T_{12}), where the chlorophyll content was 1.108 mg g^{-1} f. w. The treatment T_8 and T_{12} were increased the transpiration rate to the order of 20.72 and 14.00 percent, respectively over control.

Physiological parameters like photosynthesis, transpiration, stomatal conductance, chlorophyll content, etc. are directly linked with plant growth and development. Application of nitrogen significantly affects the rate and duration of these processes (Satchithanantham and Bandara, 2000; Wang *et al.*, 2001).). In present investigation also increased rate of photosynthesis with nitrogen application has been observed. However, different sources of nitrogen and their combinations affected the photosynthesis rate differentially (Table 2). Transpiration and stomatal conductance also increased significantly by application of nitrogen in cabbage. Again, the organic and inorganic sources of nitrogen affected these processes significantly (Table 2). The trend for all these observations was similar at 30 days after transplanting and at the time of harvesting.

Nitrogen is required for the synthesis of chlorophyll which is a major substrate of photosynthesis. In present investigation, higher rates of photosynthesis with nitrogen might be associated with chlorophyll synthesis. The increased chlorophyll content with different sources of nitrogen in present study strengthens this hypothesis. As indicated in Table 3, the chlorophyll content of cabbage increased significantly with integrated supply of nitrogen. Maximum chlorophyll content was recorded with nitrogen 50% through urea + 50% through vermicompost which was followed by nitrogen 50% through urea + 50% through poultry manure.

It is well known fact that stomata play important role in regulation of various physio-biochemical processes. The photosynthesis and transpiration are directly linked with stomatal regulation. Our results indicate that enhanced rate of photosynthesis has increased the O_2/CO_2 gas exchanges and the transpiration rate increased linearly. This increased transpiration provided a favourable environment to the leaves by cooling effect. Secondly, the enhanced transpiration might have increased the water and ion absorption through xylem from soil. These ions might have helped in various processes including the synthesis of pigments. The stomatal conductance is inversely correlated with stress conditions. The enhancement of stomatal conductance by nitrogen application in present investigation suggests the idea of availability of sufficient water for various plant processes. The similar pattern of stomatal conductance at harvest suggests that the effect of nitrogen retained upto harvest in cabbage.

On the basis of the combined effect of these physiological observations it can be inferred that application of nitrogen enhanced the pigment synthesis which resulted in increased rate of photosynthesis. The

Table 1. Effect of organic and inorganic sources of nitrogen on number of leaves and leaf area per plant in cabbage

Treatment	Number of leaves (per plant)	Leaf area (cm^2)
Control	17.10	1453.5
100% N (urea)	20.61	1749.1
75% N (urea) + 25% N (FYM)	19.65	1719.7
50% N (urea) +50 % N (FYM)	19.81	1735.4
25% N (urea) +75% N (FYM)	18.53	1649.2
100% N (FYM)	17.41	1566.9
75% N (urea) + 25% N (VC)	20.09	1796.9
50% N (urea) +50 % N (VC)	22.34	2010.6
25% N (urea) +75% N) (VC)	19.82	1744.2
100% N (VC)	18.85	1658.8
75% N (urea) + 25% N (PM)	18.38	1619.3
50% N (urea) +50 % N (PM)	20.85	1876.5
25% N (urea) +75% N (PM)	19.49	1715.1
100% N (PM)	18.21	1607.9
50% N (urea) + 25% N (FYM) + 25% N (VC)	19.18	1695.9
50% N (urea) +25 % N (FYM) + 25% N (PM)	19.68	1733.8
50% N (urea) + 25% N (VC)+ 25% N (PM)	20.32	1828.6
SEmß	0.65	51.22
CD (P=0.05)	1.85	147.19

VC= Vermicompost, PM= Poultry manure

Table 2. Effect of organic and inorganic sources of nitrogen on rate of photosynthesis in cabbage at different growth stages

Treatment	Photosynthesis (μ mol CO_2 m^{-2} s^{-1})		Transpiration (mmol H_2O m^{-2} s^{-1})		Stomatal conductance (cm s^{-1})	
	30 DAT	At harvest	30 DAT	At harvest	30 DAT	At harvest
Control	39.28	45.95	1.28	1.49	18.8	22.2
100% N (urea)	56.92	67.16	2.64	3.08	29.6	34.7
75% N (urea) + 25% N (FYM)	52.84	61.95	2.21	2.60	25.6	30.2
50% N (urea) +50 % N (FYM)	51.45	60.60	2.08	2.40	23.4	27.3
25% N (urea) +75% N (FYM)	48.15	57.68	1.66	1.97	21.4	25.8
100% N (FYM)	46.76	55.57	1.43	1.67	20.6	24.2
75% N (urea) + 25% N (VC)	55.38	65.14	2.43	2.84	28.1	33.1
50% N (urea) +50 % N (VC)	62.32	73.56	3.26	3.86	38.4	43.7
25% N (urea) +75% N) (VC)	57.36	67.22	2.85	3.37	32.9	38.2
100% N (VC)	50.41	59.22	2.03	2.39	22.6	27.3
75% N (urea) + 25% N (PM)	56.97	67.02	2.67	3.14	30.7	35.8
50% N (urea) +50 % N (PM)	59.35	70.26	3.11	3.70	34.8	40.4
25% N (urea) +75% N (PM)	53.02	62.32	2.28	2.69	26.7	31.4
100% N (PM)	49.71	57.85	1.95	2.28	21.9	26.1
50% N (urea) + 25% N (FYM) + 25% N (VC)	53.36	62.30	2.37	2.78	27.3	32.3
50% N (urea) +25 % N (FYM) + 25% N (PM)	51.78	61.18	2.12	2.47	24.7	28.9
50% N (urea) + 25% N (VC)+ 25% N (PM)	57.86	68.84	2.97	3.53	32.7	37.1
SEm±	1.36	1.28	0.076	0.094	1.43	1.44
CD (P=0.05)	3.92	3.69	0.219	0.270	4.12	4.14

VC= Vermicompost, PM= Poultry manure ; DAT= Days after transplanting

Table 3. Effect of organic and inorganic sources of nitrogen on chlorophyll content in leaves of cabbage at different growth stages

Treatment	Chlorophyll content ($mg\ g^{-1}$ f. w.)	
	30 DAT	At harvest
Control	0.517	0.965
100% N (urea)	0.573	1.049
75% N (urea) + 25% N (FYM)	0.568	1.041
50% N (urea) +50 % N (FYM)	0.563	1.036
25% N (urea) +75% N (FYM)	0.548	0.992
100% N (FYM)	0.534	0.979
75% N (urea) + 25% N (VC)	0.593	1.086
50% N (urea) +50 % N (VC)	0.687	1.167
25% N (urea) +75% N) (VC)	0.551	0.997
100% N (VC)	0.543	0.985
75% N (urea) + 25% N (PM)	0.572	1.046
50% N (urea) +50 % N (PM)	0.661	1.108
25% N (urea) +75% N (PM)	0.545	0.989
100% N (PM)	0.539	0.981
50% N (urea) + 25% N (FYM) + 25% N (VC)	0.562	1.043
50% N (urea) +25 % N (FYM) + 25% N (PM)	0.556	1.025
50% N (urea) + 25% N (VC)+ 25% N (PM)	0.617	1.082
SEm±	0.018	0.025
CD (P=0.05)	0.053	0.072

VC= Vermicompost, PM= Poultry manure ; DAT= Days after transplanting higher rate of stomatal conductance at the same time suggests that the stomatal regulation was favuorable, thus enhancing photosynthetic assimilation via increased transpiration and ion absorption. These factors might have resulted in increased growth and productivity of cabbage which is evident from the data presented elsewhere in this chapter. Enhancement in photosynthetic rate and related parameters with interactive effects of nitrogen fertilizers have also been reported in maize, soybean and wheat (Satchithanantham and Bandara; 2000; Wang *et al.*, 2001; Lu *et al.*, 2001).

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