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Impact of Integrated Nutrient Management and Gravity-Based Irrigation on Broccoli Yield: A Cluster Front Line Demonstration Approach

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ABSTRACT: Broccoli cultivation is highly popular in developed countries and has recently gained traction in Mizoram as a commercial crop due to its lucrative returns and rich nutritional and medicinal value. To promote sustainable cultivation practices, Krishi Vigyan Kendra (KVK), Aizawl, conducted Cluster Front Line Demonstrations (CFLDs) during the Rabi seasons of 2016-17 and 2020-21. These demonstrations focused on Integrated Nutrient Management (INM) using IIHR Vegetable Special in Broccoli variety CLX3512, combined with a gravity-based mini sprinkler irrigation system. The demonstrations covered a total area of 45 hectares involving 120 farmers. Results indicated a significant increase in curd yield, averaging 211.40 quintals per hectare (qt/ha), which was 37.3% higher than the 151.0 qt/ha achieved through traditional farming practices. The extension gap ranged from 39 to 76 qt/ha, while the technology gap was between 48 and 89 qt/ha. Notably, the technology index reduced from 31.79% to 17.14%, indicating an improvement in technology adoption efficiency, with a mean value of 24.50%. Economic analysis revealed that the CFLD plots yielded a higher average gross return of Rs. 6,80,400 per hectare and a mean net return of Rs. 5,58,875 per hectare. The benefit-cost ratio (BCR) in the demonstration fields was an impressive 4.6 compared to 2.41 under farmers' conventional practices. These findings underscore the potential to enhance both yield and profitability in broccoli cultivation through the adoption of recommended technologies. To ensure broader adoption, it is essential to disseminate these improved practices among farmers through targeted extension strategies such as hands-on training sessions and on-farm demonstrations.

Keywords: Broccoli, Integrated Nutrient Management, benefit-cost ratio.

INTRODUCTION

Sprouting broccoli (*Brassica oleracea* var. Italica L.), native to the Eastern Mediterranean, is derived from ancient forms of *Brassica oleracea.* The term "broccoli" comes from the Latin word *brachium*, meaning "arm" or "branch" (Thamburaj and Singh 2013). It is prized for its rich taste, flavour, and high nutritional value, surpassing other cole crops like cauliflower and cabbage in vitamin A content—130 times more than cauliflower and 22 times more than cabbage. Broccoli is also a source of essential vitamins such as thiamine, riboflavin, niacin, vitamin C, and minerals like calcium, phosphorus, potassium, and iron. Selenium, an antioxidant, and powerful anticancer compounds such as glycosinolates (40–80 mg/100 g fresh) and sulforaphane further enhance its health benefits (Hazra *et al.,* 2011). A 100 g serving provides 89.9 g moisture, 3.3 g protein, 3500 IU vitamin A, and 137 mg ascorbic acid (Singh and Nath 2012). Although broccoli is widely cultivated in developed countries, its popularity is growing in Mizoram due to its nutritional value and potential for high economic returns. Currently, it is grown on 163 hectares in Aizawl District, producing 1,157 metric tons annually, though average productivity remains low at 7.65 mt/ha compared to the national average of 17.34 mt/ha (Horticulture Statistical, 2017).

Despite its potential, broccoli cultivation in Mizoram faces challenges, including limited access to high-yielding varieties, inadequate technological know-how, and imbalanced fertilizer use. Additionally, water scarcity and inefficient irrigation management hinder productivity. Given the region's topography, adopting gravity-based micro-irrigation systems, such as mini sprinklers, can improve water management. To address these issues, Krishi Vigyan Kendra (KVK), Aizawl, implemented Cluster Frontline Demonstrations (CFLDs) during the Rabi seasons of 2016–17 and 2020–21. The demonstrations used Integrated Nutrient Management (INM) with IIHR Arka Special micronutrients, coupled with gravity-based mini sprinkler systems, to optimize water and nutrient use. A holistic approach combining mineral fertilizers with organic manure, bio-fertilizers, and green manuring is essential for improving productivity. Increasing crop yields requires balanced nutrient application, and while organic inputs can supplement, they cannot replace mineral fertilizers. Effective adoption of these advanced agricultural practices requires hands-on training, demonstrations, and education for farmers, highlighting the critical role of extension services in enhancing broccoli production in Mizoram.

MATERIALS AND METHODS

Krishi Vigyan Kendra (KVK), Aizawl, conducted Cluster Front Line Demonstrations (CFLDs) on broccoli during the Rabi seasons of 2016-17 and 2020-21, covering 45 hectares and involving 120 farmers. The focus was on Integrated Nutrient Management (INM) using IIHR Vegetable Special combined with a gravity-based mini sprinkler system. The high-yielding hybrid broccoli variety CLX3512, well-suited to Mizoram's climatic conditions, was selected for cultivation. The nursery was raised in a community participatory mode, where a lead grower prepared the seedlings under polyhouse conditions, supported by KVK through the TSP program. Seeds were provided at a minimal cost, with one-third of the seedlings retained by the leader and the remainder distributed among the group members. Nursery beds were enriched with 4-5 kg/m² of well-rotted farmyard manure (FYM) or vermicompost and maintained at a width of 75-100 cm. To prevent damping-off disease, the beds were drenched with Dithane M-45 solution (2 g/L water). Seeds were sown in rows 6-8 cm apart at a density of 800-850 seeds/m² and covered with a mixture of sand, soil, and FYM/vermicompost. To manage pests, particularly cabbage butterfly larvae, manual picking was followed by spraying Chlorpyrifos or Rogor (3 ml/L water). Transplanting was done 26 days after sowing, maintaining a spacing of 45 × 50 cm. immediately after transplanting, light irrigation was provided using the mini sprinkler system to ensure optimal plant establishment. Following transplanting, light irrigation was applied using a mini sprinkler system (Turbo/Aquamaster, Jain Irrigation) to ensure proper plant establishment, with subsequent irrigations scheduled as needed. The plant population was maintained by gap filling 6-9 days after transplanting. Weed management was carried out manually with two sessions of weeding at 20 and 40 days after transplanting. Integrated Nutrient Management (INM) practices were implemented with a recommended dose of NPK (75:38:30 kg/ha), poultry manure (2.5 t/ha), vermicompost (2.5 t/ha), slaked lime (2 t/ha), and Arka Special micronutrient (4 kg/ha). Before transplanting, the entire dose of phosphorus and potassium, along with one-third of the nitrogen, was applied, incorporating urea (46% N), single super phosphate (16% P_2O_5), and muriate of potash (60% K_2O) into the soil. The remaining nitrogen was top-dressed in two equal splits at 15-20 and 30-35 days after transplanting, followed by earthing up. To enhance yield and quality, foliar applications of Arka Vegetable Special (75 g/15 liters of water) mixed with one shampoo sachet and juice from two medium-sized lemons were applied twice, at 25 and 40 days after transplanting. Regular weeding and intercultural operations were performed to maintain crop health. In Mizoram, where farmers rely heavily on rainwater, water scarcity during dry spells presents a significant challenge. The steep terrain and porous soils hinder traditional water storage methods. To address this, water harvesting in micro-water ponds, or *Jalkunds*, was implemented as part of a NABARD-funded project titled "Micro-level Water Conservation and Utilization Technique in Mizoram." Each *Jalkund* had a storage capacity of 27,000 liters, providing irrigation water during the lean period from October to January. The gravity-based mini sprinkler system layout included 16mm-diameter laterals connected via lateral and T joints. A Jain screen filter attached to the 32mm mainline ensured clean water delivery to the system. Sprinkler stakes, elevated using locally sourced bamboo (1-1.5 meters high), provided a calibrated discharge of 50 liters per hour, with an actual measured output of 40-45 liters per hour. Irrigation was scheduled twice a week, ensuring adequate moisture for optimal broccoli growth. The technology gap is a major constraint in increasing yield and sustainability due to lack of technological know-how, non-availability of suitable variety (high yielding orhybrid), do-how, interventions, imbalanced and non-judicious uses of critical inputs etc. (Santosh Kumar *et al.,* 2018). In keeping view of this, KVK, Aizawl, Mizoram cluster demonstration on broccoli had planned and executed with closer supervision and monitoring of the KVK Scientists with the best management practices under DFI scheme with the main aim to double farmers' income by 2022-23 is central to promote farmers welfare, reduce agrarian distress and bring parity between the income of farmers and those working in non-agricultural professions. The gathered data on different vegetative growth parameters (leaf weight and number of leaves), yield attributing (curd weight and curd yield) and economics were processed, tabulated, classified and analyzed in terms of mean percent score and ranks in the light of objectives of the study. Using these data the differences between potential yield and demonstration plot yield (Yield gap-I), difference between demonstration plot yield and actual yield or yield under existing practice (Yield gap- II) and difference between potential yield, actual yield (Total yield gap) and impact of adoption and horizontal area spread were worked out. The extension gap, technology gap, technology index and impact of adoption and horizontal area spread were calculated using the formula as suggested by Samui *et al.* (2000).

Technological gap (yield gap-I) = Potential yield – Demonstration plot yield.

Extension gap (yield gap II) = Demonstration – Actual yield (Farmers plot yield practice)

Total yield gap = Potential yield – Actual yield.

Technology index (%) = Technology gap/Potential yield × 100

Impact on horizontal spread area (change %) = Area after demonstration – Area before Demonstration/ Area before Demonstration × 100

RESULT AND DISCUSSION

The technology demonstration results revealed that the yield and yield attributing parameters were significantly influenced in compare to farmers practices (Table 1 & 2). The results revealed that cluster FLD demonstration on broccoli recorded higher yield as compared to farmer's practices over the years of study. The demonstrated technologies recorded average yield of 211.40 q/ha which was 37.30 percent higher than the obtained with farmer's practices of 151.0 q/ha. In spite of increase in production yield attributed parameter also influenced significantly over the farmers practices.

Table 1: Effect of cluster front line demonstration on growth, yield attributes and yield of broccoli.

Treatment	Gross weight (g)	No. of leaves per plant	Leaf weight/pt (g)	Head weight/pt (g)	Yield (q/ha)	B:C Ratio
Technology	920.30	14.10	496.32	335.20	211.40	4.60
Local check	810.10	12.89	502.30	222.17	151.00	2.41

Extension Gap, Technology Gap, Yield Index Analysis. The study revealed a significant variation in the technology gap, ranging from 48 to 89 quintals per hectare (qt/ha) over the study period (Table 2). This gap reflects the difference between the potential yield and the yield achieved in demonstration plots. Variations in the technology gap across different years were attributed to the improved performance of recommended broccoli varieties, enhanced by specific interventions and the increasing feasibility of adopting advanced agricultural practices. The findings underscore the importance of ongoing refinement and adaptation of these technologies to maximize yield potential.

The extension gap, defined as the difference between demonstration yields and yields from traditional farmer practices, ranged from 39 to 76 qt/ha, with an average of 60.4 qt/ha (Table 2). This gap highlights the positive impact of improved agricultural practices on yield outcomes. According to Santosh Kumar *et al.* (2018) the adoption of modern technologies in demonstration plots significantly increased broccoli head yields compared to traditional methods. The data emphasize the necessity of educating farmers on adopting high-yielding varieties and advanced techniques to narrow the extension gap. Widespread adoption of these innovations can help replace older, less productive varieties, ultimately boosting overall productivity. This conclusion aligns with the findings of Hiremath and Nagaraju (2010).

The technology index, which measures the practicality and applicability of the introduced technology at the farmer level, demonstrated a marked improvement. It decreased from 31.79% in 2016-17 to 17.14% in 2020-21 (Table 2), indicating a growing feasibility and acceptance of the demonstrated practices. A lower technology index reflects the effectiveness of the introduced technology in real-world farming conditions. These results corroborate the findings of Lal *et al*. (2016); Meena *et al.* (2016), further reinforcing the potential of these agricultural interventions to enhance productivity and sustainability in broccoli cultivation.

Impact. The adoption of recommended nutrient management practices significantly boosted farmers' income from broccoli cultivation. This success led to the horizontal expansion of the technology to neighbouring villages, with 220 farmers adopting it across more than 163 hectares. Due to its high impact and growing popularity within the farming community, Doordarshan National, Aizawl, Mizoram, featured the success story of Mr. Darhmingliana, a progressive farmer from Sihphir village. The coverage included video footage of a Field Day event, attended by KVK staff and local farmers, and was broadcast on 11th January 2021, showcasing the transformative potential of these agricultural practices.

Table 2: Impact of CFLDs on extension, technology gap and yield index of broccoli.

Year	No. of Demos	Yield qt/ha		Increase yield over the farmers practice	Extension gap	Tech. gap	Tech. index
		Improved practices	Farmer Practice				
2016-17	40	191	131	45.80	60	89	31.79
2017-18	40	197	158	24.68	39	83	29.64
2018-19	40	219	162	35.19	57	61	21.79
2019-20	50	232	156	48.72	76	48	17.14
2020-21	50	218	165	32.12	53	62	22.14
Mean	44	211.4	151	37.30	60.4	68.6	24.50

Tech. – Technology

Economics. The performance of the demonstrated technology was highly promising, resulting in higher yields and larger broccoli heads. The demonstration plot achieved a yield of 211.40 q/ha compared to 151 q/ha under traditional farmer practices. The total cost of cultivation was Rs. 1,21,525/ha for the demonstration plot and Rs. 5,58,875/ha compared to Rs. 4,41,600/ha in the check plot. Farmers received continuous technical guidance on Integrated Nutrient Management (INM) and other cultivation practices from KVK scientists, ensuring proper implementation of the recommended techniques. Active farmer participation was evident, particularly in adopting the improved practices. Field Day events organized during the harvesting period received enthusiastic responses from the farming community, enhancing the effectiveness of the demonstrations. These findings align with studies by Venkatreddy & Kumarprabhu (2017); Pawar *et al.* (2018) in groundnut cultivation, as well as Santosh Kumar *et al.* (2018) in broccoli.

Table 3: Effect of CFLD on economic of good horticultural practices in broccoli.

Treatment	Gross Cost (Rs)	Gross Return (Rs)	Net Return (Rs)	B:C Ratio
Technology	121525	680400	558875	4.60
Local check	96000	459200	324550	2.41

CONCLUSIONS

The study concluded that the Cluster Front Line Demonstration (CFLD) organized by KVK Aizawl in broccoli cultivation proved to be a highly effective tool for enhancing production, productivity, and farmer capacity. It significantly improved farmers' knowledge, attitudes, and skills, resulting in not only higher broccoli yields but also the rapid horizontal spread of recommended technologies. This initiative has contributed to achieving food and nutritional security for the community while boosting farmers' income and livelihoods.

The demonstration plots showed a mean yield increase of 37.30% compared to traditional practices, creating widespread awareness and motivating other farmers to adopt the improved package of practices for broccoli cultivation. The success of CFLDs highlights the potential for applying this approach across different categories of farmers, including progressive ones, to ensure the faster and broader dissemination of advanced agricultural practices throughout the farming community.

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