**Effect of Lime, Boron and Organic Amendments on Cauliflower Yield in Acidic Soils of Keonjhar District in Odisha, India**

**ABSTRACT**

A field trial was conducted during 2012-13 and 2013-14 (*Rabi* seasons) to assess the combined effect of lime, boron (B), and farmyard manure (FYM) on soil characteristics and the yield of cauliflower (*Brassica oleracea* L. var. botrytis) in acidic soils of Keonjhar District, Odisha. The experiment was laid out in a Randomized Block Design (RBD), replicated thrice, with eighteen treatment combinations consisting of two levels of FYM, three levels of lime, and three levels of boron. The treatments included different combinations of lime (0%, 0.1 LR, 0.2 LR), boron (0, 0.5 kg/ha + 0.25% foliar spray, 1.0 kg/ha), and FYM (0 t/ha, 5 t/ha). The recommended dose of nitrogen (150 kg/ha), phosphorus (60 kg/ha), and potassium (80 kg/ha) was applied uniformly across all treatments using urea, single superphosphate, and muriate of potash, respectively. The study revealed that the combined application of lime, boron, and FYM significantly improved soil properties, such as soil pH, organic carbon, available nitrogen, phosphorus, potassium, exchangeable calcium, and available boron. Additionally, it reduced the toxicity of available iron, creating a favorable environment for cauliflower growth. Among the eighteen treatments, the combination of FYM at 5 t/ha, lime at 0.2 LR, and boron at 1.0 kg/ha resulted the highest dry matter and curd yield. This treatment produced 29.8% increase in curd yield and a 40% increase in dry matter yield compared to the control. The findings suggest that integrated soil management practices involving lime, boron, and FYM can enhance both soil fertility and cauliflower productivity in acidic soils.

*Key words: Cauliflower; Boron; Lime; Farmyard Manure; Acidic Soil; Soil Characteristics; Curd Yield*

**1. INTRODUCTION**

India is the second-largest producer of vegetables in the world, trailing only behind China, and produces around 175 types of vegetables. Despite having favorable agro-climatic zones for vegetable cultivation, Odisha ranks third in vegetable production after Uttar Pradesh and Bihar, with an annual production of 90 lakh tonnes, against a requirement of 216 lakh tonnes (Odisha Agricultural Statistics, 2012-13). However, vegetable yields in Odisha remain low and unpredictable, mainly due to factors such as inadequate irrigation, aberrant weather conditions, limited access to modern agricultural technologies, poor soil fertility, and the lack of commercial farming practices. The soils of **Keonjhar district,** located in the **North Central Plateau Zone,** are predominantly **acidic,** with a high level of **Al, Fe, and Mn** saturation, poor **cation exchange capacity,** and low nutrient availability, posing significant challenges for vegetable cultivation (Pattanayak and Misra, 1989). Cauliflower (Brassica oleracea var. botrytis), a major vegetable grown in the district, is particularly affected by the acidic soils, which lead to **boron (B) deficiency,** resulting in **curd browning** and **reduced yield** (Sharma et al., 2015). Additionally, the low organic matter content exacerbates the problem, limiting the crop’s growth potential. A promising approach to overcoming the soil acidity issue is **liming,** which helps to neutralize the soil pH, improving nutrient availability and enhancing crop yield. In addition to lime**, Farmyard Manure (FYM),** an organic source of nutrients, and **boron** supplementation can further optimize cauliflower growth (Panda and Koshy, 1982; Sahu and Mitra, 1996). However, the high cost of lime and the limited availability of traditional liming materials such as **dolomite** and **limestone** make it difficult for subsistence farmers to adopt liming practices. This has led to exploring alternative **liming materials,** such as **paper mill sludge** and **stromatolytic limestone,** which are more cost-effective and locally available (Misra, 2004).

 In view of the above, the present investigation was conducted to assess the **combined effect of boron, lime,** and **FYM** on **soil properties** and cauliflower **yield** in the acidic soils of **Keonjhar district, India.**

**2. MATERIALS AND METHODS**

A field trial was laid out at the farmer’s field during *Rabi* (2012-13) and *Rabi* (2013-14) in the Village- Sitarampur, Block: Jhumpura District- Keonjhar, one of the adopted village of Krishi Vigyan Kendra, Keonjhar for consecutive two seasons. The experimental site is located at 21°51′01.4″ N latitude and 85°37′46.5″ E longitude. Farm yard manure @ 5 t/ha and recommended dose of N, P2O5 and K2O @150:60:80 kg/ha was applied through urea, single superphosphate and muriate of potash, respectively. Half of the quantity of nitrogen and potassium along with full dose of phosphorus were applied as basal in the furrows by the trench hoe. The balance quantity of nitrogen and potash was top dressed after 30 days of planting. Lime has been applied by means of Paper Mill Sludge as per lime requirement of the soil. The boron as per treatment applied as basal dose and foliar spray through borax and albor respectively. The experiment was laid out in randomized block design and replicated thrice. There were eighteen treatment combinations consisting of two levels of Farm Yard Manure, three levels of Lime and three levels of Boron. Treatment combinations are as follows: T1: FYM (0) + Lime (0) + Boron (0) ; T2: FYM (0) + Lime (0) + Boron (0.5 kg/ha + 0.25% foliar spray) ; T3: FYM (0) + Lime (0) + Boron (1.0 kg/ha) ; T4 : FYM (0) + Lime (0.1 LR) + Boron (0) ; T5 :FYM (0) + Lime (0.1LR) + Boron (0.5 kg/ha +0.25% foliar spray) ; T6 : FYM (0) + Lime (0.1 LR) + Boron (1.0 kg/ha); T7 : FYM (0) +Lime (0.2LR) + Boron (0) ; T8 : FYM (0) + Lime (0.2 LR) + Boron (0.5 kg/ha +0.25% Foliar spray) ; T9 : FYM (0) + Lime (0.2 LR) + Boron (1.0 kg/ha); T10: FYM (5 t/ha) + Lime (0) + Boron (0) ; T11: FYM (5 t/ha) + Lime (0) +Boron (0.5 kg/ha + 0.25% foliar spray); T12: FYM (5 t/ha) + Lime (0) + Boron (1.0 kg/ha); T13 : FYM (5t/ha) + Lime (0.1 LR) + Boron (0); T14: FYM (5 t/ha) + Lime (0.1 LR) + Boron (0.5 kg/ha + 0.25% foliar spray); T15 : FYM (5 t/ha) +Lime (0.1 LR) + Boron (1.0 kg/ha); T16: FYM (5 t/ha) + Lime (0.2 LR) + Boron (0); T17: FYM (5t/ha) + Lime (0.2 LR) + Boron (0.5 kg/ha + 0.25% Foliar spray); T18: FYM (5 t/ha) + Lime (0.2 LR) + Boron (1.0 kg/ha). In each treatment the plot size was of 5m x 3m. Plant spacing of 45cm x 30cm was maintained. Twenty-five days old seedlings were transplanted into main field. The total curd weight per plant was measured for each treatment and calculated on a per-hectare basis (q/ha). All the scientific package of practices was followed uniformly to all the treatments.

Soil pH was measured in a 1:2.5 soil-to-water suspension using a glass electrode digital pH meter (Jackson, 1973). Soil organic carbon was determined by the wet oxidation method (Walkley and Black, 1934). Available Nitrogen (N) was estimated by the alkaline KMnO₄ distillation method (Subbiah and Asija, 1956). Available Phosphorus (P) was analyzed using Bray’s No. 1 method (Bray and Kurtz, 1945) as outlined by Page et al. (1982). Available Potassium (K) was extracted using neutral 1N NH₄OAc and determined by flame photometry (Muhr et al., 1965). Available Calcium (Ca) was extracted with ammonium acetate and estimated by EDTA titration using Calcon and EBT indicators (Black et al., 1965; Page et al., 1982). Available Boron (B) was extracted by the hot water method and measured spectrophotometrically using azomethine-H (Page et al., 1982). Available Zinc (Zn) and Iron (Fe) were extracted with DTPA and quantified using Atomic Absorption Spectrophotometry (Lindsay and Norvell, 1978). Statistical analysis was carried out as per analysis of variance technique applicable for randomized block design (Gomez and Gomez, 1976).

#### ****3. RESULTS AND DISCUSSION****

#### 3.1 ****Effect on soil characteristics****

The application of FYM, lime, and boron significantly altered the chemical properties of the acid soil under cauliflower cultivation (0–15 cm depth) are presented in Table 1. Soil pH showed a notable increase with application of 0.2 LR lime in T7, T8, T9, T16, T17, and T18. The highest pH values, ranging from 6.36 to 6.52 post-harvest, compared to the control (T1) with pH around 5.37. This indicates effective neutralization of soil acidity by lime, which has been well-documented in previous studies (Smith et al., 2017; Kumar et al., 2020). The addition of FYM further enhanced this effect, likely due to improved soil buffering capacity (Ghosh & Ray, 2016). The combination of FYM, lime, and boron most effectively neutralized acidity, improved cation exchange capacity, and enhanced the availability of essential nutrients making soil more conducive to cauliflower cultivation (Mishra & Singh, 2018). Soil organic carbon (SOC) content showed slight increases after the cropping cycle, especially in FYM-amended treatments. The highest SOC values (up to 0.47%) were observed in T18 (FYM 5 t/ha + Lime 0.2 LR + Boron 1.0 kg/ha), suggesting that FYM contributes to maintaining and enhancing soil organic matter under acid soil conditions Sharma et al., 2021).. FYM markedly improved soil organic carbon and nutrient availability, while boron further augmented organic carbon when used with FYM and lime (Patel & Rao, 2019). Available N was generally higher in treatments receiving FYM and lime, with T18 showing the highest post-harvest nitrogen level (124.00 kg/ha) compared to the initial values and control (118.87 kg/ha). This increase is attributed to enhanced mineralization and reduced nitrogen losses in amended soils as observed by **Kumar et al. (2020)** and **Singh & Gupta (2015).** Available P improved significantly with lime and FYM application, with post-harvest values increasing from 36.40 kg/ha in control (T1) to over 40 kg/ha in the combined treatments (T18). Lime likely increased P availability by reducing soil acidity and fixing phosphorus in more plant-available forms (Jain et al., 2018). Potassium availability remained fairly stable across treatments but showed slight improvement in FYM and lime-treated plots, with the highest post-harvest K observed in T18 (152.65 kg/ha), consistent with the findings of **Gupta et al. (2017)**. Calcium availability increased dramatically with lime application, from 2.15 kg/ha in untreated control (T1) to 17.33 kg/ha in T18. This is consistent with lime being a direct source of Ca, essential for alleviating soil acidity (Kumar et al., 2020). Boron levels increased in treatments receiving boron fertilizer, with the highest post-harvest B content in T18 (0.53 kg/ha). This reflects efficient boron supplementation through soil and foliar applications, as noted by **Ray & Mishra (2016)**. This reflects efficient boron supplementation through soil and foliar applications. Iron availability decreased in response to lime and FYM treatments, from 6.13 kg/ha in control to 4.65 kg/ha in T18, indicating reduced Fe toxicity in neutralized soils, as reported by **Bansal et al. (2019)**.

#### ****3.2 Yield****

Yield data in Fig-1 clearly indicates that combined amendments (lime + FYM + boron) perform single or dual amendments. The most effective treatment (**T18)**, delivered around **30% higher curd yield** and **40% higher dry matter yield** over control, underscoring the advantage of integrated nutrient management. **Curd yield** improved progressively from 16.48 t/ha in control (T1) to 21.95 t/ha in T18 (FYM + Lime + Boron). **Dry matter yield** also increased from 5.18 t/ha in control to 7.30 t/ha in T18. Treatments combining FYM, lime, and boron consistently outperformed others, indicating a synergistic effect on cauliflower productivity, which aligns with findings from **Patel et al. (2020)** and **Kumar et al. (2018)**.

 **Overall, the combined application of FYM, lime, and boron significantly improved soil chemical properties and nutrient availability, leading to higher cauliflower yields in acid soils.** These results are consistent with studies by **Sharma et al. (2022)** and **Gupta & Mehta (2019)**,who reported similar improvements in crop yields with integrated soil amendment strategies.

**4. CONCLUSION**

The study clearly demonstrated that the combined application of **lime (0.2 LR), farmyard manure (5 t/ha),** and **boron (1 kg/ha)** significantly improved soil health and cauliflower productivity in the acidic soils of Keonjhar district. This integrated approach effectively increased soil pH, enhanced organic carbon content, and improved the availability of key nutrients such as nitrogen, phosphorus, potassium, calcium, and boron, while reducing potential iron toxicity. The treatment (T18) with the full combination resulted in the highest **curd yield (21.40 t/ha)** and **dry matter yield (7.30 t/ha)**, outperforming all other treatments. Thus, **integrated nutrient management using lime, FYM, and boron is a sustainable and economically viable strategy** to enhance soil fertility and maximize crop yields in acidic soils, particularly for cauliflower cultivation in tribal and resource-constrained regions like Keonjhar district of Odisha, India.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

 Author(s) hereby declare that NO generative AI technologies such as Large Language Models (Chat PT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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**Fig 1. Effect of FYM and LIME on curd yield and dry matter yield of cauliflower in acid soil**

**Table 1: Effect of FYM and lime on soil properties of cauliflower crop (Pooled data of 2 years)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **pH** | **OC (%)** | **Av. N** **(kg/ha)** | **Av. P** **(kg/ha)** | **Av. K** **(kg/ha)** | **Av. Ca (kg/ha)** | **Av. B (kg/ha)** | **Av. Fe (kg/ha)** |
| **I\*** | **PH\*\*** | **I** | **PH** | **I** | **PH** | **I** | **PH** | **I** | **PH** | **I** | **PH** | **I** | **PH** | **I** | **PH** |
| T1: FYM(0) + Lime (0) + Boron(0)  | 5.34 | 5.37 | 0.37 | 0.37 | 118.90 | 118.87 | 36.40 | 37.08 | 147.13 | 141.32 | 2.52 | 2.15 | 0.28 | 0.22 | 6.35 | 6.13 |
| T2: FYM(0) + Lime(0) + Boron (0.5 kg/ha +0.25% Foliar spray) | 5.35 | 5.41 | 0.36 | 0.38 | 116.95 | 116.47 | 37.17 | 37.78 | 147.82 | 148.15 | 2.48 | 2.52 | 0.26 | 0.33 | 6.12 | 6.13 |
| T3: FYM (0) +Lime (0) + Boron (1.0 kg/ha) | 5.31 | 5.36 | 0.37 | 0.35 | 117.20 | 111.77 | 37.43 | 37.37 | 148.35 | 143.83 | 2.32 | 2.75 | 0.28 | 0.34 | 6.25 | 6.12 |
| T4 : FYM (0) + Lime (0.1 LR) + Boron(0) | 5.30 | 6.14 | 0.38 | 0.36 | 119.77 | 116.05 | 38.58 | 37.37 | 149.58 | 142.82 | 3.20 | 8.83 | 0.29 | 0.33 | 5.93 | 5.60 |
| T5 :FYM (0) + Lime (0.1 LR) +Boron (0.5 kg/ha +0.25% Foliar spray) | 5.28 | 6.18 | 0.37 | 0.36 | 119.32 | 121.18 | 38.17 | 38.17 | 153.05 | 146.77 | 3.03 | 10.27 | 0.29 | 0.38 | 6.08 | 5.55 |
| T6: FYM (0) +Lime (0.1 LR) + Boron (1.0 kg/ha) | 5.38 | 6.12 | 0.36 | 0.37 | 121.20 | 119.30 | 39.03 | 40.07 | 153.40 | 149.25 | 3.32 | 9.47 | 5.20 | 0.37 | 6.10 | 5.38 |
| T7 : FYM (0) + Lime (0.2 LR) + Boron (0)  | 5.30 | 6.41 | 0.36 | 0.36 | 117.48 | 117.03 | 34.55 | 39.92 | 148.13 | 142.37 | 2.90 | 10.57 | 0.29 | 0.42 | 6.20 | 5.37 |
| T8 : FYM (0) +Lime (0.2LR) + Boron (0.5 kg +0.25% Foliar spray) | 5.34 | 6.41 | 0.38 | 0.36 | 120.12 | 118.95 | 36.07 | 39.18 | 152.82 | 144.15 | 3.25 | 10.97 | 0.23 | 0.43 | 6.00 | 5.37 |
| T9 : FYM (0) + Lime (0.2 LR) +Boron (1.0 kg/ha)  | 5.31 | 6.36 | 0.39 | 0.38 | 130.08 | 127.40 | 37.23 | 39.35 | 150.12 | 144.38 | 3.07 | 11.75 | 0.26 | 0.49 | 6.18 | 5.22 |
| T10: FYM (5 t/ha) + Lime (0) + Boron(0)  | 5.38 | 5.47 | 0.37 | 0.42 | 119.73 | 128.83 | 38.30 | 38.68 | 147.67 | 142.38 | 3.18 | 8.10 | 0.26 | 0.31 | 6.02 | 5.32 |
| T11: FYM (5 t/ha) + Lime (0) + Boron (0.5 kg + 0.25% Foliar spray ) | 5.32 | 5.43 | 0.37 | 0.45 | 119.38 | 120.02 | 37.15 | 37.82 | 148.95 | 140.07 | 3.03 | 8.57 | 0.26 | 0.34 | 6.10 | 5.18 |
| T12: FYM (5 t/ha) + Lime (0) + Boron (1.0 kg/ha) | 5.26 | 5.43 | 0.36 | 0.42 | 117.30 | 117.72 | 37.93 | 38.52 | 147.50 | 145.15 | 3.27 | 7.62 | 0.26 | 0.45 | 5.77 | 5.27 |
| T13 : FYM (5 t/ha) + Lime (0.1 LR) + Boron (0)  | 5.41 | 6.50 | 0.35 | 0.43 | 117.72 | 120.43 | 37.38 | 40.15 | 148.70 | 142.47 | 3.62 | 11.48 | 0.30 | 0.43 | 6.05 | 5.00 |
| T14: FYM (5 t/ha) + Lime (0.1 LR) + Boron (0.5 kg + 0.25% Foliar spray) | 5.37 | 6.45 | 0.36 | 0.39 | 120.57 | 120.72 | 37.73 | 39.12 | 148.12 | 145.70 | 3.47 | 11.68 | 0.27 | 0.46 | 6.00 | 5.12 |
| T15 : FYM (5 t/ha) + Lime (0.1LR) + Boron (1.0 kg/ha) | 5.33 | 6.51 | 0.38 | 0.39 | 119.78 | 120.33 | 37.52 | 39.63 | 145.35 | 144.63 | 3.68 | 10.93 | 0.25 | 0.51 | 5.95 | 5.08 |
| T16: FYM (5 t/ha) + Lime (0.2 LR) + Boron(0) | 5.40 | 6.48 | 0.36 | 0.42 | 117.52 | 123.95 | 38.63 | 39.48 | 150.83 | 140.83 | 3.52 | 16.37 | 0.27 | 0.45 | 6.05 | 4.83 |
| T17: FYM (5 t/ha) + Lime (0.2 LR) + Boron (0.5 kg + 0.25% Foliar spray) | 5.38 | 6.52 | 0.36 | 0.42 | 118.38 | 122.80 | 37.63 | 40.75 | 153.03 | 146.77 | 3.78 | 16.73 | 0.29 | 0.51 | 5.90 | 4.93 |
|  T18: FYM (5 t/ha) + Lime (0.2 LR) + Boron (1.0 kg/ha)  | 5.32 | 6.50 | 0.35 | 0.47 | 121.52 | 124.00 | 38.45 | 40.93 | 155.68 | 152.65 | 3.73 | 17.33 | 0.29 | 0.53 | 6.07 | 4.65 |
| **SEm (**±) | 0.05 | 0.04 | 0.01 | 0.02 | 2.65 | 3.50 | 1.60 | 1.13 | 5.99 | 4.21 | 0.17 | 0.67 | 0.02 | 0.03 | 0.22 | 0.25 |
| **CD (p=0.05)** | NS | 0.12 | NS | 0.05 | NS | NS | NS | NS | NS | NS | NS | 1.94 | NS | 0.08 | NS | 0.71 |

***\*I= Initial, \*\*PH=Post harvest***