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Effect of Integrated Nutrient Management in Red Cabbage Grown under Shade House Condition

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A field experiment was conducted during *rabi*, 2015-16 at Hi-Tech Horticulture Unit, University of Agricultural Sciences, Dharwad to investigate the "Studies on integrated nutrient management in red cabbage grown under shade house condition". The treatments consists of three levels of recommended dose of fertilizer that is 100 % (100:150:125 kg NPK/ha) and 75 % (75:112:75 kg NPK/ha) and 50 % RDF (50:75:62.5 kg NPK/ha), three levels of recommended dose of nitrogen (100 %, 50 % and 50 % RDN) provided through FYM and vermicompost and bio-fertilizers (*Azotobactor* and PSB). Among the various treatments, treatment T_{11} receiving 75 per cent RDF + FYM and VC (1:1) equivalent to 25 per cent RDN registered better growth and yield parameters such as, maximum plant height (35.36 cm), number of leaves (21.10), plant spread (69.64 cm), stalk length (9.85 cm), diameter of head (13.76 cm) at harvest, minimum days taken for head initiation (35.92 days), average head weight (845 g) and head yield (37.18 t ha^{-1})

Introduction

Red cabbage is a nutritious and delicious vegetable. It is an excellent source of calcium, manganese, magnesium, iron, potassium, vitamin C, A, E, K and dietary fibre. Red cabbage being a heavy feeder and exhaustive crop responds very well to nutrients application. The increasing use of chemical fertilizers to increase vegetable production has been widely recognized but its long run impact on soil health, ecology and other natural resources are detrimental which affect living organisms including beneficial soil microorganisms and human being. The escalating prices of chemical fertilizers and its detrimental impact on the soil health, environment and human health urged the farmer to adopt alternative source of nutrients for vegetable production. Therefore, to reduce

dependency on chemical fertilizers and conserving the natural resources in align with sustainable vegetable production are vital issues in present time which is only possible through integrated plant nutrient supply system (Merentola *et al.,* 2012). Besides fertilizers, there are several sources of plant nutrients like organic manures, biofertilizers *etc.* These nutrient sources apart from manuring of soil also improve overall soil productivity (Chumyani *et al.,* 2012). Therefore, the study was undertaken to find out the study influence of INM on growth and yield of red cabbage grown under shade house.

Materials and Methods

The experiment was carried out in Hi-Tech Horticulture Unit, Main Agricultural Research Station, Saidapur farm, University of Agricultural Sciences Dharwad. The experiment consists of fourteen treatments and two replications laid out in a randomized complete block design. The treatments consists of T_1- 100 % RDF + FYM @ 25 t ha^{-1} (Control), T_2- 75 % RDF + FYM equivalent to 25 % RDN, T_3- 75 % RDF + FYM equivalent to 25 % RDN + *Azatobactor* + PSB, T_4- 75 % RDF + VC equivalent to 25 % RDN, T_5- 75 % RDF + VC equivalent to 25 % RDN + *Azatobactor* + PSB, T_6- 50 % RDF + FYM equivalent to 50 % RDN, T_7- 50 % RDF + FYM equivalent to 50 % RDN + *Azatobactor* + PSB, T_8- 50 % RDF + VC equivalent to 50 % RDN, T_9- 50 % RDF + VC equivalent to 50 % RDN + *Azatobactor* + PSB, T_{10}- 75 % RDF + Each FYM & VC (1:1) equivalent to 25 % RDN, T_{11}- 75 % RDF + Each FYM & VC (1:1) equivalent to 25 % RDN + *Azatobactor* + PSB, T_{12}- 50 % RDF + Each FYM & VC (1:1) equivalent to 50 % RDN, T_{13}- 50 % RDF + Each FYM & VC (1:1) equivalent to 50 % RDN + *Azotobacte*r + PSB and T_{14}- Each FYM & VC (1:1) equivalent to 100 % RDN + *Azatobactor* + PSB (Organic).

Note: FYM = Farm yard manure, VC = Vermicompost, Recommended dose of fertilizer (RDF) for cabbage = 150:100:125 kg NPK ha^{-1} + FYM, PSB=Phosphate solubilizing bacterium.

The experiment was carried out in a shade house covered using 35 per cent green colour shading net. Seedlings of red cabbage variety Red queen were raised by sowing the seeds in plastic portrays (98 cells) by using coco peat as growing media. The protrays were filled with the coco peat as growing media. Seeds were sown and were covered with a thin layer of same growing medium, watered lightly. 45 days old seedlings were transplanted on the raised beds at spacing of 45×30 cm distance inside the shade house. Recommended dose of FYM (25 t/ha) applied to all the treatments commonly. The entire calculated dose of Vermicompost and farmyard manure as per treatment combinations were applied in the individual specified plots two weeks before transplanting of the seedlings by broadcasting method and was thoroughly mixed up well with the soil. Before transplanting of the seedlings recommended dose of NPK were applied as per treatment combination. The observations were recorded for growth and yield parameters like, plant height, number of leaves, plant spread, stalk length, diameter of head at harvest, minimum days taken for head initiation, average head weight and head yield. The data on various observations collected during period of study were subjected to statistical analysis as described by Gomez and Gomez (1984).

Results and Discussion

The data pertaining to the various observations on growth and yield parameters in red cabbage have been shown in Table 1, 2 and 3. Application of 75 per cent RDF + FYM and VC (1:1) equivalent to 25 per cent RDN (recommended dose of nitrogen) +

Azotobactor + PSB (Phosphate solubalizing bacteria) - T_{11} recorded significantly higher plant height (35.36 cm) at harvest which was on par with T_{10}, T_{13} and T_9 and lowest plant height was recorded in control (30.22 cm) receiving 100 per cent RDF + FYM (T_1). This increased plant height might be due to the favorable effect of chemical fertilizers along with vermicompost and FYM which might have enhanced the soil fertility coupled with improved soil moisture retention capacity (Chaudhary *et al.,* 2015).). Earlier workers attributed this to application of biofertilizers helped in secretion of growth promoting substances, which might have lead to better root development, transportation of water, uptake and deposition of nutrients (Tekasangla *et al.,* 2015). Present findings are in agreement with those reported by Maurya *et al.,* (2008) in broccoli and Singh *et al.,* (2009) in cauliflower

The number of leaves in red cabbage was significantly influenced by application of different source of nutrients. The maximum number of leaves at harvest were recorded in T_{11} (21.10) receiving 75 per cent RDF + FYM and VC (1:1) equivalent to 25 per cent RDN + Azotobactor + PSB which was on par with T_9 and T_{13} and minimum number of leaves were recorded in control (15.30).

This increase in number of leaves might be due to increased absorption of primary nutrients which resulted in increased synthesis of carbohydrates, proteins and fats which are utilized in building up of new cells. These results are in conformity with findings of Chaudhary *et al.,* (2015) while in working with cabbage and Maurya *et al.,* (2008) in broccoli.

Significantly higher plant spread at harvest was recorded in T_{11} (69.64 cm) receiving 75 per cent RDF + FYM and VC (1:1) equivalent to 25 per cent RDN + Azotobactor + PSB which was on par with T_9, T_5 and T_{13} and lower plant spread was recorded in control (55.35 cm). This increased plant spread might be due to added vermicompost and FYM in integrated nutrient management (INM) which might have improved the physical, chemical and biological properties of soil which in turn helps in better nutrient absorption and utilization by plant resulting in better plant growth. This might be attributed to certain growth promoting substances secreted by the biofertilizers which in turn helps in better root development, better transportation of water, uptake and deposition of nutrients (Tekasangla *et al.,* 2015). In red cabbage significantly higher stalk length was recorded in T_{11} (9.85 cm) receiving 75 per cent RDF + FYM and VC (1:1) equivalent to 25 per cent RDN + Azotobactor + PSB which was on par with T_{13} and T_9 and lower stalk length was recorded in control (7.60 cm). This might be due increased uptake and continuous supply of primary nutrients which might have enhanced cell division and cell elongation. Earlier researchers attributed this to integrated use of nutrients which has enhanced cell division, multiplication and cell elongation in meristematic region of plant ultimately promoting the vegetative growth of the plant (Kumar *et al.,* 2013b). Results of the present study are in line with findings of Kachari and Korla (2009) and Singh *et al.,* (2009) in cauliflower.

Head diameter of red cabbage differed significantly with application of different source of nutrients.

The treatment (T_{11}) receiving combination of inorganic fertilizers (75 % RDF), organics (FYM and VC (1:1) equivalent to 25 per cent RDN and biofertilizers (Azotobactor + PSB) recorded higher head diameter (13.76 cm) which was on par with T_{13} and T_9 and lower head diameter was recorded in control (11 cm).

Table.1plant height (cm), number of leaves and plant spread (cm) as influenced by integrated nutrient management in red cabbage grown under shade house

Treatment	Plant height at harvest (cm)	Number of leaves at harvest	Plant spread at harvesting (cm)
T_1 - 100 % RDF + FYM (Control)	30.22	15.30	55.35
T_2 - 75 % RDF + FYM equivalent to 25 % RDN	31.89	16.20	56.88
T_3 - 75 % RDF + FYM equivalent to 25 % RDN + *Azatobactor* + PSB	32.63	17.69	61.80
T_4 - 75 % RDF + VC equivalent to 25 % RDN	33.26	17.26	59.50
T_5 - 75 % RDF + VC equivalent to 25 % RDN + *Azatobactor* + PSB	33.30	18.08	68.52
T_6 - 50 % RDF + FYM equivalent to 50 % RDN	33.21	17.04	64.90
T_7 - 50 % RDF + FYM equivalent to 50 % RDN + *Azatobactor* + PSB	32.10	18.30	61.51
T_8 - 50 % RDF + VC equivalent to 50 % RDN	32.93	16.54	61.60
T_9 - 50 % RDF + VC equivalent to 50 % RDN + *Azatobactor* + PSB	33.83	20.43	68.70
T_{10} - 75 % RDF + FYM and VC (1:1) equivalent to 25 % RDN	34.10	16.31	65.70
T_{11} - 75 % RDF + FYM and VC (1:1) equivalent to 25 % RDN + *Azatobactor* + PSB	35.36	21.10	69.64
T_{12} - 50 % RDF + FYM and VC (1:1) equivalent to 50 % RDN	32.74	17.41	64.53
T_{13} - 50 % RDF + FYM and VC (1:1) equivalent to 50 % RDN + *Azatobactor* + PSB	33.93	20.40	68.25
T_{14} - Each FYM and VC (1:1) equivalent to 100 % RDN + *Azatobactor* + PSB	31.69	17.35	64.07
S.Em. ±	0.54	0.26	0.47
C.D. at 5 %	1.72	0.81	1.45

RDF – Recommended dose of fertilizer PSB – Phosphate solubilizing bacteria
FYM – Farmyard manure VC – Vermicompost RDN – Recommended dose of nitrogen

Table.2 Stalk length (cm), days taken for head initiation (days) and head diameter (cm) as influenced by integrated nutrient management in red cabbage grown under shade house

Treatment	Stalk length (cm)	Days taken for head initiation (days)	Head diameter (cm)
T_1 - 100 % RDF + FYM (Control)	7.60	39.10	11.00
T_2 - 75 % RDF + FYM equivalent to 25 % RDN	8.05	38.54	12.62
T_3 - 75 % RDF + FYM equivalent to 25 % RDN + *Azatobactor* + PSB	8.65	39.80	12.50
T_4 - 75 % RDF + VC equivalent to 25 % RDN	8.50	39.83	11.74
T_5 - 75 % RDF + VC equivalent to 25 % RDN + *Azatobactor* + PSB	8.80	39.10	12.69
T_6 - 50 % RDF + FYM equivalent to 50 % RDN	8.85	39.90	12.56
T_7 - 50 % RDF + FYM equivalent to 50 % RDN + *Azatobactor* + PSB	8.70	37.96	12.52
T_8 - 50 % RDF + VC equivalent to 50 % RDN	8.29	38.83	11.73
T_9 - 50 % RDF + VC equivalent to 50 % RDN + *Azatobactor* + PSB	9.30	36.16	13.03
T_{10} - 75 % RDF + FYM and VC (1:1) equivalent to 25 % RDN	8.30	39.15	12.36
T_{11} - 75 % RDF + FYM and VC (1:1) equivalent to 25 % RDN + *Azatobactor* + PSB	9.85	35.92	13.76
T_{12} - 50 % RDF + FYM and VC (1:1) equivalent to 50 % RDN	8.60	38.60	12.65
T_{13} - 50 % RDF + FYM and VC (1:1) equivalent to 50 % RDN + *Azatobactor* + PSB	9.55	37.06	13.40
T_{14} - Each FYM and VC (1:1) equivalent to 100 % RDN + *Azatobactor* + PSB	7.90	40.55	11.62
S.Em. ±	0.21	0.83	0.38
C.D. at 5 %	0.65	2.53	1.16

RDF – Recommended dose of fertilizer
FYM – Farmyard manure
PSB – Phosphate solubilizing bacteria
VC – Vermicompost
RDN – Recommended dose of nitrogen

Table.3 Average head weight (g) and head yield ha^{-1} (t) as influenced by integrated nutrient management in red cabbage grown under shade house condition

Treatment	Average head weight (g)	Head yield (t/ha)
T_1 - 100 % RDF + FYM (Control)	550.00	24.20
T_2 - 75 % RDF + FYM equivalent to 25 % RDN	620.00	27.28
T_3 - 75 % RDF + FYM equivalent to 25 % RDN + *Azatobactor* + PSB	615.00	28.03
T_4 - 75 % RDF + VC equivalent to 25 % RDN	620.00	27.28
T_5 - 75 % RDF + VC equivalent to 25 % RDN + *Azatobactor* + PSB	730.00	32.12
T_6 - 50 % RDF + FYM equivalent to 50 % RDN	606.00	26.66
T_7 - 50 % RDF + FYM equivalent to 50 % RDN + *Azatobactor* + PSB	723.00	31.81
T_8 - 50 % RDF + VC equivalent to 50 % RDN	660.00	29.01
T_9 - 50 % RDF + VC equivalent to 50 % RDN + *Azatobactor* + PSB	791.00	34.80
T_{10} - 75 % RDF + FYM and VC (1:1) equivalent to 25 % RDN	650.00	28.60
T_{11} - 75 % RDF + FYM and VC (1:1) equivalent to 25 % RDN + *Azatobactor* + PSB	845.00	37.18
T_{12} - 50 % RDF + FYM and VC (1:1) equivalent to 50 % RDN	630.00	27.72
T_{13} - 50 % RDF + FYM and VC (1:1) equivalent to 50 % RDN + *Azatobactor* + PSB	789.00	33.80
T_{14} - Each FYM and VC (1:1) equivalent to 100 % RDN + *Azatobactor* + PSB	637.00	26.06
S.Em. ±	19.09	0.84
C.D. at 5 %	57.81	2.57

RDF – Recommended dose of fertilizer PSB – Phosphate solubilizing bacteria
FYM – Farmyard manure VC – Vermicompost RDN – Recommended dose of nitrogen

This might be due to synergestic effect of vermicompost, FYM and biofertilizers provided better nourishment to plants due to sustained release of nutrients and increased growth parameters ultimately increased head diameter (Chaudhary *et al.,* 2015) Days taken for head initiation were significantly influenced by application of different source of nutrients. Earliest head initiation was recorded in T_{11} (35.92days) receiving 75 per cent RDF + FYM and VC (1:1) equivalent to 25 per cent RDN + Azotobactor + PSB which was on par withT_9, T_7 and T_{13}. While head initiation was delayed by about 5 days in T_{14} receiving only organic manures and biofertilizers compared to T_{11}. The minimum days taken for head initiation may be due to higher NPK and increased nutrient transport from root to the aerial parts and increased rate of photosynthesis and assimilation of photosynthates resulting in early head formation (Kumari *et al.,* 2015). These results are in line with findings of Sangeetashree *et al.,* (2014) in cauliflower.

Average head weight differed significantly due to combined application of different source of nutrients. Maximum head weight of 845 g was recorded with combined application of 75 per cent RDF + FYM and VC (1:1) equivalent to 25 per cent RDN + Azotobactor + PSB which was on par with T_9 and T_{13}. Whereas, least average head weight was recorded in control (550 g). Increase in head weight of red cabbage might be due to the fact that biofertilizers in combination with inorganic and organic fertilizers helped in better root proliferation and rhizosphere development, uptake of nutrients and water, higher leaf area development ultimately higher rate of photosynthetic activity (Chaudhary *et al.,* 2015). These findings are in agreement with those reported by Bahadur *et al.,* 2006 in cabbage, Maurya *et al.,* 2008 in broccoli.

Yield per hectare were significantly influenced by combined application of different source of nutrients. Treatment T_{11} receiving 75 per cent RDF + FYM and VC (1:1) equivalent to 25 per cent RDN + Azotobactor + PSB recorded higher yield of 37.18 t ha^{-1} which was on par with T_9 (34.80 t ha^{-1}) receiving 50 per cent RDF + VC equivalent to 50 per cent RDN + Azotobactor + PSB and T_{13} (33.80 t ha^{-1}) receiving 50 per cent RDF + FYM and VC (1:1) equivalent to 50 per cent RDN + Azotobactor + PSB and lower yield (24.20 t ha^{-1}) was recorded in treatment receiving 100 per cent RDF and FYM (control). The more yield in this treatment could be directly related to higher values of head diameter, head weight and photosynthetic rate. The increased in yield might be due to the performance of the vegetative growth which might have influenced the production of more amounts of carbohydrates accumulated in head and thereby increased the yield. This may be because of appropriate dose of nitrogen, as nitrogen is a constituent of protein and chlorophyll and it play vital role in photosynthesis process. Further, application of NPK in conjunction with biofertilizers might have favored the effective utilization of nutrient availability in the soil, which in turn increased the yield per hectare. These results are in consonance with those reported by Chaudhary *et al.,* 2015, Tekasangla *et al.,* 2015 in cauliflower, Merentola *et al.,* 2012 in cabbage

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