



Enhancing Cauliflower Yield and Quality through Lime, Boron, and Farmyard Manure in Acidic Soils of Keonjhar District, Odisha, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field trial was conducted during Rabi seasons (2012-13 and 2013-14) in the acidic soils of Keonjhar district of Odisha to assess the effect of lime, boron, and farmyard manure (FYM) on yield and quality of cauliflower (*Brassica oleracea* L. var. *botrytis*). The experiment was arranged in a randomized block design with three replications and involved eighteen treatment combinations. These treatments consisted of two levels of FYM (0 and 5 t/ha), three levels of lime (0, 0.1 LR, and 0.2 LR), and three levels of boron (0, 0.5 kg/ha with 0.25% foliar spray and 1.0 kg/ha), with all plots receiving a uniform recommended dose of N, P₂O₅ and K₂O (150:60:80 kg/ha). Results indicated that the combined application of FYM at 5 t/ha, lime at 0.2 LR and boron at 1.0 kg/ha produced the highest dry matter yield. This treatment increased curd yield by 29.8% and dry matter yield by 40% over the control. Additionally, significant improvements were observed in growth attributes with increases of 35% in plant height, 48.4% in the number of leaves, 10.3% in plant spread, 37.5% in stalk length, 13.9% in curd diameter, 43% in curd weight, and 9.4% in curd length. Quality parameters including ascorbic acid and protein content, were also enhanced through combined application of FYM, lime and boron. The best treatment registered a net return of Rs. 1,24,450/- with a benefit-cost ratio of 4.27, making it highly recommended for cauliflower cultivation in red and lateritic soils of Odisha.

Keywords: Cauliflower; yield; quality; boron; lime; farmyard manure; acid soil.

1. INTRODUCTION

India is the world's second-largest producer of vegetables after China, cultivating 175 different types of vegetables. Cauliflower (*Brassica oleracea* L. var. *botrytis*) is one of the most important vegetable crops in India. The country produces 33,94,897 tonnes of cauliflower from an area of 2,38,632 hectares, and its productivity (147.00 q/ha) exceeds the world average of 136.24 q/ha. However, there is still potential to increase productivity to approximately 300 q/ha through improved nutrient and soil management practices (Kalloo & Pandey, 2002). The ten agro-climatic zones in Odisha are suitable for growing most vegetables found across the country.

In Keonjhar district, cauliflower is cultivated throughout the year, and its production as an off-season vegetable is particularly valuable because it fetches a high market price, thereby improving the economic status of local farmers. Nevertheless, the crop often exhibits deficiency symptoms such as browning of the curd, marginal leaf mottling, and a hollow stem, rendering the curd unfit for human consumption and reducing overall yield. The combined effect of acidic soils and low organic matter significantly hampers the productivity and quality of cauliflower.

Low yields and uncertain production in the state are primarily due to factors such as the lack of irrigation facilities, increasingly erratic weather

conditions, limited financial resources among farmers, insufficient knowledge of modern technology, non-availability of high-yielding seeds, inadequate cold storage facilities, a non-commercial approach to cultivation, limited land under vegetable production, and poor nutrient management. Increasing productivity requires both an expansion in the area under vegetable cultivation and improvements in productivity per unit area through technological innovations. Nevertheless, there is an urgent need to develop better production technologies for higher productivity and profitability. The soils in Keonjhar district is mostly acidic, with a light-textured surface and heavier subsoil, and typically have low available potassium. Acidic soils in the region impose several constraints on crop production, low water holding capacity and reduced cation exchange capacity (Pattanayak & Misra, 2002). Amelioration of soil acidity, appropriate nutrient supplementation, judicious use of chemical fertilizers and balanced application of organic amendments are crucial for managing acid soils (Pattanayak, 2013). Liming, which involves the application of compounds containing calcium (or calcium plus magnesium), is an effective method to neutralize soil acidity, restore buffering capacity, and reduce phosphorus fixation (Mishra & Pattanayak, 2002). Odisha's acid soils, which account for more than two-thirds of the state's total soil area, are also deficient in boron. Studies have recorded a 53% yield response in red and lateritic soils with the application of boron at rates

of 1.5 to 2.0 kg/ha (Sahu & Mitra, 1992). Furthermore, organic manures can influence boron availability by adsorbing the nutrient and modifying the soil's mineral surfaces (Yermiyaho et al., 1998).

In view of the above, the present study was carried out to assess the effect of lime, boron and farm yard manure on yield and quality of cauliflower in acidic soils in Keonjhar district.

2. MATERIALS AND METHODS

A field trial was conducted at a farmer's field in Sitarampur village, Jhumpura Block, Keonjhar district (an adopted village of Krishi Vigyan Kendra, Keonjhar) during two consecutive Rabi seasons (2012-13 and 2013-14). The experimental site is located at 21°51'01.4" N latitude and 85°37'46.5" E longitude. Prior to transplanting, farmyard manure (FYM) was applied at a rate of 5 tonnes per hectare. The recommended doses of nitrogen, phosphorus (P_2O_5) and potassium (K_2O) were applied at rates of 150, 60, and 80 kg/ha, respectively, using urea, single superphosphate, and muriate of potash. Half of the nitrogen and potassium along with the full dose of phosphorus were incorporated as a basal application in the furrows using a trench hoe, while the remaining nitrogen and potash were top-dressed 30 days after planting. Lime was applied in the form of paper mill sludge according to the soil's lime requirement. Boron was applied as per the treatment specifications, with a basal dose using borax and a foliar spray. The experiment was arranged in a randomized block design with three replications. Eighteen treatment combinations were formulated based on two levels of FYM (0 and 5 t/ha), three levels of lime (0, 0.1 LR, and 0.2 LR, where LR denotes the lime rate based on the soil requirement), and three levels of boron (0, 0.5 kg/ha combined with 0.25% foliar spray, and 1.0 kg/ha). The treatment combinations were comprised in eighteen treatments i.e. 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)

Each treatment plot measured 5 m × 3 m, and the plants were spaced at 45 cm × 30 cm. Twenty five day old seedlings were transplanted into the main field, and all recommended cultural practices were uniformly followed across treatments. At harvest, ten plants were randomly sampled from each plot. The total curd weight per plant was measured for each treatment and calculated on a per-hectare basis (q/ha). Statistical analysis was carried out using the analysis of variance (ANOVA) technique for a randomized block design following the methodology of Gomez and Gomez (1976).

3. RESULTS AND DISCUSSION

3.1 Dry Matter and Curd Yield

Results revealed that data on curd and dry matter yield of cauliflower during 2012-13 and 2013-14 and pooled analysis are presented in Table 1. The control (T₁) recorded a curd yield of 16.48 t/ha. Lime application (T₄, T₇) increased yield to 17.98 t/ha and 18.67 t/ha, respectively. Adding FYM (T₁₃, T₁₆) further improved yield to 20.08 t/ha and 21.43 t/ha. The highest yield (21.95 t/ha) was in T₁₈ (Lime, Boron, and FYM). The lowest dry matter yield (5.18 t/ha) was in T₁. Lime (T₄, T₇) increased it to 5.73 t/ha and 6.01 t/ha, while FYM with Lime (T₁₃, T₁₆) improved it to 6.63 t/ha and 7.17 t/ha. The highest dry yield (7.30 t/ha) was in T₁₈. Similar findings align with Kumar et al. (2012), who reported improved cauliflower yield with FYM + Boron (1.5 kg/ha) in the Western Himalayas. Singh et al. (2009) also found that boron (2 kg/ha) significantly increased curd and dry matter yield, while Kotur (1991) observed the highest curd yield with Boron (1.5 kg/ha) + Lime. Prasad et al. (2000) also reported that 1.0 kg B/ha as optimal for mid-season cauliflower. Boron enhances carbohydrate and protein synthesis (Verma, 1983) and their translocation to storage organs (Sharma, 2002).

Table 1. Effect of FYM and LIME on curd yield and biochemical content in cauliflower crop in acid soil (pooled data of two years)

Treatments	Curd yield (t/ha)	Dry matter yield (t/ha)	Ascorbic acid (mg/100g)	Crude protein (g/100 g)
T ₁ : FYM(0) + Lime (0) + Boron(0)	16.48	5.18	15.98	1.52
T ₂ : FYM(0) + Lime(0) + Boron (0.5 kg/ha +0.25% Foliar spray)	16.78	5.32	16.72	1.59
T ₃ : FYM (0) +Lime (0) + Boron (1.0 kg/ha)	17.85	5.65	16.45	1.64
T ₄ : FYM (0) + Lime (0.1 LR) + Boron(0)	17.98	5.73	16.75	1.61
T ₅ :FYM (0) + Lime (0.1 LR) +Boron (0.5 kg/ha +0.25% Foliar spray)	18.15	5.83	17.70	1.67
T ₆ : FYM (0) +Lime (0.1 LR) + Boron (1.0 kg/ha)	18.38	5.95	17.73	1.68
T ₇ : FYM (0) + Lime (0.2 LR) + Boron (0)	18.67	6.01	16.75	1.60
T ₈ : FYM (0) +Lime (0.2LR) + Boron (0.5 kg +0.25% Foliar spray)	18.73	6.06	17.93	1.74
T ₉ : FYM (0) + Lime (0.2 LR) +Boron (1.0 kg/ha)	19.60	6.30	18.32	1.74
T ₁₀ : FYM (5 t/ha) + Lime (0) + Boron(0)	17.28	5.73	16.60	1.62
T ₁₁ : FYM (5 t/ha) + Lime (0) + Boron (0.5 kg + 0.25% Foliar spray)	18.10	6.03	17.98	1.63
T ₁₂ : FYM (5 t/ha) + Lime (0) + Boron (1.0 kg/ha)	18.18	5.98	18.48	1.72
T ₁₃ : FYM (5 t/ha) + Lime (0.1 LR) + Boron (0)	20.08	6.63	18.63	1.74
T ₁₄ : FYM (5 t/ha) + Lime (0.1 LR) + Boron (0.5 kg + 0.25% Foliar spray)	20.55	6.75	18.62	1.78
T ₁₅ : FYM (5 t/ha) + Lime (0.1LR) + Boron (1.0 kg/ha)	21.00	6.96	19.33	1.82
T ₁₆ : FYM (5 t/ha) + Lime (0.2 LR) + Boron(0)	21.43	7.17	18.65	1.83
T ₁₇ : FYM (5 t/ha) + Lime (0.2 LR) + Boron (0.5 kg + 0.25% Foliar spray)	21.67	7.24	20.37	1.82
T ₁₈ : FYM (5 t/ha) + Lime (0.2 LR) + Boron (1.0 kg/ha)	21.95	7.30	20.48	1.83
SEm (±)	0.62	0.18	0.51	0.05
CD (p=0.05)	1.79	0.52	1.47	0.15

3.2 Quality

Biochemical content data of cauliflower for 2012-13 and 2013-14 and pooled analysis are presented in Table 1. The control (T₁) recorded 15.98 mg/100g of ascorbic acid. Lime application (T₄, T₇) increased it to 16.75 mg/100g. Adding FYM to Lime (T₁₃, T₁₆) further raised levels to 18.63 mg/100g and 18.65 mg/100g, respectively. The highest content (20.48 mg/100g) was in T₁₈ (Lime, Boron, and FYM) while the lowest crude protein content (1.52 g/100g) was in T₁. Lime application (T₄, T₇) increased it to 1.61 g/100g and 1.60 g/100g, while FYM with Lime (T₁₃, T₁₆) enhanced it to 1.74 g/100g and 1.83 g/100g. The highest value (1.83 g/100g) was observed in T₁₆ and T₁₈.

Singh et al. (2009) reported a significant increase in protein content with boron application, corroborated by Chander et al. (2010), who found FYM + Boron improved nutritional quality. Paithankar et al. (2013) also reported that 0.3% borax foliar spray enhanced ascorbic acid and TSS in tomatoes

4. ECONOMICS

Effect of lime, boron and FYM application on economics of different treatments on cauliflower crop is presented in Table 2. The highest gross return (Rs. 1,64,625/-) was recorded in T₁₈ (Lime, Boron, and FYM), yielding a net return of Rs. 1,25,086/- and a Benefit-Cost (B:C) ratio of 4.16, compared to 3.49 in the control.

Table 2. Effect of lime, boron and FYM application on economics of different treatments on cauliflower crop (pooled data of two years)

Treatments	Cost of cultivation (Rs.)	Gross Return (Rs.)	Net Return (Rs.)	Cost Benefit (B:C) ratio
T ₁ : FYM(0) + Lime (0) + Boron(0)	35409	123625	88216	3.49
T ₂ : FYM(0) + Lime(0) + Boron (0.5 kg/ha +0.25% Foliar spray)	36249	125875	89626	3.47
T ₃ : FYM (0) +Lime (0) + Boron (1.0 kg/ha)	35569	133875	98306	3.76
T ₄ : FYM (0) + Lime (0.1 LR) + Boron(0)	36099	134875	98776	3.74
T ₅ : FYM (0) + Lime (0.1 LR) +Boron (0.5 kg/ha +0.25% Foliar spray)	36939	136125	99186	3.69
T ₆ : FYM (0) + Lime (0.1 LR) + Boron (1.0 kg/ha)	36259	137875	101616	3.80
T ₇ : FYM (0) + Lime (0.2 LR) + Boron (0)	36699	140000	103301	3.81
T ₈ : FYM (0) + Lime (0.2 LR) + Boron (0.5 kg + 0.25% Foliar spray)	37539	140500	102961	3.74
T ₉ : FYM (0) + Lime (0.2 LR) +Boron (1.0 kg/ha)	36859	147000	110141	3.99
T ₁₀ : FYM (5t/ha) + Lime (0) + Boron(0)	38089	129625	91536	3.40
T ₁₁ : FYMv(5 t/ha) + Lime(0) +Boron (0.5 kg + 0.25% Foliar spray)	38929	135750	96821	3.49
T ₁₂ : FYM (5 t/ha) + Lime (0) + Boron (1.0 kg/ha)	38249	136375	98126	3.57
T ₁₃ : FYM (5t/ha) + Lime (0.1 LR) + Boron (0)	38779	150625	111846	3.88
T ₁₄ : FYM (5t/ha) + Lime (0.1 LR) + Boron (0.5Kg + 0.25% Foliar spray)	39619	154125	114506	3.89
T ₁₅ : FYM (5 t/ha) + Lime (0.1 LR) + Boron (1.0 kg/ha)	38939	157500	118561	4.04
T ₁₆ : FYM (5 t/ha) + Lime (0.2 LR) + Boron (0)	39379	160750	121371	4.08
T ₁₇ : FYM (5 t/ha) + Lime (0.2 LR) + Boron (0.5 kg + 0.25% Foliar spray)	40219	162500	122281	4.04
T ₁₈ : FYM (5 t/ha) + Lime (0.2 LR) + Boron (1.0 kg/ha)	39539	164625	125086	4.16

5. CONCLUSION

Cauliflower (*Brassica oleracea* L. var. botrytis) is a crucial off-season crop in Keonjhar, but acidic soil and boron deficiency limit its yield and quality. It can be concluded that combined application lime, FYM, and boron significantly improves crop yield, quality and profitability in acidic soils, making it an effective strategy for cauliflower cultivation in red and lateritic soils of Keonjhar district in Odisha

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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