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Response of Integrated Nitrogen Management on growth, yield and soil parameters in Cauliflower (*Brassica oleracea* var.)"- A review

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ABSTRACT
Cauliflower is a fleshy feeder of mineral elements, it removes a huge sum of macronutrients from the soil. The escalating prices of inorganic fertilizers and its prejudice affect on the soil health, environment and human health urged the farmer to adopt alternative source of nutrients for Cauliflower production. Therefore, to reduce addiction on chemical fertilizers and conserving the natural resources in align with sustainable Cauliflower production are critical issues in present time which is only possible through integrated plant nutrient supply system. The availability of micro and macronutrients improved by integrated use of fertilizers also.Use of inorganic fertilizers and organic manures had led to intensive scientific activity for the commercial exploitation providing a useful tool in the hands of agriculturist for increasing the crop production and maintenance of soil health.
Keywords-C*auliflower, Inorganic fertilizers, Soil Health and Fertilizers.*

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INTRODUCTION

The use of nitrogenous fertilizers upsurges tremendously in order to fulfil growing food needs since the green revolution. Nitrogen applied through fertilizers of ammonical nature produce acidic conditions in the soil [18]. The annual consumption of fertilizers increased from about 255.36 LMT in 2012-13 to 259.49 LMT in 2016-17 [4]. In general agriculture, the use of chemical fertilizers cannot be ruled out completely. However, there is a need for the integrated application of different sources of nutrients for sustaining the required crop productivity by integrated nutrient management. The concept of integrated nutrient management requires the optimum use of organic, inorganic and bio-sources of plant nutrients [55].Manure is organic matter, mostly derived from animal excreta except in case of green manure, basically of plant origin can be used as organic fertilizer in agriculture. These are comparatively cheap and eco-friendly inputs. These have huge potential for maintaining nutrient supply which can reduce the dependence of farmers on chemical fertilizers use. Organic management resulted in the significantly higher activity of soil enzymes such as dehydrogenase and phosphatase [19].The use of organic soil amendments has been associated with desirable soil properties including higher water holding capacity and cation exchange capacity.Farmyard manure has been used for centuries as a fertilizer for farming. Organic manures help in improving soil structure and soil biomass [15]. Farmyard manure improves the soil physical conditions by increasing water holding capacity to 2%. It also improves the chemical properties of the soil by increasing soil organic carbon, nitrogen, phosphorus and potassium content in the soil

[8].Vermicomposting is a process of composting with the use of earthworms. In this process, by feeding the worms with organic materials, some of the bacteria like actinomycetescontained in the ingested materialhave a useful role in decomposition of organic wastes, added to them and accelerate the decomposition of organic materials.Soil physico-chemical properties such as pH, EC, available nitrogen, phosphorus, potassium, iron, zinc, copper and manganese were found differ in soils treated with application of vermicompost [34]. Nutrients are available as ions in three forms i.e. ions held as colloidal particles, ions absorbed on colloidal surface and ions in solution form [27]. Cauliflower (*Brassica oleracea* var. *botrytis*) is one of the most important vegetable crops belonging to the family Brassicaceae. It is widely cultivated all over India and abroad for its special nutritive values, high productivity and wider adaptability under different ecological conditions. Cauliflower contains various kinds of vitamins, especially vitamin C. It also contains minerals like potassium, sodium, calcium, iron, phosphorus and magnesium [40]. Cauliflower growsin cool temperate climate and sensitive to high temperature. Cauliflower grows best on a neutral or slightly acidic soil (pH 6.0 to 6.5). Among different factors responsible for low cauliflower production, nutrition is of main importance. The diverse agro-climatic conditions, varied soil types and abundant rainfall under foothills condition of Punjab enable the favourable cultivation of cauliflower.Cauliflower is a heavy feeder of mineral elements, it removes a large amount of macronutrients from the soil. 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 [36]. The use of organic manures in combination with chemical fertilizers offers a great opportunity to increase cauliflowers yield and soil productivity.

So keeping in view the above discussion the present research project entitled "Response of Integrated Nitrogen Management on plant growth, yield and soil parameters in Cauliflower (*Brassica oleracea*)"has been reviewd.

REVIEW OF LITERATURE

Use of inorganic fertilizers and organic manures had led to intensive scientific activity for the commercial exploitation providing a useful tool in the hands of agriculturist for increasing the crop production and maintenance of soil health. The literature has been reviewed and presented here under appropriate heading in this chapter.

INTEGRATED EFFECT OF VARIOUS NUTRIENT SOURCES ON GROWTH AND YIELD OF CAULIFLOWER

Growth analysis is still the most simple and precise method to evaluate the contribution of different ecological processes in plant development. Integrated use of organic manures with mineral fertilizers improve the growth of crops due to frequently availability of nutrients to plant at all growth stages [17, 22].

Singh *et al.* [56] laid down an experiment to study the effect on yield of cabbage as influenced by integrated nutrient management at Bundelkhand University, Jhansi. Application of 50% NPK + 5 t poultry manure resulted in maximum plant height (21.42 cm) as well as yield (609.5 q ha^{-1}). Ahmad *et al.* [2] studied the influence of integrated application of farmyard manure, leaf manure, poultry manure and chemical fertilizers on growth and yield of carrot. Plant height (39.98 cm) and root length (21cm) was recorded maximum when total nitrogen requirement completed through poultry manure and farmyard manure as compared to control in which plant height and root length was recorded 22.42 cm and 11.25 cm, respectively.

Shree *et al.* [50] examined the response of cauliflower to different organic manures and inorganic fertilizers. Maximum yield was obtained (252.48 q ha^{-1}) through the application of half dose of NPK + FYM @ 5 t ha^{-1} + vermicompost @ 2 t ha^{-1} + *Azospirillum* ascompared to yield (235.71 q ha^{-1}) in RDF treated plots. Kumar *et al.* [29] reported that greater plant height , number of leaves $plant^{-1}$, width of leaf , length of stalk, spread of the plant , diameter of curd and yield of curd was observed under the treatment that involved half dose of NPK + vermicompost + *Azospirillium* + VAM. An investigation was conducted at University

of Agricultural Sciences, Dharwad by Shalini *et al*. [47] and they found maximum plant height (16.42 cm), number of leaves plant^{-1} (19.42), dry weight plant^{-1} (35.41 g) and yield (37.21 q ha^{-1}) in knolkhol crop with the use of 50% N (Urea) + 50% N (vermicompost) + *Azospirillum*.

Prabhakar *et al*. [42] demonstrated the effectiveness of various organic sources of nutrients on cauliflower. Maximum curd yield (21.23 t ha^{-1}) was recorded with the application of farmyard manure along with recommended dose of fertilizers. An experiment was laid down by Manohar *et al*. [33] and described that maximum yield (359.24 q ha^{-1}) was obtained with the application of FYM @ 20 t ha^{-1}. Likewise, highest plant height (60.98 cm) and no. of primary branches plant^{-1} (6.79) was also recorded with 20 t ha^{-1} FYM application.

Malik *et al*. [32] studied the effect of integrated use of inorganic fertilizers and organic manures on growth and yield of sweet pepper. They reported that the application of inorganic fertilizers along with FYM @ 40 t ha^{-1} resulted in maximum number of fruits plant^{-1} (20.45 and 19.00), fruit length (8.40 and 8.20 cm), fruit diameter (8.09 cm and 7.70 cm), average fruit weight (94.85 g and 93 g) and average fruit yield plot^{-1} (38.79 kg and 35.34 kg). A research was undertaken by Chaudhary *et al*. (2018b) to investigate the effect of integrated nutrient management on yield and growth of cabbage. They revealed that the highest head length (17.5 cm) and head diameter (14.7 cm) was obtained with the application of 100% RDF. However, maximum head weight (1176.7 g) and yield (470.7 q ha^{-1}) was recorded in 50% N as mineral fertilizers + 50% N through FYM treated plots.

Kumar *et al*. [31] demonstrated the effect of organic sources compared to chemical fertilizers on growth and yield of turmeric and reported highest fresh rhizome yield plant^{-1} (606.65 g) with the application of 75% RDF + 25% vermicompost. Mohanta *et al*. [37] studied the effect of integrated nutrient management on broccoli and revealed that the application of 50% NPK fertilizers + FYM @ 10 t ha^{-1} inclined the plant height (54.68 cm) and head diameter (13.83 cm). Maximum gross yield (233.56 q ha^{-1}) was observed under the treatment 50% NPK + vermicompost @ 2.5 t ha^{-1}. Prativa and Bhattarai [43] described that highest plant height (116.16 cm), individual fruit weight (52.80 g) and yield (25.74 Mt ha^{-1}) was recorded under application of 16.66 Mt ha^{-1} FYM + 8.33 Mt ha^{-1} vermicompost + NPK. Kumar [29] revealed that maximum plant height (166.30 cm), dry weight (102.36 g) and yield/plant (6084.25 g) was obtained when 50% RDF was applied along with vermicompost @ 5 t ha^{-1}.

Bharathi *et al*. [9] conducted a field study to evaluate the influence of organic and inorganic nutrient sources on chilli at Regional Agricultural Research Station, Lam, Guntur during Kharif season of 2003-04 and 2004-05. They observed that maximum dry chilli yield (5397 kg ha^{-1}) was obtained with 100% recommended dose of nitrogen through inorganic fertilizers that was on par with yield (4885 kg ha^{-1}) under the treatment of GM + 50% recommended N.

Kumar *et al*. [30] conducted a field experiment to assess the influence of organic manures on the growth of radish at Horticulture Research Farm, Babasaheb Bhimrao Ambedkar University, Lucknow. They found that combined application of vermicompost 50% + poultry manures 50% has produced maximum plant height (37.91 cm), total plant weight (302.44 g), root weight (197.22 g) and root length (18.91 cm).

Chatterjee *et al*. [11] laid out a field experiment at the Instructional Farm of UBKV, Pundibari, Coochbehar. They observed the effect of organic amendments in cabbage and found that application of 75% RDF + vermicompost @ 5 Mt ha^{-1} + biofertilizer resulted in maximum plant height (23.39 cm), head weight (1547.34 g) and head yield (27.86 t ha^{-1}). Similarly, Chatterjee *et al*. [11] determined the influence of different nutrient sources on the head yield of cabbage. They found that treatment of 75% RDF + 5 t ha^{-1} vermicompost + biofertilizer has resulted in highest head yield (27.86 t ha^{-1}) as compared tohead yield (11.88 t ha^{-1})in 100% RDF treated plots.

Effect of organic manures and biofertilizers on broccoli growth was evaluated by Meena *et al*. [35] at Babasaheb Bhimrao Ambedkar University, Uttar Pradesh. Maximum curd diameter (10.52 cm), curd weight (305.33 g) and yield (125.2 q ha^{-1}) was observed under the treatment RDF (25%) + vermicompost (25%) + *Azotobacter* (25%). An experiment was conducted by Chaudhary *et al*. [12] to assess the influence of integrated nutrient management on growth and yield of cabbage. Growth parameters like plant height (29.6 cm) and number of open leaves plant^{-1} (11.1) as well as yield (41.5 t ha^{-1}) was recorded

maximum with treatment of 100% RDN + vermicompost @ 10 t ha^{-1} + *Azotobacter* + PSB. Mukherjee [38] reported that improved 1000 grain weight (194.68 g), grain yield (26.74 q ha^{-1}) and straw yield (29.10 q ha^{-1}) was recorded through the application of RDF + *Rhizobium* + PSB over the control.

Simarmata *et al.* [51] conducted a field trial to assess the effect of organic sources of nutrient along with chemical fertilizers in cauliflower at The University of Bengkulu, Indonesia. Maximum height of plant (39.4 cm) was observed under the treatment of 50% RDF + compost of trailing daisy weeds @ 10 t ha^{-1} whereas maximum curd weight $plant^{-1}$ (490.78 g) was recorded through the application of 50% RDF + compost of cow manure @ 20 t ha^{-1}. Islam *et al.* [24] reported that combined application of cow dung (4 t ha^{-1}) + Urea (130 kg ha^{-1}) significantly increased the number of leaves per plant (174), plant fresh weight (378.5 g) and average green fruit weight (142.1 g) in sweet pepper.

Kumar and Biradar [29] conducted an experiment at Main Agriculture Research Station, University of Agricultural Sciences, Dharwad to demonstrate the influence of integrated nutrient management on the yield of broccoli. Maximum plant height (35.4 cm), plant spread (83.4 cm^2), stalk length (23.4 cm), curd weight (398 g), curd diameter (18.0 cm) and curd yield (19.5 t ha^{-1}) was obtained with the application of 75% RDF + FYM and Vermicompost (1:1) equivalent to 25% RDN.

In a field experiment, Gebremichael *et al.* [20] observed the response of onion to integrated nutrient management at Selekeleka Research site, Ethiopia in October 2015. Treatment of 50% N from inorganic fertilizers combined with 5 t ha^{-1} vermicompost resulted in maximum plant height (71.67 cm), mean bulb weight (92.64 g) and total yield (35.25 t ha^{-1}). Alam *et al.* [2] demonstrated the influence of chemical fertilizers along with vermicompost on cabbage and found that maximum plant height (19.87 cm), whole plant fresh weight (3846 g $plant^{-1}$), whole plant dry weight (371.8 g $plant^{-1}$) and yield (59.21 t ha^{-1}) was recorded through 100% RDF + vermicompost @ 1.5 t ha^{-1} application.

INTEGRATED EFFECT OF VARIOUS NUTRIENT SOURCES ON PROPERTIES OF SOIL OF CAULIFLOWER

Soil chemical properties are of important consideration for selection of any crop in an area. Application of organic manures effect the various soil properties in positive way. Organic manures effects the pH through production of organic acids, EC through addition of salts by manures and organic carbon through organic matter addition [5]

Bandyopadhyay *et al.* [7] demonstrated the effect of FYM and chemical fertilizers on soil physical properties under the soybean at Indian Institute of Soil Science, Bhopal, Madhya Pradesh. They noticed that combined use of chemical fertilizers with FYM significantly inclined the soil organic carbon by 29.8% and 45.2% comparative to full NPK and control treatment. Shirale *et al.* [49] reported maximum decline in pH (-0.17) with FYM @ 10 Mg ha^{-1} and maximum EC was observed in plots that received the higher amount of inorganic fertilizers whereas the highest positive change in organic carbon (+1.10) was found under the treatment of 150% NPK. Kaur *et al.* [28] revealed that soil pH varied from 7.58 to 7.65 under different treatments that received various organic manures. Maximum decrease in pH (7.58) was observed in treatment (FYM @ 15 t ha^{-1} + N 120 kg P 30 kg in wheat and N 120 kg P 60 kg in pearl millet). Maximum 0.99% organic carbon was recorded with the application of FYM @ 15 t ha^{-1}. Sepehya *et al.* (2012) investigated that the application of the 50% NPK + 50% N through FYM proved significantly higher soil organic carbon (90.0 g kg^{-1}) and CEC [14.1 cmol (p^+) kg^{-1}].

Ullah *et al.* [56] noticed that soil pH was decreased with organic manures application. Similarly, organic carbon was decreased with inorganic fertilizer use and increased with application of organic manures. Gopinath *et al.* [21] revealed that long term application of FYM increased the soil pH (6.95) over the initial status (6.90). Similarly, FYM application escalated the soil organic carbon content to 1.10% from 1.02% which was at the initial level. Desta [16] conducted a field experiment to evaluate the effect of organic and inorganic fertilizers on soil properties under maize at Antra catchment located in Chilga. He described that combined application of organic and inorganic fertilizers improved the soil porosity by (31.8%), pH (0.9%), SOC (58.1%), Total N (20.0%), CEC (3.1%), available P (29.8%) and S (38.9%) over the control.

Adeniyan *et al*. [1] evaluated the effect of different organic manures with NPK fertilizers in a pot experiment to improve soil chemical properties. They reported that cow dung application increased the pH to 6.30 from acidic level that was at the initial (5.08). Besides that, treatment of cane rat droppings resulted in higher organic carbon (1.96%) and CEC [3.10 cmol (p^+) kg^{-1}] than NPK alone application.

Parvathi *et al*. [41] studied the nutrient status of soil on long-term basis during 1981-2011 under the intensive cropping of groundnut at Regional Agricultural Research Station, Andhra Pradesh. FYM @ 5 t ha^{-1} once in 3 years resulted in highest soil pH (5.57) as well as highest organic carbon content (0.40%). Apart from this, maximum EC (0.07 dS m^{-1}) was recorded in NPK + Gypsum + $ZnSO_4$ treatment.

Sunitha *et al*. [54] in a field experiment at the Agricultural Research Station, Honnavile, Shivmoga during Kharif 2007 found that the application of 100% N declined the soil pH. Maximum cation exchange capacity [8.99 cmol (p^+) kg^{-1}] was recorded under treatment of 50% N + 25% N through Green leaf manure + 25% N through FYM + *Azospirillium* as compared to control where CEC was 7.92 cmol (p^+) kg^{-1}. FYM along with *Azospirillium* resulted in highest organic carbon (6.90 g kg^{-1}).

Chaudhary *et al*. [12] noticed that soil pH varied from 7.53 to 7.80. Maximum pH (7.80) was recorded with application of FYM @ 10 t ha^{-1} along with 100% RDN + *Azotobacter* + PSB. Superior organic carbon content (0.46%) was found under the two treatments 100% RDN + vermicompost @ 10 t ha^{-1} and 100% RDN + vermicompost @ 10 t ha^{-1} + *Azotobacter* + PSB.

Rather and Sharma [44] evaluated the effect of integrated nutrient management on soil properties in wheat and described that minimum pH (7.1), EC (0.23 dS m^{-1}) and maximum organic carbon content (4.6 g kg^{-1}) was recorded under the treatment of 100% recommended NPK + vermicompost + Zinc + PSB. Singh *et al*. [52] evaluated the response of garden pea to integrated nutrient management. He revealed that soil pH varied from 7.4 to 7.7 and highest organic carbon (0.54%) was observed through the application of 50% NPK + Biofertilizer + FYM @ 5.0 t ha^{-1} + poultry manure @ 1.25 t ha^{-1} + Vermicompost @ 1.25 t ha^{-1}.

Chopra *et al*. [14] laid down an experiment to evaluate the influence of integrated nutrient management in tomato and reported that maximum EC (1.12 dS m^{-1}) and organic carbon (24.85 mg kg^{-1}) was recorded with the application of 50% RDF + Agro residue vermicompost @ 5 t ha^{-1}. However, lowest EC (0.35 dS m^{-1}) was found under the control and minimum organic carbon (10.35 mg kg^{-1}) was observed in 100% RDF applied treatment. Azarmi *et al*. [6] also assessed the effect of vermicompost on the soil in tomato. They revealed that with increase in the amount of vermicompost applied, soil organic carbon content was also increased from 0.624% to 1.323%. Soil pH was decreased maximum (7.33) in 15 t ha^{-1} vermicompost treated plots as compared to control in which 8.0 pH was observed. Mukta *et al*. [39] studied the effect of vermicompost and inorganic fertilizers under tomato crop and showed that soil pH was minimum (6.32) under the control and maximum (6.75) under the 10 t ha^{-1} vermicompost + 50% RDF applied treatment. Maximum organic carbon content (0.87%) was also found under the plots treated with vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers. Kannan *et al*. [26] revealed that increase in organic carbon level (0.84%) was observed when recommended dose of fertilizers was applied along with vermicompost in maize.

Sharma *et al*. [48] investigated the impact of integrated nutrient management on the soil under onion. They showed that soil pH did not differ significantly under different treatments. Soil pH varied from 6.0 to 6.4. Maximum organic carbon was recorded in two treatments *viz*. 20 t ha^{-1} FYM + FYM (150-100-75 kg ha^{-1}) and 10 t ha^{-1} FYM + mustard oil cakes (1 t ha^{-1}) + NPK (125-100-100 kg ha^{-1}). Chakraborty *et al*. (2017) studied the influence of INM on soil physico-chemical properties in bitter gourd. They reported that pH of the soil varied from 6.35 (Mustard oil cake @ 7.0 t ha^{-1}) to 6.90 (RDF of NPK). Application of RDF of NPK (90:60:60) + Mustard oil cake @ 1.75 t ha^{-1} resulted in maximum CEC (13.01 meq/100g). Highest organic carbon (1.28%) was obtained under the treatment of FYM @ 25.0 t ha^{-1}.

An investigation was carried out by Jat and Singh [25] at Agricultural Research Farm, Banaras Hindu University, Varanasi to describe the effect of integrated nutrient management on the soil. Soil pH varied from 7.93 (70% RDF + 30% N by pressmud) to 8.32

(control). Significantly superior organic carbon (0.48%) and CEC [10.17 cmol (p^+) kg^{-1}] was recorded with the treatment of 70% RDF + 15% N by FYM + 15% N by pressmud.

Singh *et al*. [55] investigated the effect of organic manures combined with inorganic fertilizers under rice-wheat cropping system at Crop Research Center, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. Application of 100% NPK + Green manure resulted in increased organic carbon content by 1.38% and 1.40% after the harvest of rice and wheat, respectively over the control.

Islam *et al*. [23] evaluated the effect of chemical fertilizers and organic manures under tomato in a field experiment conducted in the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University (BAU), Mymensingh. They noticed that pH of the soil varied from 5.53 (100% RDF) to 6.88 (poultry manure @ 3 t ha^{-1} + rice straw @ 5 t ha^{-1} + plant hormone @ recommended dose). Maximum organic carbon (4.22%) was recorded with the application of poultry manure @ 3 t ha^{-1} + rice straw @ 5 t ha^{-1} + plant hormone at recommended rates.

Reena *et al*. [45] conducted a study to assess the effect of integrated nutrient management on soil under wheat at C.S. Azad University of Agriculture and Technology, Kanpur. Application of N_{150} + P_{60} +K_{60} + Sulphur + Boron + FYM resulted in minimum pH (7.4) and maximum organic carbon (0.46%). Beside this, maximum pH (7.8) and minimum organic carbon (0.43%) was found under the control.

CONCLUSION

Integrated nutrient management with organic sources like vermicompost, Farm yard manures were found effective in increasing the plant growth as well as soil parameters in Cauliflowee at combined approach with inorganic fertilizers.

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