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On Farm Study on the Efficacy of Nutrient Management Treatments on *Bt.* Cotton

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Abstract— *A farmer's participatory field experiment was conducted during two kharif seasons of 2020 and 2021 at farmers' fields in Mokheri, Bhojka, Kalimali and Phalodivillages of Jodhpur district of Rajasthan on loamy fine to coarse and medium to low in fertility status. To test the OFT on Efficient use of foliar fertilization technology in Bt cotton cropdeeloped by the Junagadh Agriculture University, Gujarat.The study aimed to analyze the performance and adoption of improved new agriculture technology is a crucialaspects under innovation diffusion process and the most important forenhancing agriculture production at a faster rate. These aspect On Farm Trials technology is one of the most powerful tools for assessment and transfer of technology.The present study was find out the production enhancement and economics through On Farm Trials technology of Bt. cottonon farmers' fields. The technology On Farm Trial recorded additional pooled yield over farmers' practices under OFTs the seed cotton and stalkyieldsof Bt. cottonwas increased 14.70 and11.48percent over farmers' practices. Adoption of improvedpackage of practices under OFTs in Bt. cotton cultivation recorded higher B:C ratio 2.19 as compared to farmers' practices 1.96 and net returns under OFTs was Rs. 69,287 and farmers' practicesRs 54,287 recorded. Improved technology (OFTs seed cotton and stalk yields was 19.5 and 23.3 q/ha as compared to farmers' practices 17.0 and 20.9q/ha. Thus, it may be concluded thatuse of fertilizers as per recommendation with foliar spray of WSF 1 % NPK (19:19:19) at flowering, Boll formation and Boll development stages is effective and economical feasible practice in Bt. Cotton of farming community under irrigated conditon of Rajasthan.*

Keywords— ***Economics, WSF, On Farm Trial, Productivity, Bt. C***

I. INTRODUCTION

Bt. cotton(*Gossypium spp.)is*King of fibreis one of the most important textile fibres in the world, accounting for around 35 per cent of total world fibre use. It is a major cash crop in the world and is grown commercially in more than 52 countries. It is grown in both irrigated as wella s rainfed conditions and seed cotton yield is manly depends on timing and intensity of rainfall. It is mainly grown for fibre production and seed yield is considered to be secondary importance. Now a days farmers are unable to gain maximum production of *Bt.* Cotton as compared to area under cultivation due to several constraints, uneven distribution of rainfall throught the growing season,imbalanced use chemical fertilizers without knowing soil nutrients status and requirement of the crop. World cotton area is stagnant from last fie decades but production ha sbeen sharply increased due to introduction of *Bt.* cottonhybrids. Intensive agriculture with very high nutrient turnover in the soil- plant system coupled with low and imbalanced fertilizers use resulting in deterioration of soil fertility and productivity and this is serios threat to long term sustainability of crop produccction. The area under *Bt.* Cotton is increasing continuously but productivity are due to derecasingsoil

fertility especially micronutrients,imbalanced fertilizers use and occurrences of physiological disorders like Square dropping and drying, leaf reddening and boll drop. Etc. Amomg all these, imbalanced use fertilizers is the major problem. These nutrientare more importance in *Bt.* Cotton synchronized boll developmentaltered the soure-sink relationship due tomrapid translocation of saccharides and nutrients from leavesto development bolls (Hebbar *et* al., 2007). Tooercome the problems, additional nutrition through foliarspary is required over and above the normal fertilizers recommendation. This is on eof most efficient ways to supplying essential nutrients for a growing crop. Bt cotton hybrids now constitute about 90 per cent of the cotton area sown in the country (Kakade et al., 2017). The obvious reasons for low productivity of cotton can be attributed to large area (more than 90 per cent) under rainfed conditions, use of sub-optimum doses of fertilizers, application of nutrients and irrigation water at improper stages of crop growth as well as the imbalanced plant nutrition. To overcome these problems, it is imperative to apply optimum doses of nutrients with judicious use of irrigation water at proper crop growth stages. Water and fertilizers are the most important critical inputs for producing vigorous healthy plants and improving the yield of cotton crop. However, the rising prices for fertilizers and other inputs are of increasing concern for farmers as fertilizer and water management has an important impact on the profitability of cotton production. Hence careful scheduling, quantity and method of application of both water and fertilizer are needed. Drip fertigation is an efficient method of applying fertilizers where irrigation water is utilized as the carrier and distributor of plant nutrients thus ensuring accurate and uniform application of nutrients in the vicinity of active root zone and influences the uptake and yield of the crop with minimum losses of nutrients through volatilization, leaching and fixation in the soil (Yende, 2003 and Pawar et al., 2014). However, fertigation with liquid fertilizer or 100 per cent water soluble fertilizer has been found to increase the efficacy in the application of fertilizer besides reducing the quantity of fertilizers applied. This in turn, reduces the cost of production and also minimizes the ground water pollution thereby preventing ecological disturbances and health risks occurred due to leaching and accumulation of nitrates in the deeper layers. As such use of fertigation could prove as a blessing for Indian farming may pave the way for efficient use of costly and scarce fertilizers. In India, due to continuos use of imbalanced chemical fertilizers resulted in adverse effect on the production of land and high cost of fertilizers enforced to farmers to search alternatiesto fertilizers. Scientific and efficient use offertilizers play back to farmers more profit as per unit cost of cultivation. that The water soluble fertilizers gives a better crop response than either hand or broadcasting methods. soluble fertilizers like NPK (19:19:19) at flowering, Boll formation and Boll development stages is completely dissolved easily in water and are immediately available for crops. The water soluble NPK fertilizers play major role in growth Boll formation and Boll development for cotton. The *Bt.* Cotton production was 6.13 million tonnes from an area of 662498 hectares with a productivity of 1573 kg/ha in Rajasthan. In the Phalodi district, the *Bt.* cotton crop is grown in an area of 106412 ha with an annual production of over 267465 million tons with a productivity of 427 kg/ha (GoR, 2024).

To conducting the On Farm Trials on farmers' field help to identify potential technology compared to farmers' practices and powerful tools to find out the suitable technology for aarea(Singh *et al.,* 2013) it help in improving the socio-economic status. Fertigation is the most effective and convenient mean of maintaining optimum fertility levels and water supply according to specific needs of each crop and types of soil resulting in higher yields and better quality of crops. Fertigation offers advantages of saving in fertilizers as well as increase in fertilizer use efficiency (Nakayama and Bucks, 1986)

II. MATERIALS AND METHODS

The present study On Farm Trials were conducted on*Bt.* cottonin irrigated condition in Jodhpur district of Rajasthan. *Bt.* cottonis an important cash crop of the area in *kharif* season. Farmers of this area usually prefer use of DAP in standing crop of cotton after first and second irrigation. They believe that it increases plant growth and yield. Therefore, the present OFT is undertaken by KVK Phalodi to find out low costefficient fertilizer in Bt cotton. The title of OFT was: "Efficient use of foliar fertilization in *Bt* cotton crop".TheJunagadh Agriculture University, Gujarat recommended a practice use of fertilizers as per recommendation with foliar spray of WSF NPK (19:19:19) at flowering, Boll formation and Boll development stages. So, KVK Phalodi decided to sort out the problems at farmer's field in the district. In total 08 on farm trials were conducted on farmers' field in villages *viz.*,Mokheri, Bhojka, Kalimaliand Phalodiof Jodhpur district of Rajasthan during 2020 and 2021. Each on farm trials was conducted on an area of 0.4 ha, adjacent-to the onfarm trials plot was kept as farmer's practices. Observation on two major performance indicators *viz.* (1) Technical observations: Plant height (cm) of *Bt.* cottonat harvest stage, nos of sympodial branches per plant, yield and yield attributes of *Bt.* cottonduring crop season, (2) Economic indicator: likes Gross cost (Rs./ha) Gross return (Rs./ha),

Net return (Rs./ha) and Benefits Cost Ratio and ICBR and (3) Farmers reaction and feedback:On assessed technology were also observed and all the observations collected from eight on farm trials (assessed and control plots) and there feasibility and economic viability were evaluated.The package of improved technologies like line sowing, nutrient management, seed treatment and whole package were used in the onfarm trials. The private sectors *Bt.* cottonvarieties were included in on farm trials methods used for the present study with respect to on farm trials and farmers' practices. In case of local check plots, existing practices being used by farmers were followed. In general, soils of the area under study were loamy fine to coarse and medium to low in fertility status. The spacing was 108 cm between rows and 60 cm between plants in the rows. Seed sowing was done in the last week of May to first week of June, with a seed rate of 1.8 kg/ha. The crop was fertilized with recommended dose of fertilizers *viz*., 150:40:0 NPK/ha. Full dose of P and one third part of N were applied at basal application and remaining N was applied in 2 equal splits at first irrigation and boll development stage. Other management practices were applied as per the PoP for *kharif* crops by Department of Agriculture, Agro-climatic Zone Ia-Arid Western Plains Zone (DOA, 2020-21). Data with respect to seedcottonyieldand stalk yield from on farm trials plots and from farmer's fields cultivated following local practices adopted by the farmers of the area were collected and evaluated.Herbicides were applied with manually operated knapsack sprayer delivering a spray volume of 500 l/ha through flat-fan nozzle at pre-emergence and 30 DAS. The crop was harvested in last week of October during both of the years. Average total annual rainfall received389.9 mm during crop growing season in 2020 and 262 mm in 2021, as most of the annual rain occurred in monsoon season. Economics were calculated using prevailing market price of inputs. Keeping these facts in view aOFT was conducted to study the effect of water soluble fertilizers through foliar spray at different stages on quality, nutrient content and nutrient uptake of *Bt.*Cotton.

Treatments details:

Farmer's practices (T1): Use of DAP in standing crop (Farmer's Practice)

Recommended technology(T2): Use of fertilizers as per recommendation 150:40:0 NPK/ha (Recommended practice)

Assessed technology (T3): Use of fertilizers as per recommendation with foliar spray of WSF 1 % NPK (19:19:19) at flowering, Boll formation and Boll development stages (Assessed technology)

III. RESULTS AND DISCUSSION

(i) **Plant height (cm):** It was observed in table 1 that Plant height was maximum in T_3 (132, 136 and 134 cm) followed by T_2 (129, 132 and 130.5 cm) and farmer practice (124, 126 and 125 cm) in both years of trials as well as in pooled data. It enhanced the plant height by 6.45 and 2.32 per cent in 2020, 7.93 and 3.03 per cent in 2021 and 7.20 and 2.60 per cent in pooled analysis at harvest stage, over T1 and T2 treatments, respectively.

(ii) **Sympodial branches per plant:** The sympodial branches per plant were maximum in T_3 (12.5, 12.47 and 12.48) followed by T_2 (11.40, 11.65 and 10.83) and farmer practice (10.65, 10.83 and 10.74) in both years of trials as well as in pooled data.

(iii) **Numbers of bolls per plant:** It was observed that numbers of bolls per plant were maximum in T_3 (55, 58 and 56.5) followed by T_2 (51, 54 and 52.5) and farmer practice (46, 49 and 47.5) in both years of trials as well as in pooled data. It enhanced the numbers of bolls per plant by 19.56 and 7.84 per cent in 2020, 18.36 and 7.40 per cent in 2021 and 18.94 and 7.60 per cent in pooled analysis over T1 and T2 treatments, respectively.

(iv) **Impact of OFTs on seed cotton yield and stalk & Biological yields:** KVK Phalodi assessed efficient use of foliar fertilization in *Bt* cotton hybrid crop using of DAP instanding crop (Farmer's Practices-T_1), use of fertilizers as per recommendation (Recommended practices-T_2) and fertilizers as per recommendation with foliar spray of WSF 1 % NPK (19:19:19) at flowering, Boll formation and Boll development stages (T_3). It was observed that seed cotton yield under T_3 treatment increased by 14.20 % and 6.62 % during 2020 and 15.11 % and 7.02 % during 2021 whereas, seed cotton yield increased by14.70 % and 6.55 % in pooled analysis over farmer practice (T_1) and Recommended practice (T_2). The seed cotton yield was maximum in T_3 (19.30,19.8 and 19.5 q/ha) followed by T_2 (18.10, 18.50 and 18.3 q/ha) and farmer practice (16.9, 17.2 and 17.0q/ha) in both years of trials as well as in pooled data. Further, the stalk yield under T_3 treatment increased by 12.20 % and 2.22 % during 2020 and 10.28 % and 3.05 % during 2021 whereas, seed cotton yield increased by 11.48 % and 2.65 % in pooled analysis over farmer practice (T_1) and Recommended practice (T_2). The stalk yield was maximum in T_3 (23.0, 23.6 and 23.3 q/ha) followed by T_2 (22.5, 22.90 and 22.7 q/ha) and farmer practice (20.5, 21.2 and 20.9 q/ha) in both years of trials as well as in pooled data, respectively. The technology of On Farm Trial recorded additional yield

over farmers' practices under OFTs. The results are close conformity with the research results of Sharma *et al.*, 2016. The data (Table 2) indicated that both years of trials as well as in pooled data observed that treatment T3 produced the maximum biological yield of *Bt.* Cotton was 42.3, 43.4 and 42.8 q/ha followed by T_2 treatment 40.6, 41.4 and 41.0 q/ha and over farmers' practices (37.4, 38.6 and 37.9 q/ha). It registered remarkable increase in biological yield of *Bt.* Cotton was to the extent of 12.92 and 4.39 % over T1 and T2 treatments, respectively in pooled analysis. Further, the harvest index from T_3 group was also the highest (45.56) followed by T_1 (44.85) and T_2 (44.63), respectively.

Table 1. The growth parameters & yield attributes influenced by different treatments of foliar fertilization of Bt. cotton during 2020 and 2021

Treatments	Plant height at harvest			Nos of sympodial branches/plant			Nos of bolls/plant		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T1	124	126	125	10.65	10.83	10.74	46	49	47.5
T2	129	132	130.5	11.40	11.65	11.52	51	54	52.5
T3	132	136	134	12.5	12.47	12.48	55	58	56.5

Table 2. Effect of foliar fertilization treatments on Seed cotton yield, Stalk and biological yields (q/ha) and harvest index (%) yield of Bt.cotton during 2020 and 2021

Treatments	Seed cotton yield			Stalk yield			Biological yield			Harvest index (%)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T1	16.9	17.2	17.0	20.5	21.4	20.9	37.4	38.6	37.9	45.19	44.56	44.85
T2	18.1	18.5	18.3	22.5	22.9	22.7	40.6	41.4	41	44.58	44.69	44.63
T3	19.3	19.8	19.5	23.0	23.6	23.3	42.3	43.4	42.8	45.63	45.62	45.56

Table 3. Impact of foliar fertilization treatments on economics on Bt. cotton during 2020 and 2021

Treatments	Gross cost			Gross returns			Net returns			B: C ratio		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T1	56175	56900	56538	92950	129000	110825	36775	72100	54287	1.65	2.26	1.96
T2	56875	57600	57238	99550	138750	118950	42675	81150	61712	1.75	2.40	2.07
T3	57427	58100	57788	106150	148500	127075	48723	90350	69287	1.84	2.55	2.19

Table 4. Observation on farmers feedback on assessed technology (Use of fertilizers as per recommendation with foliar spray of WSF 1 % NPK (19:19:19) at flowering, Boll formation and Boll development stages on Bt. cotton

SNo	Particulars	Percent
1	Adaptability	75
2	Level of assessed technology acceptance to the farmers	85
3	Compatibility to farming system components	75
4	Compatibility to household internal resources	70
5	Affordability	90

ECONOMICS

The economics parameters of On Farm Trial of *Bt.* Cotton crop are calculated in table 3 and Fig.1). it clearly observed that net returns in *Bt.* cotton were affected to a great extent by foliar spray of WSF practices during both the years of trials as well as in pooled mean. Providing the highest net return under treatment T3 (Fertilizers as per recommendation with foliar sprayof WSF 1 % NPK (19:19:19) at flowering, Boll formation and Boll development stages) of Rs 69287/ha followed by T_2 (Recommended practices) of Rs 61712/ha and T_1 (farmers practices) of Rs. 54287. It provided additional net returns of Rs 15000/ha and 7575 with B:C ratio of 2.19 and over T2 and T1. The higher cost of cultivation Rs 57788/ha observed in T3 group followed by T2 of Rs 57238/ha in On Farm Trial of *Bt.* cotton crop as compared to farmers' practices (56538). The T3 plots have higher mean gross return of Rs 127075/ha followed by T2 of Rs 118950/ha as compared to farmers' practices (110825). Hence, favourable B:C ratio proved the intervention made under in On Farm Trial and convinced the farmers on the utility of technology. The higher net returns and B:C ratioin the demonstrations on improved technologies as compared to farmers' practices and at par with results of present study was also reported by Sreelakshmi *et al.* 2012 and Joshi *et al.* 2014. The farmers' feedback were collected on assessed technology after conducted OFTs for two years trials and its mentioned in Table 4. These observation find out that 75 per cent adaptability, 85 per cent assessed technology acceptance to the farmers, 75 per cent compatibility to farming system components, 70 per cent compatibility to household internal resources and 90 per cent affordability on farmers reactions on assessed technology (Fertilizers as per recommendation with foliar spray of WSF 1 % NPK (19:19:19) at flowering, Boll formation and Boll development stages)

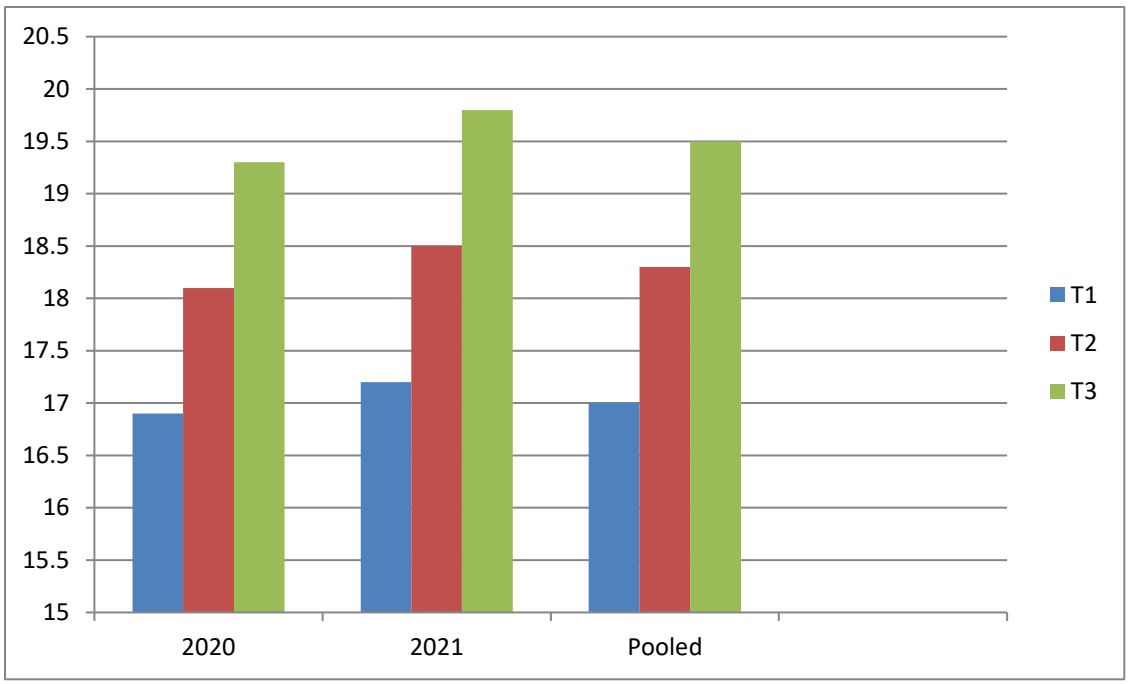

Fig 1. BCR of Bt. cottonunder On Farm Trial in Jodhpur districtof Rajasthan

IV. CONCLUSION

It may be concluded that the seed cotton productivity and net returns in *Bt.*cotton increased statisticallywith improved technologyuse of fertilizers as per recommendation with foliar spray of WSF 1 % NPK (19:19:19) at flowering, Boll formation and Boll development stages.Hence, this practice may be widely popularized for improving socio-economic condition of poor farming community of wester Rajasthan. However, the yield levels under On Farm Trial was better as compared to farmers' practices.The OFTsalso strengthened the interactions and trust between farmers and KVK scientists. It was also concluded that besides other practices of nutrient and weed management, insect-pest management, and water stress are to be given for attention to enhancing*Bt.*cottonproduction in the area. This will subsequently increase the income as well as the livelihood of the farming community of the Jodhpur district.

Fig 2. Performance of fertilizers as per recommendation with foliar spray of WSF 1 % NPK (19:19:19) at flowering, Boll formation and Boll development stageson Bt. cottonunder On Farm Trial in Jodhpur district of Rajasthan (T3)

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