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Impact of front line demonstration on yield and economics of tomato (*Solanum lycopersicum* Mill.) in tribal area of Dungarpur district of Rajasthan

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Abstract
Tomato (*Solanum lycopersicum* Mill.) is one of the major vegetable crops cultivated in India, which plays a major role in supplementing the income of small and marginal farmers of tribal area of Dungarpur district of Rajasthan. The front line demonstrations (FLDs) were conducted on tribal farmer's field in Dungarpur district of Rajasthan for three consecutive years (2016-17 to 2018-19) at three adopted tribal villages. Prevailing farmer's practices were treated as control for comparison with demonstrated technology. The result of FLDs conducted by Krishi Vigyan Kendra, Faloj, Dungarpur in tomato crop shows a greater impact on farmer's livelihood due to significant increase in yield over local check. The improved tomato yield in the demonstration practices was attributed primarily to the use of improved technologies such as improved hybrids such as Arka Rakshak using vegetable special seed treatment & priming, transplanting methods & time, spacing, balanced nutrient application & WSF spray including secondary and micronutrients, integrated pest and disease management, weed management and proper irrigation methods. The average yield of tomato is increased by 21.02 per cent over the yield obtained under farmer's practices of tomato cultivation. On an average extension gap, technology gap and technology index under three years FLD programme was 65.0 q/ha, 376.3 q/ha and 50.17 per cent. The benefit cost ratio of tomato ranged from 2.91 to 4.23 in demonstration practice plots and from 2.38 to 3.18 in farmer's practice plots during three years of demonstration with an average of 3.57 in demonstration and 2.81 under farmer's practices. Present results clearly show that the yield and economics of tomato can be boost up by adopting recommended technologies.

Keywords: Demonstration, economics, tomato, Dungarpur, *Solanum lycopersicum* Mill

Introduction
Tomato (*Solanum lycopersicum* Mill.) is an important vegetable crop grown almost throughout the world including tropical and temperate regions. It is cultivated both in the green houses on protective structures as well as under natural conditions. It ranks first among processed vegetables. It is consumed fresh in salad, fried in culinary preparations and processed in various forms *viz*. ketchup, sauces, puree, paste, powder, juice soup and chutney etc. The fast foods such as pizza, burger, noodles etc. will not taste the same without addition of tomato sauces. Tomato is a rich source of vitamins A and C and is referred to as "poor man orange". It adds variety of colours to the food. Tomato is a very good appetizer and its soup is said to be a good remedy for patients suffering from constipation. Lycopene that imparts red colour to ripe tomatoes is reported to possess anticancerous properties. It also serve as a natural anti-oxidant as the Beta-carotene functions to help prevent and neutralize free radical chain reaction and ascorbic acid is an effective scavenger of superoxide, hydrogen peroxide, singlet oxygen and other free radicals (Dhaliwal, 2014) [4]. It is one of the most sensitive vegetable crops and fails miserably if growing conditions are too harsh. It is highly sensitive to frost. Dry and hot weather results in flower drops and poor fruit set. It can be grown in almost all states of India except in higher altitudes. Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh, Punjab, Haryana and Assam are important tomato growing states in India. In India during 2018-19 it was cultivated in 0.78 million hectare area with a production of 19.76 million tonnes. In Rajasthan its area and production were 18120 hectare and 88730 tonnes respectively. In Rajasthan the productivity of tomato was recorded 4.90t/ha, which was almost five time lower than the India's productivity i.e. 25.32t/ha (Anonymous, 2018). There is lot of scope of tomato growing in tribal area of Dungarpur district. The main objective of Front line Demonstration (FLD) is to introduce suitable agriculture practices like high yielding varieties, seed treatment, spacing, timely sowing, nutrient management including

micronutrients, growth hormones, pest and disease management etc. among the farmers accompanied with organizing extension programmes (field day) for horizontal dissemination of the technologies. FLD is playing a very important role for transfer of technologies and changing scientific treatment of the farmers by seeing and believing principle. In order to have better impact of the demonstrated technologies for farmers and field level extension functionaries, Front Line Demonstrations was conducted at farmer's field, in a systemic manner, to show case the high yielding new varieties, to convince them to about the potential of improved production technologies to enhance yield of tomato. Generally, the agricultural technology is not accepted by the farmers as such in all respects. There is always gap between the recommended technology by the scientist and its modified form at the farmer's level which is major absentee in the efforts of increasing agricultural production in the country. It is need of the hour to reduce this technological gap between the agricultural technology recommended by the scientists or researchers and its acceptance by the farmers on their field. In view of the above facts, front line demonstrations were undertaken in a systematic manner on farmer's field to show the worth of improved practices and convince the farmers to adopt in their farming system.

Materials and Methods

The frontline demonstrations were conducted by Krishi Vigyan Kendra, Faloj in Dungarpur district during 2016-17, 2017-18 and 2018-19, a total 100 front line demonstrations on tomato variety Arka Rakshak was conducted at farmer's field in the tribal area of Dungarpur district. The yield and economic performance of frontline demonstrations, the data on output were collected from demonstrated practices as well as farmer practices and finally the vegetable fruit yield, cost of cultivation, net returns with the benefit cost ratio was worked out. For the purpose of investigation, Dungarpur district, where FLDs were conducted during 2016-17, 2017-18 and 2018-19. For selection of beneficiary farmers, a list of farmers where FLDs on tomato vegetable were conducted (Table 1) during 2016-17, 2017-18 and 2018-19 was prepared and taking equal representation. The data were collected through personal contacts with the help of well-structured interview schedule. The gathered data were processed, tabulated, classified and analyzed in terms of mean percent score and ranks in the light of objectives of the study. More than 10 percent difference between beneficiary and non-beneficiary farmers' was considered as significant difference. The extension gap, technology gap, technology index, marginal benefit cost ratio and relative economic efficiency were calculated using the formula as suggested by Papnai, *et al*. 2017 [13].

Extension gap = Demonstrated practice yield- farmer's practice yield

Technology gap = Potential yield- Demonstration yield

Additional return = Demonstration return- farmer's practice return

$$\text{Technology index} = \frac{\text{Potential yield - Demonstration yield}}{\text{Potential yield}} \times 100$$

Table 1: Level of use and gap in adoption of tomato technologies in study area

Crop operations	Improved package of practices	Farmers practices	Gap
Variety	Arka Rakshak	Dev	Full gap
Soil testing	Have been done in all locations	Not in practice	Full gap
Seed rate	100 gm /ha	200 gm /ha	Partial gap
Seed treatment	Seed was treated with Captan @ 2-3g /kg seeds or carbendazim @ 1 g /kg seed and with Imidacloprid @ 2.0 g/Kg seed	Not in practice	Full gap
Transplanting method	Transplanting in raised bed distance Row to Row 120 cm & Plant to Plant 90 cm	Flat bed transplanting Row to Row 60 cm & Plant to Plant 30 cm	Partial gap
Transplanting time	February	April	Partial gap
Fertilizer dose	Fertilizer @ 180 kg N, 130 Kg, P2 O5 and 150 Kg K_2O	Nil/without recommendation	Partial gap
Weed management	Pendimethaline @ 1.0 Kg/ ha was applied immediately after transplanting.	Hand weeding /rarely used	Partial gap
WSF Spray	Foliar spray of 2% N:P:K 19:19:19 20,40,60 DAT	No application	Full gap
Plant protection	Need based in case of severe infestations of TLCV Imidacloprid 17.8% SL or dimethoate and other systemic chemicals	No application of chemicals/rarely used and without knowledge	Partial gap

Results and Discussion

The data were analyzed, and the technology gap, extension gap, and technology index were calculated according to the formula and an economic analysis was performed according to procedure, with the results presented in tables 2 and 3.

Yield analysis

The perusal of data (Table 2) indicate that due to initiation of front line demonstrations the tomato yield ranged from 365.9 q/ ha to 382.6 q/ha in demonstration practice plots and from 305.9 q/ ha to 310.6 q/ha in farmer's practice plot in three years of demonstrations conducted. An average yield of 373.7 q/ha was obtained under demonstration practice plots as compared to farmer's practice plots 308.8 q/ha in consecutively. The average yield of tomato is increased by 21.02 per cent over the yield obtained under farmer's practices of tomato cultivation. The result revealed the positive effects of FLD over the farmer's practices as it enhanced the yield of tomato in tribal area of Dungarpur district of Rajasthan. The improved tomato yield in the demonstration practices was attributed primarily to the use of improved technologies such as improved hybrids such as Arka Rakshak using vegetable special seed treatment & priming, transplanting methods & time, spacing, balanced nutrient application & WSF spray including secondary and micronutrients, integrated pest and disease management, weed management and proper irrigation methods. The results confirm the findings in different crops by Mishra *et al*., (2009) [12], Singh *et al*., (2011) [22], Mishra *et al*., (2014) [11], Singh *et al*., (2016) [19], Shalini *et al*., (2016) [17], Singh (2017) [18], Karipe and Krishnaveni (2017) [6], Kumar *et al*., (2017) [8], Kirankumar *et al*., (2017) [7], Singh *et al*., (2018) [20, 21], Singh and Tripathi (2018) [21], Rai *et al*., (2019) [15], Misra *et al*., (2019) [9, 10], Yadav and Tripathi (2019), Misra *et al*., (2019) [9, 10], Chaitanya *et al*., (2020) [3], Parmar *et al*., (2020) [14], Rathod *et al*., (2022) [16] and Bhati *et al*., (2022) [2]. The increment in yield ranged between 17.80 to 25.07 per cent. The per cent increase in yield over farmer's practice was highest (25.07) during 2018-19. However variations in the yield of tomato in different years might be due to the variations in soil moisture availability, improved variety (Arka Rakshak), improved production techniques and change in the location of demonstrations every year. The above findings are in similarity with the findings of Mishra *et al*., (2009) [12], Mishra *et al*., (2014) [11], Singh *et al*., (2016) [19], Shalini *et al*., (2016) [17], Singh (2017) [18], Karipe and Krishnaveni (2017) [6], Kumar *et al*., (2017) [8], Kirankumar *et al*., (2017) [7], Singh *et al*., (2018) [20, 21], Singh and Tripathi (2018) [21], Rai *et al*., (2019) [15], Misra *et al*., (2019) [9, 10], Yadav and Tripathi (2019), Misra *et al*., (2019) [9, 10], Chaitanya *et al*., (2020) [3], Parmar *et al*., (2020) [14], Rathod *et al*., (2022) [16] and Bhati *et al*., (2022) [2].

Table 2: Productivity, technology gap, technology index and extension gap in tomato under FLD

Years	Area (ha)	No. of farmers	Yield (q/ha)			Additional yield over FP (kg/ha)	Increase in yield (%)	Extension gap (q/ha)	Technology gap (q/ha)	Technology index (%)
			Potential	DP	FP					
2016-17	4.0	30	750	365.9	310.6	5530	17.80	55.3	384.1	51.21
2017-18	4.0	30	750	372.7	309.8	6290	20.30	62.9	377.3	50.31
2018-19	5.5	40	750	382.6	305.9	7670	25.07	76.7	367.4	48.99
Average	13.5	100	750	373.7	308.8	6496.7	21.04	65.0	376.3	50.17

Potential yield = 750q/ha, DP = Demonstrated practice and FP = Farmers practice

Extension gap

Extension gap of 55.3, 62.9 and 76.7 q/ha was observed (Table 2) during 2016-17, 2017-18 and 2018-19 respectively. On an average extension gap in three years FLD programme was 65.0 q/ha. This emphasized the need to educate the farmers through various techniques for the adoption of improved agricultural production technologies to reverse this trend of wide extension gap. More and more use of latest production technologies like trellising in tomato with high yielding variety/hybrid will subsequently change this alarming trend of galloping extension gap. Similarly, extension gap in different location in front line demonstrations were documented by Mishra *et al*., (2009) [12], Mishra *et al*., (2014) [11], Shalini *et al*., (2016) [17], Desai, *et al*., (2016), Singh (2017) [18], Kirankumar *et al*., (2017) [7], Singh *et al*., (2018) [20, 21], Singh and Tripathi (2018) [20], Rai *et al*., (2019) [15], Misra *et al*., (2019) [9, 10], Yadav and Tripathi (2019), Misra *et al*., (2019) [9, 10], Chaitanya *et al*., (2020) [3], Parmar *et al*., (2020) [14], Rathod *et al*., (2022) [16] and Bhati *et al*., (2022) [2].

Technology gap

The technology gap, the differences between potential yield and yield of demonstration practice plots was 384.10, 377.30 and 367.4 q/ha (Table 2) during 2016-17, 2017-18 and 2018-19, respectively. On an average technology gap under three year FLD programme was 376.3 q/ha. This may be attributed to dissimilarities in soil fertility, salinity and to erratic rainfall and other vagaries of weather in the demonstration area. Hence, location specific recommendations may become necessary to narrow down the gap. These findings are similar to the finding of Mishra *et al*., (2009) [12], Mishra *et al*., (2014) [11], Singh *et al*., (2016) [19], Desai, *et al*., (2016) [5], Singh (2017) [18], Kirankumar *et al*., (2017) [7], Singh *et al*., (2018) [20, 21], Singh and Tripathi (2018) [21], Rai *et al*., (2019) [15], Misra *et al*., (2019) [9, 10], Yadav and Tripathi (2019), Misra *et al*., (2019) [9, 10], Chaitanya *et al*., (2020) [3], Parmar *et al*., (2020) [14], Rathod *et al*., (2022) [16] and Bhati *et al*., (2022) [2].

Technology Index

The technology index shows the feasibility of the demonstrated technology at the farmer's field. The technology index varied from 48.99 to 51.21 (Table 2). On an average technology index of 50.17 per cent was observed during the three years of FLD programme, which shows the effectiveness of technical interventions. This accelerates the adoption of demonstrated technical interventions to increase the yield performance of tomato. The results of the present study are in consonance with the finding Mishra *et al*., (2009) [12], Mishra *et al*., (2014) [11], Shalini *et al*., (2016) [17], Desai, *et al*., (2016) [5], Singh (2017) [18], Kirankumar *et al*., (2017) [7], Singh *et al*., (2018) [20, 21], Singh and Tripathi (2018) [21], Rai *et al*., (2019) [15], Misra *et al*., (2019) [9, 10], Yadav and Tripathi (2019), Misra *et al*., (2019) [9, 10], Chaitanya *et al*., (2020) [3], Parmar *et al*., (2020) [14], Rathod *et al*., (2022) [16] and Bhati *et al*., (2022) [2].

Table 3: Comparative B:C analysis of tomato under demonstration practice and farmers practice

Years	Cost of cultivation		Gross return (Rs./ha)		Net return (Rs./ha)		Additional net return (Rs/ha)	B:C ratio	
	DP	FP	DP	FP	DP	FP		DP	FP
2016-17	125600	117600	365900	279540	240300	122700	55300	2.91	2.38
2017-18	130500	128900	465875	371760	335375	206475	78625	3.57	2.88
2018-19	135800	130000	573900	412965	438100	308100	115050	4.23	3.18
Average	130633	125500	468558	354755	337925	212425	82992	3.57	2.81

Economic returns

In order to find the economic feasibility of the demonstration technologies over and above the control, some economic indicators like cost of cultivation, net return and B: C ratio was worked out. The economic viability of improved demonstrated practices over farmer's practices was calculated depending on prevailing price of inputs and outputs cost and represented in terms of B: C ratio (Table 3). It was found that the cost of production of tomato under demonstration practices varied from of Rs.125600 to 135800/ha with an average of Rs.130633/ha as against Rs.117600 to 130000/ha with an average Rs.125500/ha under farmers practice. The additional cost increased in demonstration was mainly due to more cost involved in balanced fertilizer application, & WSF spray including secondary and micronutrients, procurement of improved hybrid seed and IPM practices. The cultivation of tomato under improved technologies gave higher net return of Rs.240300/ha, Rs.335375/ha and Rs.438100/ha in the year 2016-17, 2017-18 and 2018-19 respectively with an average net return of Rs.337925/ha which was lower Rs.122700/ha in farmer's practices during 2016-17. The benefit cost ratio of tomato ranged from 2.91 to 4.23 in demonstration practice plots and from 2.38 to 3.18 in farmer's practice plots during three years of demonstration with an average of 3.57 in demonstration and 2.81 under farmer's practices. This may be due to higher yield obtained and lower cost of cultivation under improved technologies compared to local check (farmers practice). These results are in accordance with findings of Mishra *et al*., (2009) [12], Singh *et al*., (2011) [22], Mishra *et al*., (2014) [11], Singh *et al*., (2016) [19], Shalini *et al*., (2016) [17], Singh (2017) [18], Karipe and Krishnaveni (2017) [6], Kumar *et al*., (2017) [8], Kirankumar *et al*., (2017) [7], Singh *et al*., (2018) [20, 21], Singh and Tripathi (2018) [21], Rai *et al*., (2019) [15], Misra *et al*., (2019) [9, 10], Yadav and Tripathi (2019), Misra *et al*., (2019) [9, 10], Chaitanya *et al*., (2020) [3], Parmar *et al*., (2020) [14], Rathod *et al*., (2022) [16] and Bhati *et al*., (2022) [2]. The B: C ratio was recorded to be higher under demonstration against control during all the years of study. Extension agencies in the district need to provide proper technical support to the farmers through different extension methods to reduce the extension gap for better tomato production in the tribal area of Dungarpur district of Rajasthan.

Conclusion

The results clearly indicated that the higher average yield was obtained in demonstration practice plots over the years compared to farmer's practice due to high knowledge and adoption of full package of practices i.e. use of transplanting method, application of farm yard manure, recommended dose of fertilizers, fertigation, mulching, preparation of raised beds, pheromone traps and timely application of plant protection chemicals whereas due to lack of knowledge on use of bio fertilizers, balanced dose of fertilizer, WSF spray, IPM practices yields were low in farmer's practice. The FLD produced a significant positive result and provided an opportunity to demonstrate the productivity potential and profitability of the latest technology (intervention) under real farming situation. Therefore the study concludes that FLDs conducted by KVK, Faloj, Dungarpur in Tomato crop made significant impact on horizontal spread of the technology. Therefore, target oriented training programmes on improved vegetable production technology along with multiple demonstration is required to enhance the level of knowledge and skills of growers which help in adoption of technology. This could circumvent some of the constraints in the existing transfer of technology system in the tribal area of Dungarpur district of Rajasthan. The productivity gain under FLD over existing practices of tomato cultivation has created greater awareness and motivated other farmers to adopt the demonstrated technologies for tomato production in the district which helps to enhance the vegetable production, consumption, nutritional security and overall livelihood security of the farmers in the tribal area of Dungarpur district of Rajasthan.

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