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Effect of Potash Application on Incidence of Bollworms in Bt Cotton Hybrid

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Authors' contributions

This work was carried out in collaboration between all authors. Author KHP designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors HRD and RDP managed the analyses of the study. Author GRB and TS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Investigations on "Effect of potash application on incidence of bollworms in Bt cotton hybrid" were carried out at the Main Cotton Research Station, Surat during *Kharif* 2018-19 with twelve treatment combinations comprising three levels of potash (K_2O) applications (0, 40 and 80 kg ha^{-1}) as main treatments and two levels of potash mobilizing bacteria (KMB) @0 and 2.5 lit ha^{-1} and two levels of foliar sprays of potassium nitrate (KNO_3) @0 and 3% at squaring, flowering and boll development

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as sub treatments under ETL based interventions in split plot design with three replications.The main treatment sub treatment and interactiion effect on bollworm were discussed.The treatment combination *viz.*, K_2O application @80 kg ha^{-1} along with the application of potash mobilizing bacteria (KMB) @2.5 litre ha^{-1} as basal application at 15 days after sowing and foliar sprays of potassium nitrate (KNO_3) @3% during squaring (60DAS), flowering (75DAS) and boll development stages (90DAS) on G. Cot. Hy. 8 BG II recorded highest seed cotton yield (2777 kg ha^{-1}), provided effective management of bollworms requiring one spray against pink bollworm affording good protection against ABW and SBW.

Keywords: Bt cotton; bollworms; potash (murate of potash); potassium mobilizing bacteria; KNO3 (potassium nitrate).

1. INTRODUCTION

Cotton is a well-known fibre crop, often referred as “white gold” because of its higher economical value and it provides employment to 60 million people directly or indirectly in cultivation, processing and trade in the country. The cotton production remained stagnant over the years due to biotic and abiotic constraints. Among the biotic threats, insect pests being major in India. The insect pests spectrum of cotton is quite complex and as many as 1326 species of insect pests have been reported on this crop throughout the world of which >165 different species of insects and mites found to devour cotton at different stages of crop growth in India [1]. In India, transgenic technology after approval in 2002 reached to >94 % area of the cotton cultivation in the country and has provided durable protection against intended bollworm pests till the end of first decade. The gradual field evolved resistance in pink bollworm by the time recognized and the continued benefits of technology against intended bollworms, especially of pink bollworm started to decline in recent years due to several reasons [2]. The gradual evolve of resistance in lab or field populations of pink bollworm to *Cry1Ac* and *Cry2Ab2* or both the genes in Indian populations lead farmers to incur additional cost for its management [3-8]. Several factors *viz.*, nutrition, temperature, moisture, salinity, CO_2 level, C:N ratio *etc.* played important role in proper expression of the genes over the period of times in different parts of the transgenic plant [9,10]. Gujarat soil is rich in K content, the availability may be increased through the use of such organic amendments, foliar applications or potash mobilizing bacteria with supplementation of the K in deficient soils [11,12]. The balanced use of fertilizers does not affect much the gene expression but the lower dose of nitrogen reduced the expression of gene in Bt cotton. Further, cotton appears to be more sensitive to K deficiencies than other crops, as root system of cotton is less dense than that of other crops [13]. It has been found that potash application enhanced protein synthesis resulting in reduced amino acid content of the plant sap, may stabilize expression of genes in transgenic crop and reduced the development and multiplication of insect pests especially of bollworms. Systematic study of gene expression and quantification over a period of time will provide clue to understand the field evolved resistance to toxins and factors influencing its expression.

2. MATERIALS AND METHODS

The materials used, procedure followed and techniques adopted in the present investigation are given as under.

Effect of potash on incidence of bollworms on Bt cotton: The field experiment was conducted with three levels of potash (0, 40 and 80 kg ha^{-1}) as main treatments and two levels of potash mobilizing bacteria (KMB) @0 and 2.5 lit ha^{-1} and two levels of foliar spray of potassium nitrate (KNO_3) @0 and 3% at squaring, flowering and boll development as sub treatments under Split Plot Design.

Pink bollworm and its damage: The number of healthy and damage flowers by larvae of pink bollworm from five randomly selected plants were counted at 15 days interval starting from 75 days after sowing (DAS) till 120 DAS in each of the treatment combinations. Further, the number and stage of larvae inside the damage flower was also recorded. Similarly, number of larvae of pink bollworm (both small and big larvae) per 10 green bolls was recorded at 15 days interval starting from 90 to 135 DAS from each of the treatment combinations. For the purpose, 10 green bolls were plucked from each of the experimental units and brought to the laboratory and observed for the damage and presence of the larvae. The sampled green bolls were critically observed visually and under microscope for judging the damage through external surface and confirmation with the dissection of the each sampled bolls. Based on observations, the per cent damage by pink bollworm to green boll and their locules were calculated. Similarly, the number of small (first and second instar) and big (third and fourth instar) larvae was counted from the damaged green bolls by critically observing the samples under stereo-zoom microscope. At harvest, the damage to open bolls and locules by pink bollworm was recorded by counting the number of healthy and damaged open bolls and locules by the pink bollworm separately from five plants in each treatment combinations. The ETL for pink bollworm is ≥ 10 % fruiting body damage (rosette flower, green bolls or open bolls).

Spotted and American bollworm and their damage: The number of damaged square were counted based on number of healthy and damaged squares by spotted bollworm and American bollworm separately from five randomly selected plants from each of the experimental plot during squaring time at one week interval (75 to 120 DAS). Similarly, number of healthy and damage green bolls were also counted from five randomly selected plants in each of the treatment combinations during fruiting periods at one week interval (90 to 135 DAS).

3. RESULTS AND DISCUSSION

Effect of potash application on incidence of bollworms: The incidence of bollworms and their damage to flowers, squares and green bolls were recorded during the period of occurrence and the insecticide was applied in the respective treatment combinations based on the ETL. The period of occurrence of bollworms and the number of sprays against sucking pests in general and bollworms in particular in different treatment combinations are given in Table 1 which revealed that the pink bollworm was active from 75 days after sowing (DAS) till the end of the crop period and the damage to fruiting parts crossed ETL for 1 to 3 times in different treatment combinations whereas spotted bollworm and American bollworm were active from 75 to 150 DAS and the population and damage did not cross ETL in any of the treatment combinations.

Pink bollworm and its damage: PBW damage was observed from 75 DAS, starting with the rosette stage of flowers. Potash @80 kg ha^{-1} combined with KMB and foliar sprays reduced PBW damage significantly. Higher endotoxin levels in plants treated with these combinations showed reduced bollworm infestation.

Spotted & American bollworm and their damage: Both ABW and SBW were observed below ETL throughout the growing period. The incidence of these pests was significantly lower in plots treated with potash at 80 kg ha^{-1}. Correlations between larval populations and endotoxin levels were analyzed, highlighting the role of potash in minimizing damage.

The pink bollworm infestation and damage was found above ETL as the technology of Bt cotton lost its effectiveness against pink bollworm. Various workers have reported the gradual evolve of resistance in lab or field populations of pink bollworm to *Cry1Ac* and *Cry2Ab2* or both the genes [3-8]. Further in the present study, the population and damage of spotted bollworm and American bollworm was found below ETL throughout the activity period showing effectiveness of the Bt technology against them.

Squaring (60DAS)

Flowering (75DAS)

Boll Development (90DAS)

Plate 1. Different Stages of Cotton Crop

Table 1. ETL based interventions against bollworms in different treatment combinations

Treatment combination	Sucking pests	Bollworms															Total no. of spray
		Pink bollworm				American bollworm					Spotted bollworm						
	Total No. of spray	Period of occurrence	DAS at which flower damage crossed ETL	DAS at which green boll damage crossed ETL	No. of spray	Period of occurrence	DAS at which larval population crossed ETL	DAS at which square damage crossed ETL	DAS at which green boll damage crossed ETL	No. of spray	Period of occurrence	DAS at which larval population crossed ETL	DAS at which square damage crossed ETL	DAS at which green boll damage crossed ETL	No. of spray		
K_0B_0NFS	4	75 to 165	75, 105	105, 135	3	75 to 150	-	-	-	0	75 to 150	-	-	-	0		7
K_0B_0FS	4	DAS (first	75, 105	105, 135	3	DAS (first	-	-	-	0	DAS (first	-	-	-	0		7
K_0B_1NFS	4	week of	75, 105	105, 135	3	week of	-	-	-	0	week of	-	-	-	0		7
K_0B_1FS	4	October to	75, 105	105, 135	3	October to	-	-	-	0	October to	-	-	-	0		7
$K_{40}B_0$NFS	4	second week	75	135	2	last week of	-	-	-	0	last week of	-	-	-	0		6
$K_{40}B_0$FS	3	of January)	75	-	1	December)	-	-	-	0	December)	-	-	-	0		4
$K_{40}B_1$NFS	4		75	135	2		-	-	-	0		-	-	-	0		6
$K_{40}B_1$FS	3		75	-	1		-	-	-	0		-	-	-	0		4
$K_{80}B_0$NFS	3		75	135	2		-	-	-	0		-	-	-	0		5
$K_{80}B_0$FS	2		75	-	1		-	-	-	0		-	-	-	0		3
$K_{80}B_1$NFS	3		75	135	2		-	-	-	0		-	-	-	0		5
$K_{80}B_1$FS	2		75	-	1		-	-	-	0		-	-	-	0		3

Note: Common insecticides sprays for PBW during 75 and 105 DAS based on ETL population and damage. K=K_2O, B=KMB , F=Foliar spray of KNO_3

Table 2. Damage of pink bollworm to flowers in different treatments during 2018-19

Factors	% Rosette flower/5 Plants recorded at 15 days interval									
	75 DAS		90 DAS		105 DAS		120 DAS		Pooled	
	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV
A. Main Treatment (Potash Fertilizer) K										
K_0	13.88	21.78	5.52	13.55	11.89	20.14	8.02	16.43	9.83	17.98
K_{40}	12.22	20.30	3.80	11.15	5.53	13.56	5.92	14.07	6.87	14.77
K_{80}	11.08	19.36	2.11	8.24	4.78	12.57	4.74	12.55	5.68	13.18
GM		20.48		10.98		15.42		14.35		15.31
SEm ±		1.07		0.14		0.12		0.10		0.42
CD (5%)		NS		0.58		0.48		0.41		1.23
CV %		18.12		4.67		2.75		2.50		12.37
B. Sub Treatment										
Potash Mobilizing Bacteria (B)										
B_0	12.46	20.53	4.41	11.97	7.87	16.00	6.33	14.48	7.77	15.75
B_1	12.33	20.43	3.20	10.00	6.92	14.84	6.12	14.22	7.14	14.87
GM		20.48		10.99		15.42		14.35		15.31
SEm ±		0.57		0.18		0.16		0.18		0.14
CD (5%)		NS		0.53		0.49		NS		NS
Foliar sprays of Potassium Nitrate (F)										
NFS	12.40	20.53	3.96	11.17	7.90	15.98	6.33	14.47	7.65	15.54
FS	12.39	20.43	3.66	10.79	6.89	14.86	6.12	14.23	7.26	15.08
GM		20.48		10.98		15.42		14.35		15.31
SEm ±		0.57		0.18		0.16		0.18		0.14
CD (5%)		NS		NS		0.49		NS		NS
Interactions	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	CD (5%)
KB	1.00	NS	0.31	NS	0.28	0.85	0.31	NS	0.27	NS
KF	1.00	NS	0.31	NS	0.28	NS	0.31	NS	0.27	NS
BF	0.81	NS	0.25	NS	0.23	NS	0.25	NS	0.23	NS
KBF	1.41	NS	0.44	NS	0.40	NS	0.44	NS	0.40	NS
PK									0.54	NS
PB									0.32	NS
PF									0.32	NS
PKBF									0.80	NS
CV%		11.99		7.00		4.57		5.36		9.07

Note: P=Period, NS=Non significant, TV= Transformed mean (Arc sine), OV= Original Values, GM=General Mean

Table 3. Incidence of pink bollworm larvae (small and big) during 2018-19

Factors	Number of pink bollworm larvae (small and big)/10 green bolls recorded at 15 days interval									
	90 DAS		105 DAS		120 DAS		135 DAS		Pooled	
	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV
A. Main Treatment (Potash Fertilizer) K										
K_0	1.16	1.70	1.50	2.21	1.33	1.90	1.25	2.29	1.31	2.02
K_{40}	0.91	1.62	1.41	1.84	1.08	1.74	1.16	1.99	1.14	1.62
K_{80}	0.83	1.46	1.16	1.71	1.08	1.74	1.00	1.88	1.02	1.46
GM		1.59		1.92		1.79		2.05		1.83
SEm ±		0.05		0.06		0.04		0.07		0.03
CD (5%)		NS		0.25		NS		0.29		0.08
CV %		12.02		11.40		9.22		12.79		11.56
B. Sub Treatments										
Potash Mobilizng Bacteria (B)										
B_0	2.28	1.65	3.44	1.97	3.05	1.87	4.11	2.12	3.22	1.90
B_1	1.89	1.53	3.11	1.87	2.50	1.72	3.61	1.98	2.78	1.78
GM		1.59		1.92		1.80		2.05		1.83
SEm ±		0.04		0.05		0.06		0.07		0.03
CD (5%)		NS		NS		NS		NS		0.85
Foliar sprays of Potassium Nitrate (F)										
NFS	2.22	1.64	3.39	1.95	3.00	1.86	4.61	2.24	3.31	1.92
FS	1.94	1.55	3.17	1.89	2.55	1.73	3.11	1.86	2.69	1.76
GM		1.59		1.92		1.79		2.05		1.83
SEm ±		0.04		0.05		0.06		0.07		0.05
CD (5%)		NS		NS		NS		0.21		NS
Interactions	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	0.07	NS	0.10	NS	0.11	NS	0.12	NS	0.05	NS
KF	0.07	NS	0.10	NS	0.11	NS	0.12	NS	0.05	NS
BF	0.06	NS	0.08	NS	0.09	NS	0.10	NS	0.04	NS
KBF	0.10	NS	0.14	NS	0.16	NS	0.18	NS	0.07	NS
PK									0.06	NS
PB									0.06	NS
PF									0.06	0.17
PKBF									0.15	NS
CV%		11.72		12.87		15.66		15.21		14.18

Note: P=Period, TV= Square root + 0.5 whereas, OV= Original Values, NS= Non-Significant, GM= General Mean

Table 4. Incidence of pink bollworm larvae (big) during 2018-19

Factors	Number of pink bollworm larvae (big)/ 10 green bolls recorded at 15 days interval									
	90 DAS		105 DAS		120 DAS		135 DAS		Pooled	
	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV
A. Main Treatment (Potash Fertilizer) K										
K_0	1.16	1.27	1.50	1.40	1.33	1.34	1.25	1.30	1.31	1.32
K_{40}	0.91	1.15	1.41	1.37	1.08	1.24	1.16	1.25	1.14	1.25
K_{80}	0.83	1.11	1.16	1.25	1.08	1.22	1.00	1.18	1.02	1.19
GM		1.17		1.34		1.27		1.24		1.26
SEm ±		0.05		0.03		0.07		0.09		0.03
CD (5%)		NS		NS		NS		NS		0.08
CV %		16.17		9.99		20.19		26.94		19.16
B. Sub Treatments										
Potash Mobilizng Bacteria (B)										
B_0	1.05	1.21	1.44	1.38	1.33	1.33	1.38	1.36	1.30	1.32
B_1	0.88	1.14	1.27	1.30	1.00	1.20	0.88	1.13	1.01	1.19
GM		1.18		1.34		1.27		1.25		1.26
SEm ±		0.07		0.05		0.05		0.06		0.03
CD (5%)		NS		NS		NS		0.18		0.09
Foliar sprays of Potassium Nitrate (F)										
NFS	1.05	1.21	1.38	1.35	1.22	1.29	1.27	1.30	1.23	1.29
FS	0.88	1.14	1.33	1.33	1.11	1.24	1.00	1.18	1.08	1.22
GM		1.17		1.34		1.26		1.24		1.25
SEm ±		0.07		0.05		0.05		0.06		0.03
CD (5%)		NS		NS		NS		NS		NS
Interactions	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	0.12	NS	0.10	NS	0.10	NS	0.11	NS	0.05	NS
KF	0.12	NS	0.10	NS	0.10	NS	0.11	NS	0.05	NS
BF	0.10	NS	0.08	NS	0.08	NS	0.09	NS	0.04	NS
KBF	0.18	NS	0.14	NS	0.14	NS	0.15	NS	0.07	NS
PK									0.06	NS
PB									0.06	NS
PF									0.06	NS
PKBF									0.15	NS
CV%		26.75		18.51		19.99		21.65		21.69

Note: P=Period, TV= Square root + 0.5 whereas, OV= Original Values, NS= Non-Significant, GM= General Mean

Table 5. Open bolls and locule damage by pink bollworm at harvest

Factors	Open bolls damage (%)		Locules damage (%)	
	OV	**TV**	**OV**	**TV**
A. Main Treatment (Potash Fertilizer) (K)				
K_0	15.01	22.73	9.93	18.33
K_{40}	12.77	20.83	8.15	16.51
K_{80}	9.01	17.22	5.09	12.93
GM		**20.26**		15.92
SEm ±		**1.02**		0.68
CD (5%)		**4.02**		2.69
CV %		**17.50**		14.91
B. Sub Treatment				
Potash Mobilizing Bacteria				
B_0	12.20	20.28	7.91	16.14
B_1	12.33	20.24	7.54	15.71
GM		**20.26**		15.93
SEm ±		**0.54**		0.27
CD (5%)		**NS**		NS
Foliar sprays of Potassium Nitrate (F)				
NFS	12.09	20.06	7.51	15.65
FS	12.43	20.46	7.94	16.20
GM		**20.26**		15.93
SEm ±		**0.54**		0.27
CD (5%)		**NS**		NS
Interactions				
	SEm ±	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	0.94	NS	0.47	NS
KF	0.94	NS	0.47	NS
BF	0.77	NS	0.39	NS
KBF	1.33	NS	0.67	NS
CV%		**11.44**		**7.35**

Note: TV= Transformed mean (Arc sine) whereas, OV= Original Values,
NS= Non- Significant, GM= General Mean

Table 6. Effect of potash application on damage to green bolls by pink bollworm

Factors	% Green boll damage recorded at 15 days interval									
	90 DAS		105 DAS		120 DAS		135 DAS		Pooled	
	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV
A. Main Treatment (Potash Fertilizer) K										
K_0	8.33	13.94	16.66	23.84	9.16	16.18	15.00	22.49	12.29	19.11
K_{40}	7.50	14.04	9.16	14.61	7.50	13.26	10.83	17.53	8.75	14.86
K_{80}	5.00	9.66	8.33	13.94	7.50	14.04	12.50	19.67	8.33	14.33
GM		**12.55**		**17.46**		**14.49**		19.90		16.10
SEm ±		2.63		2.95		3.74		3.20		1.49
CD (5%)		NS		NS		NS		NS		NS
CV %		72.65		58.69		89.43		55.71		67.97
B. Sub Treatment										
Potash Mobilizing Bacteria										
B_0	7.22	13.03	12.22	18.14	10.00	17.90	13.33	20.09	10.69	17.29
B_1	6.66	12.06	10.55	16.79	6.11	11.09	12.22	19.71	8.88	14.91
GM		**12.55**		**17.47**		**14.50**		19.90		16.10
SEm ±		2.47		2.45		1.74		1.44		1.03
CD (5%)		NS		NS		5.17		NS		NS
Foliar sprays of Potassium Nitrate										
NFS	8.88	15.43	12.22	18.14	8.88	15.95	13.88	21.58	10.97	17.78
FS	5.00	9.66	10.55	16.79	7.22	13.03	11.66	18.21	8.61	14.42
GM		**12.55**		**17.47**		**14.49**		**19.90**		16.10
SEm ±		2.47		2.45		1.74		1.44		1.02
CD (5%)		NS		NS		NS		NS		2.89
Interactions	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	4.28	NS	4.25	NS	3.01	NS	2.49	NS	1.73	NS
KF	4.28	NS	4.25	NS	3.01	NS	2.49	NS	1.75	NS
BF	3.49	NS	3.47	NS	2.46	NS	2.03	NS	1.44	NS
KBF	6.05	NS	6.01	NS	4.26	NS	3.53	NS	2.45	NS
PK									3.16	NS
PB									2.07	NS
PF									2.07	NS
PKBF									5.08	NS
CV%		83.54		59.62		50.98		30.75		54.71

Note: P=Period, NS= Non-Significant TV= Transformed mean (Arc sine) whereas, OV= Original Values and GM= General Mean

Table 7. Incidence of larva of spotted bollworm in different treatments during 2018-19

Factors	Av. number of larvae of Spotted bollworm/ 5 plants recorded at days after sowing																	
	113		120		127		134		141		148		155		162		Pooled	
	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV
A. Main Treatment (Potash Fertilizer) K																		
K_0	0.50	0.96	0.66	1.03	0.41	0.90	0.41	0.90	1.08	1.20	1.75	1.48	2.25	1.64	2.33	1.67	1.17	1.22
K_{40}	0.16	0.79	0.91	1.15	0.33	0.87	0.25	0.83	0.50	0.96	0.33	0.87	0.25	0.83	1.08	1.22	0.47	0.94
K_{80}	0.00	0.70	0.25	0.83	0.00	0.70	0.00	0.70	0.00	0.70	0.08	0.75	0.16	0.79	0.00	0.70	0.06	0.73
GM		**0.82**		**1.01**		**0.83**		**0.81**		**0.95**		**1.03**		**1.03**		**1.09**		**0.97**
SEm ±		0.09		0.09		0.04		0.08		0.09		0.07		0.05		0.07		0.06
CD (5%)		NS		NS		0.15		NS		NS		0.28		0.23		0.29		0.20
CV %		41.97		33.42		16.81		37.18		35.36		24.55		18.82		21.48		28.97
B. Sub Treatment																		
Potash Mobilizing Bacteria (B)																		
B_0	0.22	0.82	0.55	0.96	0.33	0.87	0.27	0.84	0.38	0.90	0.66	1.01	0.94	1.12	1.22	1.23	0.57	0.97
B_1	0.22	0.82	0.66	1.05	0.16	0.79	0.16	0.79	0.66	1.00	0.77	1.06	0.83	1.05	1.05	1.17	0.56	0.97
GM		**0.82**		**1.01**		**0.83**		**0.82**		**0.95**		**1.04**		**1.09**		**1.20**		**0.97**
SEm ±		0.03		0.05		0.06		0.05		0.05		0.05		0.05		0.04		0.01
CD (5%)		NS		NS		NS		NS		NS		NS		NS		NS		NS
Foliar sprays of Potassium Nitrate (F)																		
NFS	0.16	0.79	0.55	0.98	0.33	0.87	0.27	0.84	0.44	0.91	0.77	1.06	0.94	1.11	1.16	1.21	0.58	0.97
FS	0.27	0.85	0.66	1.03	0.16	0.79	0.16	0.79	0.61	0.99	0.66	1.01	0.83	1.06	1.11	1.19	0.56	0.96
GM		**0.82**		**1.00**		**0.83**		**0.81**		**0.95**		**1.04**		**1.09**		**1.20**		**0.97**
SEm ±		0.03		0.05		0.06		0.05		0.05		0.05		0.05		0.04		0.01
CD (5%)		NS		NS		NS		NS		NS		NS		NS		NS		NS
Interactions	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	0.05	NS	0.08	NS	0.11	NS	0.09	NS	0.09	0.28	0.09	NS	0.08	NS	0.07	NS	0.03	NS
KF	0.05	NS	0.08	NS	0.11	NS	0.09	NS	0.09	NS	0.09	NS	0.08	NS	0.07	NS	0.03	NS
BF	0.04	NS	0.07	NS	0.09	NS	0.07	NS	0.07	NS	0.07	NS	0.07	NS	0.06	NS	0.02	NS
KBF	0.08	NS	0.12	NS	0.16	NS	0.13	NS	0.13	NS	0.13	NS	0.12	NS	0.10	NS	0.04	NS
PK																	0.08	0.23
PB																	0.05	NS
PF																	0.05	NS
PKBF																	0.12	NS
CV%		17.14		21.60		34.71		28.24		24.10		22.53		20.10		15.48		22.87

Note: P=Period, TV= Transformed mean (Arc sine) whereas, OV= Original Values and NS= Non-Significant, GM=General Mean

Table 8. Damage to square by spotted bollworm in different treatments in 2018-19

Factors	% Square damage by SBW/ 5 Plants recorded at days after sowing																			
	75		82		89		96		102		109		116		123		130		Pooled	
	OV	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**
A. Main Treatment (Potash Fertilizer) (K)																				
K_0	1.16	6.06	2.02	8.13	3.61	10.89	3.97	11.46	4.30	11.94	3.25	10.34	3.05	10.02	2.91	9.80	3.27	10.34	3.06	9.89
K_{40}	0.24	2.27	0.30	2.77	0.80	4.90	0.72	4.66	0.94	5.46	1.61	7.18	2.00	8.05	2.47	9.00	2.66	9.37	1.30	5.96
K_{80}	0.24	2.27	0.27	2.38	0.33	3.15	0.58	4.27	0.72	4.75	0.91	5.44	1.05	5.84	1.28	6.26	1.55	7.09	0.77	4.61
GM		3.53		4.43		6.31		6.80		7.38		7.66		7.97		8.35		8.93		6.82
SEm ±		0.31		0.23		0.25		0.22		0.32		0.31		0.24		0.34		0.25		0.41
CD (5%)		1.21		0.90		1.00		0.88		1.25		1.22		0.97		1.34		1.00		1.25
CV %		30.38		18.06		13.92		11.46		15.01		14.07		10.73		14.17		9.92		14.23
B. Sub Treatment																				
Potash Mobilizing Bacteria (B)																				
B_0	0.57	3.59	1.00	4.93	1.70	6.73	1.85	7.04	1.99	7.52	2.09	8.05	2.05	8.03	2.38	8.72	2.50	8.98	1.79	7.07
B_1	0.53	3.48	0.73	3.93	1.46	5.89	1.66	6.55	1.98	7.24	1.75	7.26	2.01	7.91	2.05	7.99	2.49	8.89	1.63	6.57
GM		3.54		4.43		6.31		6.80		7.38		7.66		7.97		8.36		8.94		6.82
SEm ±		0.46		0.43		0.33		0.29		0.25		0.20		0.19		0.27		0.22		0.10
CD (5%)		NS		NS		NS		NS		NS		0.61		NS		NS		NS		NS
Foliar sprays of Potassium Nitrate (F)																				
NFS	0.57	3.74	0.88	4.49	1.61	6.42	1.86	7.02	1.99	7.45	1.97	7.85	2.14	8.23	2.31	8.58	2.46	8.89	1.76	6.96
FS	0.53	3.33	0.85	4.37	1.55	6.21	1.64	6.57	1.98	7.32	1.87	7.46	1.92	7.71	2.12	8.12	2.53	8.97	1.67	6.67
GM		3.54		4.43		6.31		6.80		7.38		7.66		7.97		8.35		8.93		6.82
SEm ±		0.46		0.43		0.33		0.29		0.25		0.20		0.19		0.27		0.22		0.10
CD (5%)		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS
Interactions																				
	SEm ±	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	0.81	NS	0.75	NS	0.57	NS	0.50	NS	0.44	NS	0.35	NS	0.33	NS	0.47	NS	0.39	NS	0.17	NS
KF	0.81	NS	0.75	NS	0.57	NS	0.50	NS	0.44	NS	0.35	NS	0.33	NS	0.47	NS	0.39	NS	0.17	NS
BF	0.66	NS	0.61	NS	0.46	NS	0.41	NS	0.36	NS	0.29	NS	0.27	NS	0.39	NS	0.32	0.95	0.14	NS
KBF	1.14	NS	1.06	NS	0.81	NS	0.72	NS	0.63	NS	0.50	NS	0.47	NS	0.67	NS	0.55	NS	0.24	NS
PK																			0.28	0.80
PB																			0.31	NS
PF																			0.31	NS
PKBF																			0.76	NS
CV%		56.26		41.71		22.28		18.36		14.91		11.45		10.38		14.03		10.76		19.47

Note: P=Period, TV= Transformed mean (Arc sine) whereas, OV= Original Values, NS= Non-Significant, General Mean

Table 9. Damage to green bolls by spotted bollworm in different treatments during 2018-19

Factors	**% Green boll damage/ 5 plants recorded at days after sowing**											
	113		**120**		**127**		**134**		**141**		**Pooled**	
	OV	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**
A. Main Treatment (Potash Fertilizer) (K)												
K_0	3.30	10.40	3.19	10.22	3.36	10.51	3.77	11.16	2.33	8.21	3.19	10.10
K_{40}	1.08	5.68	1.44	6.86	2.24	8.43	1.61	7.17	0.80	4.82	1.43	6.59
K_{80}	0.36	3.00	0.80	5.03	0.63	4.47	0.64	4.43	0.28	2.35	0.54	3.86
GM		6.36		7.37		7.80		7.59		5.13		6.85
SEm ±		0.32		0.51		0.53		0.31		0.65		0.23
CD (5%)		1.26		2.01		2.11		1.25		2.55		0.68
CV %		17.58		24.10		23.86		14.56		44.01		24.59
B. Sub Treatment												
Potash Mobilizing Bacteria (B)												
B_0	1.64	6.48	1.92	7.64	2.11	7.98	2.07	7.78	1.44	5.92	1.83	7.16
B_1	1.51	6.24	1.70	7.10	2.05	7.64	1.94	7.39	0.83	4.03	1.61	6.54
GM		6.36		7.37		7.80		7.59		5.13		6.85
SEm ±		0.47		0.19		0.21		0.25		0.50		0.16
CD (5%)		NS		NS		NS		NS		1.49		0.45
Foliar sprays of Potassium Nitrate (F)												
NFS	1.64	6.59	1.94	7.65	2.16	8.04	2.05	7.75	1.48	5.96	1.85	**7.20**
FS	1.51	6.13	1.68	7.09	1.99	7.57	1.96	7.42	0.79	4.29	1.59	**6.50**
GM		6.36		7.37		7.80		7.59		5.13		6.85
SEm ±		0.47		0.19		0.21		0.25		0.50		**0.16**
CD (5%)		NS		NS		NS		NS		1.49		**0.45**
Interactions												
	SEm ±	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	0.81	NS	0.34	NS	0.38	NS	0.44	NS	0.86	NS	0.27	NS
KF	0.81	NS	0.34	NS	0.38	1.13	0.44	NS	0.86	NS	0.27	NS
BF	0.66	NS	0.27	NS	0.31	NS	0.36	NS	0.70	NS	0.22	NS
KBF	1.15	NS	0.48	NS	0.53	1.60	0.62	NS	1.22	NS	0.38	NS
PK											0.48	NS
PB											0.35	NS
PF											0.35	NS
PKBF											0.86	NS
CV%		31.37		11.35		11.91		14.23		41.51		21.89

Note: P=Period, TV= Transformed mean (Arc sine) whereas, OV= Original Values, NS= Non-Significant, GM= General Mean

Table 10. Open bolls and locules damage by spotted bollworm at harvest

Factors	**Open bolls damage (%)**		**Locules damage (%)**	
	OV	**TV**	**OV**	**TV**
A. Main Treatment (K)				
K_0	4.11	11.65	3.09	10.10
K_{40}	3.54	10.77	2.75	9.51
K_{80}	3.49	10.73	2.30	8.68
GM		11.05		9.43
SEm ±		0.36		0.18
CD (5%)		NS		0.71
CV %		11.58		6.66
B. Sub Treatment				
Potash Mobilizing Bacteria				
B_0	3.80	11.17	2.82	9.64
B_1	3.63	10.92	2.61	9.22
GM		11.05		9.43
SEm ±		0.22		0.18
CD (5%)		NS		NS
Foliar sprays of Potassium Nitrate (F)				
NFS	3.82	11.20	2.77	9.53
FS	3.61	10.89	2.66	9.33
GM		11.05		9.43
SEm ±		0.22		0.18
CD (5%)		NS		NS
Interactions				
	SEm ±	CD (5%)	SEm ±	CD (5%)
KB	0.39	NS	0.32	NS
KF	0.39	NS	0.32	NS
BF	0.32	NS	0.26	NS
KBF	0.56	NS	0.46	NS
CV%		**8.78**		8.54

Note: TV= Transformed mean (Arc sine) whereas, OV= Original Values, NS= Non-Significant, GM= General Mean

Table 11. Incidence of larva of American bollworm in different treatments during 2018-19

Factors	Av. number of larvae of American bollworm/ 5 plants recorded at days after sowing																			
	106		113		120		127		134		141		148		155		162		Pooled	
	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV	OV	TV
A. Main Treatment (Potash Fertilizer) K																				
K_0	0.83	1.09	0.83	1.08	0.75	1.08	1.25	1.27	2.00	1.56	1.41	1.34	1.08	1.24	0.33	0.87	1.00	1.19	1.05	1.19
K_{40}	0.16	0.79	0.08	0.75	0.08	0.75	0.25	0.83	0.33	0.87	0.16	0.79	0.25	0.83	0.17	0.79	0.08	0.75	0.17	0.79
K_{80}	0.00	0.70	0.00	0.70	0.00	0.70	0.00	0.70	0.00	0.70	0.08	0.75	0.00	0.70	0.00	0.70	0.00	0.70	0.01	0.71
GM		**0.86**		**0.84**		**0.84**		**0.93**		**1.05**		**0.96**		**0.92**		**0.79**		**0.88**		**0.90**
SEm ±		0.06		0.07		0.05		0.09		0.03		0.04		0.05		0.03		0.02		**0.03**
CD (5%)		0.26		0.28		0.23		0.37		0.15		0.18		0.20		0.11		0.10		**0.10**
CV %		27.28		29.20		23.99		35.42		12.78		17.38		19.17		13.32		10.91		**22.39**
B. Sub Treatment																				
Potash Mobilizing Bacteria (B)																				
B_0	0.38	0.89	0.33	0.86	0.38	0.89	0.55	0.96	0.83	1.06	0.55	0.95	0.44	0.93	0.16	0.79	0.33	0.87	0.44	0.91
B_1	0.27	0.83	0.27	0.83	0.16	0.79	0.44	0.91	0.72	1.03	0.55	0.96	0.44	0.91	0.16	0.79	0.38	0.89	0.38	0.88
GM		**0.86**		**0.85**		**0.84**		**0.94**		**1.05**		**0.96**		**0.92**		**0.79**		**0.88**		**0.90**
SEm ±		0.06		0.06		0.03		0.05		0.05		0.07		0.05		0.05		0.05		**0.01**
CD (5%)		NS		NS		NS		NS		NS		NS		NS		NS		NS		**NS**
Foliar sprays of Potassium Nitrate (F)																				
NFS	0.27	0.84	0.33	0.86	0.38	0.89	0.50	0.93	0.77	1.04	0.66	1.00	0.44	0.92	0.16	0.79	0.33	0.87	0.43	0.90
FS	0.38	0.89	0.27	0.83	0.16	0.79	0.50	0.93	0.77	1.05	0.44	0.91	0.44	0.92	0.16	0.79	0.38	0.89	0.39	0.89
GM		**0.86**		**0.84**		**0.84**		**0.93**		**1.04**		**0.95**		**0.92**		**0.79**		**0.88**		**0.90**
SEm ±		0.06		0.06		0.03		0.05		0.05		0.07		0.05		0.05		0.05		**0.01**
CD (5%)		NS		NS		NS		NS		NS		NS		NS		NS		NS		**NS**
Interactions	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	0.11	NS	0.11	NS	0.06	NS	0.09	NS	0.10	NS	0.12	NS	0.08	NS	0.09	NS	0.08	NS	**0.03**	**NS**
KF	0.11	NS	0.11	NS	0.06	NS	0.09	NS	0.10	NS	0.12	NS	0.08	NS	0.09	NS	0.08	NS	**0.03**	**NS**
BF	0.09	NS	0.09	NS	0.05	NS	0.07	NS	0.08	NS	0.10	NS	0.07	NS	0.07	NS	0.06	NS	**0.02**	**NS**
KBF	0.16	NS	0.16	NS	0.08	NS	0.12	NS	0.14	NS	0.17	NS	0.12	NS	0.13	NS	0.12	NS	**0.04**	**NS**
PK																			**0.05**	**0.16**
PB																			**0.05**	**NS**
PF																			**0.05**	**NS**
PKBF																			**0.14**	**NS**
CV%		32.88		33.59		18.30		23.80		24.06		31.99		23.24		29.45		23.51		**27.13**

Note: P=Period, TV= Transformed mean (Arc sine) whereas, OV= Original Values, NS= Non-Significant, GM= General Mean

Table 12. Damage to square by American bollworm in different treatments in 2018-19

Factors	**% Square damage by ABW/ 5 Plants recorded at days after sowing**																			
	75		**82**		**89**		**96**		**102**		**109**		**116**		**123**		**130**		**Pooled**	
	OV	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**
A. Main Treatment (Potash Fertilizer) (K)																				
K_0	0.33	2.59	1.61	7.19	1.11	5.92	1.38	6.56	3.38	10.59	3.91	11.40	2.19	8.49	3.33	10.50	3.77	11.17	2.33	8.27
K_{40}	0.27	2.38	0.22	2.15	0.16	1.78	0.44	3.75	0.55	4.19	0.74	4.91	0.77	4.91	0.58	3.93	0.80	4.98	0.50	3.67
K_{80}	0.22	1.88	0.19	1.77	0.08	1.03	0.24	2.40	0.27	2.52	0.44	3.72	0.28	2.65	0.24	2.40	0.47	3.87	0.27	2.47
GM		2.28		3.70		2.91		4.24		5.77		6.68		5.35		5.61		6.67		4.80
SEm ±		0.31		0.32		0.39		0.28		0.12		0.22		0.43		0.40		0.30		0.44
CD (5%)		NS		1.28		1.53		1.12		0.48		0.87		1.69		1.60		1.19		1.33
CV %		48.30		30.52		46.44		23.30		7.38		11.58		27.90		25.23		15.79		23.47
B. Sub Treatment																				
Potash Mobilizing Bacteria (B)																				
B_0	0.33	2.64	0.72	3.83	0.48	3.15	0.77	4.42	1.44	6.02	1.77	6.85	1.10	5.48	1.40	5.67	1.88	7.08	1.10	5.02
B_1	0.22	1.93	0.62	3.57	0.42	2.67	0.60	4.05	1.36	5.51	1.62	6.50	1.05	5.22	1.36	5.56	1.47	6.27	0.97	4.59
GM		2.29		3.70		2.91		4.24		5.77		6.68		5.35		5.62		6.68		4.81
SEm ±		0.61		0.47		0.40		0.33		0.30		0.18		0.27		0.35		0.17		0.12
CD (5%)		NS		NS		NS		NS		NS		NS		NS		NS		0.52		NS
Foliar sprays of Potassium Nitrate (F)																				
NFS	0.31	2.48	0.7	3.80	0.46	3.00	0.79	4.50	1.46	6.00	1.72	6.72	1.18	5.74	1.49	6.07	1.74	6.85	1.09	5.02
FS	0.24	2.10	0.64	3.60	0.44	2.82	0.59	3.98	1.35	5.53	1.68	6.63	0.98	4.96	1.27	5.15	1.62	6.50	0.98	4.59
GM		2.29		3.70		2.91		4.24		5.76		6.67		5.35		5.61		6.68		4.80
SEm ±		0.61		0.47		0.40		0.33		0.30		0.18		0.27		0.35		0.17		0.12
CD (5%)		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS
Interactions	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	1.06	NS	0.82	NS	0.69	NS	0.58	NS	0.53	NS	0.31	NS	0.48	NS	0.60	NS	0.30	NS	0.20	NS
KF	1.06	NS	0.82	NS	0.69	NS	0.58	NS	0.53	NS	0.31	NS	0.48	NS	0.60	NS	0.30	0.90	0.20	NS
BF	0.86	NS	0.67	NS	0.56	NS	0.47	NS	0.43	NS	0.25	NS	0.39	NS	0.49	NS	0.24	NS	0.17	NS
KBF	1.50	NS	1.17	NS	0.98	NS	0.82	NS	0.75	NS	0.44	NS	0.68	NS	0.86	NS	0.43	NS	0.29	NS
PK																			0.32	0.93
PB																			0.37	NS
PF																			0.37	NS
PKBF																			0.90	NS
CV%		113.48		54.81		58.18		33.71		22.64		11.48		22.07		26.55		11.21		32.74

Note: P=Period, TV= Transformed mean (Arc sine) whereas, OV= Original Values, NS= Non-Significant, GM= General Mean

Table 13. Damage to green bolls by American bollworm in different treatments during 2018-19

Factors	**% Green boll damage/ 5 plants recorded at days after sowing**											
	113		**120**		**127**		**134**		**141**		**Pooled**	
	OV	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**	**OV**	**TV**
A. Main Treatment (Potash Fertilizer) (K)												
K_0	3.08	9.99	3.88	11.28	3.58	10.88	4.16	11.74	3.94	11.42	3.73	11.06
K_{40}	1.44	6.86	0.94	5.46	1.61	7.18	0.72	4.66	0.80	4.90	1.10	5.81
K_{80}	0.27	2.35	0.72	4.75	0.91	5.44	0.58	4.27	0.33	3.15	0.56	4.00
GM		**6.40**		**7.16**		**7.83**		**6.89**		**6.49**		6.96
SEm ±		0.55		0.39		0.24		0.30		0.14		0.47
CD (5%)		2.19		1.55		0.98		1.18		0.55		1.56
CV %		30.2		19.16		11.04		15.15		7.57		17.84
B. Sub Treatment												
Potash Mobilizing Bacteria (B)												
B_0	1.60	6.48	1.90	7.41	2.20	8.22	1.94	7.18	1.75	6.83	1.88	7.22
B_1	1.59	6.32	1.79	6.92	1.86	7.45	1.70	6.60	1.62	6.15	1.71	6.69
GM		**6.40**		**7.17**		**7.83**		**6.89**		**6.49**		6.96
SEm ±		0.36		0.32		0.17		0.28		0.29		0.13
CD (5%)		NS		NS		0.53		NS		NS		0.36
Foliar sprays of Potassium Nitrate (F)												
NFS	1.75	6.64	1.88	7.31	2.10	8.06	1.90	7.07	1.72	6.59	1.87	**7.13**
FS	1.44	6.16	1.81	7.03	1.96	7.61	1.73	6.71	1.66	6.39	1.72	**6.78**
GM		**6.4**		**7.17**		**9.15**		**6.89**		**6.49**		**6.96**
SEm ±		0.36		0.32		0.17		0.28		0.29		**0.12**
CD (5%)		NS		NS		NS		NS		NS		**NS**
Interactions												
	SEm ±	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	0.62	NS	0.55	NS	0.31	NS	0.49	NS	0.50	NS	0.22	NS
KF	0.62	NS	0.55	NS	0.31	NS	0.49	NS	0.50	NS	0.22	NS
BF	0.51	NS	0.45	NS	0.25	NS	0.40	NS	0.41	NS	0.18	NS
KBF	0.88	NS	0.78	NS	0.43	NS	0.70	NS	0.71	NS	0.32	NS
PK											0.35	1.05
PB											0.29	NS
PF											0.29	NS
PKBF											0.72	NS
CV%		23.99		18.96		9.71		17.65		19.10		17.95

Note: P=Period, TV= Transformed mean (Arc sine) whereas, OV= Original Values, NS= Non-Significant, GM= General Mean

Table 14. Open bolls and locules damage by American bollworm at harvest

Factors	Open bolls damage (%)		Locules damage (%)	
	OV	TV	OV	TV
A. Main Treatment (Potash Fertilizer) (K)				
K_0	3.88	11.31	3.06	10.05
K_{40}	3.02	9.94	2.38	8.85
K_{80}	2.61	9.27	2.23	8.54
GM		**10.17**		**9.15**
SEm ±		**0.29**		**0.18**
CD (5%)		**1.16**		**0.72**
CV %		**10.11**		**7.00**
B. Sub Treatment				
Potash Mobilizing Bacteria				
B_0	3.43	10.60	2.68	9.38
B_1	2.91	9.74	2.43	8.91
GM		**10.17**		**9.15**
SEm ±		**0.20**		**0.18**
CD (5%)		**0.60**		**NS**
Foliar sprays of Potassium Nitrate (F)				
NFS	3.28	10.35	2.61	9.22
FS	3.06	10.00	2.51	9.07
GM		**10.17**		**9.15**
SEm ±		**0.20**		**0.18**
CD (5%)		**NS**		**NS**
Interactions				
	SEm ±	**CD (5%)**	**SEm ±**	**CD (5%)**
KB	0.35	NS	0.31	NS
KF	0.35	NS	0.31	NS
BF	0.28	NS	0.25	NS
KBF	0.50	NS	0.44	NS
CV%		**8.55**		**8.43**

Note: TV= Transformed mean (Arc sine) whereas, OV= Original Values, NS= Non-Significant, GM= General Mean

Table 15. Boll worm incidence irrespective of main and sub treatments and their correlation with expression of *Cry1Ac* and *Cry2Ab* in boll rind

PBW larvae/10 green bolls			SBW larva/5 plants		ABW larva/5 plants		*Cry1Ac*/boll rind (μg g^{-1} of fresh tissue)			*Cry2Ab2*/boll rind (μg g^{-1} of fresh tissue)		
90 DAS	**105 DAS**	**120 DAS**	**111DAS**	**118 DAS**	**111DAS**	**118 DAS**	**90 DAS**	**105 DAS**	**120 DAS**	**90 DAS**	**105 DAS**	**120 DAS**
P1	**P2**	**P3**	**S1**	**S2**	**A1**	**A2**	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**
2.08±0.51	3.28±0.92	2.78±0.52	0.22±0.26	0.61±0.34	0.31±.41	0.28±0.42	3.20±0.16	3.06±0.18	3.01±0.20	81.79±7.57	85.79±6.42	87.86±9.07
Correlation value												
P1							0.0111			-0.5929**		
	P2							0.0609			-0.2248	
		P3							-0.2216			-0.4555*
			S1					0.1030			-0.2313	
				S2					0.5315**			0.064
					A1			-0.2813			-0.2288	
						A2			0.0442			-0.5064**

*Note: Table value at 5%=0.331 and at 1%=0.4266, *=Significant, **= Highly-significant*

Table 16. Seed cotton yield as influenced by different treatment combinations

Factors	Seed cotton yield (kg ha^{-1})	
A. Main Treatment (K)		
K_0	2103.90	
K_{40}	2471.45	
K_{80}	2692.90	
GM	2422.75	
SEm ±	67.55	
CD (5%)	265.19	
CV %	9.66	
B. Sub Treatment I (B)		
Potash Mobilizing Bacteria		
B_0	2376.37	
B_1	2469.13	
GM	2422.75	
SEm ±	28.93	
CD (5%)	85.95	
Foliar sprays of Potassium Nitrate (F)		
NFS	2379.80	
FS	2465.70	
GM	2422.75	
SEm ±	28.93	
CD (5%)	NS	
Interactions		
	SEm±	**CD(5%)**
KB	50.10	NS
KF	50.10	NS
BF	40.91	NS
KBF	70.86	NS
CV%	**5.07**	

Table 17. Economics of main and sub-treatments

Treatment	Seed cotton yield (Kg/ha)	No. of spray		Total spray	Gross realization (Rs./ha)	Fixed cost	Variable cots						Total expenditure (Rs./ha)	Net realization (Rs./ha) (Rounding to near rupee)	BCR
							Treatment cost								
						Cost of cultivation (Rs./ha) excluding picking and inputs (Fixed cost)	Potassium and its application cost	Potash Mobilizing Bacteria and its application cost	Potassium Nitrate and its apllication cost	Insecticide and its application		Gross treatment cost			
		SP	BW							SP	BW				
A. Main Treatment (K)															
K_0	2103.91	4.00	3.00	7.00	94675.95	35000.00	0.00	315.50	3414.00	5111.00	3378.00	12218.50	47218.50	47457.00	2.01
K_{40}	2471.45	3.50	1.50	5.00	111215.25	35000.00	1623.00	315.50	3414.00	4278.00	2294.00	11924.50	46924.50	64290.00	2.37
K_{80}	2692.90	2.50	1.50	4.00	121180.61	35000.00	2889.00	315.50	3414.00	2579.50	2294.00	11492.00	46492.00	74688.00	2.61
B. Sub-treatment 1 (B)															
B_0	2376.37	3.33	2.00	5.33	106936.73	35000.00	1504.00	0.00	3414.00	3989.50	2655.33	11562.83	46562.83	60373.00	2.30
B_1	2469.14	3.33	2.00	5.33	111111.15	35000.00	1504.00	631.00	3414.00	3989.50	2655.33	12193.83	47193.83	63917.00	2.36
C. Sub-treatment 2 (F)															
NFS	2379.80	3.67	2.33	6.00	107091.08	35000.00	1504.00	315.50	0.00	4555.67	2864.00	9239.17	44239.17	62851.00	2.42
FS	2465.71	3.00	1.67	4.67	110956.80	35000.00	1504.00	315.50	6828.00	3423.33	2446.67	14517.50	49517.50	61439.00	2.24

Note: SP= Sucking pest, BW= Bollworm, BCR=Benefit Cost Ratio

Table 18. Economics of various treatment combinations at ETL based interventions

Treatment	Seed cotton yield (Kg/ha)	No. of Sprays		Total Spray	Gross realization (Rs./ha)	Fixed cost	Variable cost					Total expenditure (Rs./ha)	Net realization (Rs./ha) (Rounding to near rupee)	BCR
						Cost of cultivation (Rs./ha) excluding picking and inputs (Fixed cost)	Potassium and its application cost	Potash Mobilizing Bacteria and its application cost	Potassium Nitrate and its apllication cost	Insecticide and its application cost				
		SP	BW							SP	BW			
K_0B_0NFS	2047.33	4	3	7	92129.9	35000	0	0	0	5111	3378	43489	48641	2.12
K_0B_0FS	2119.34	4	3	7	95370.3	35000	0	0	6828	5111	3378	50317	45053	1.90
K_0B_1NFS	2088.48	4	3	7	93981.6	35000	0	631	0	5111	3378	44120	49862	2.13
K_0B_1FS	2160.49	4	3	7	97222.1	35000	0	631	6828	5111	3378	50948	46274	1.91
$K_{40}B_0$NFS	2272.63	4	2	6	102268.4	35000	1623	0	0	5111	2607	44341	57927	2.31
$K_{40}B_0$FS	2500.00	3	1	4	112500.0	35000	1623	0	6828	3445	1981	48877	63623	2.30
$K_{40}B_1$NFS	2489.71	4	2	6	112037.0	35000	1623	631	0	5111	2607	44972	67065	2.49
$K_{40}B_1$FS	2623.46	3	1	4	118055.7	35000	1623	631	6828	3445	1981	49508	68548	2.38
$K_{80}B_0$NFS	2705.76	3	2	5	121759.2	35000	2889	0	0	3445	2607	43941	77818	2.77
$K_{80}B_0$FS	2613.17	2	1	3	117592.7	35000	2889	0	6828	1714	1981	48412	69181	2.43
$K_{80}B_1$NFS	2674.90	3	2	5	120370.5	35000	2889	631	0	3445	2607	44572	75799	2.70
$K_{80}B_1$FS	2777.78	2	1	3	125000.1	35000	2889	631	6828	1714	1981	49043	75957	2.55

Note: Av. Seed cotton price Rs. 45 kg^{-1} during 2018-19 and labour charge @ Rs. 178/8 working hours day^{-1}, SP= Sucking pest, BW= Bollworm, K= K_2O levels , B= KMB application, F=foliar sprays of KNO_3, BCR=Benefit Cost Ratio

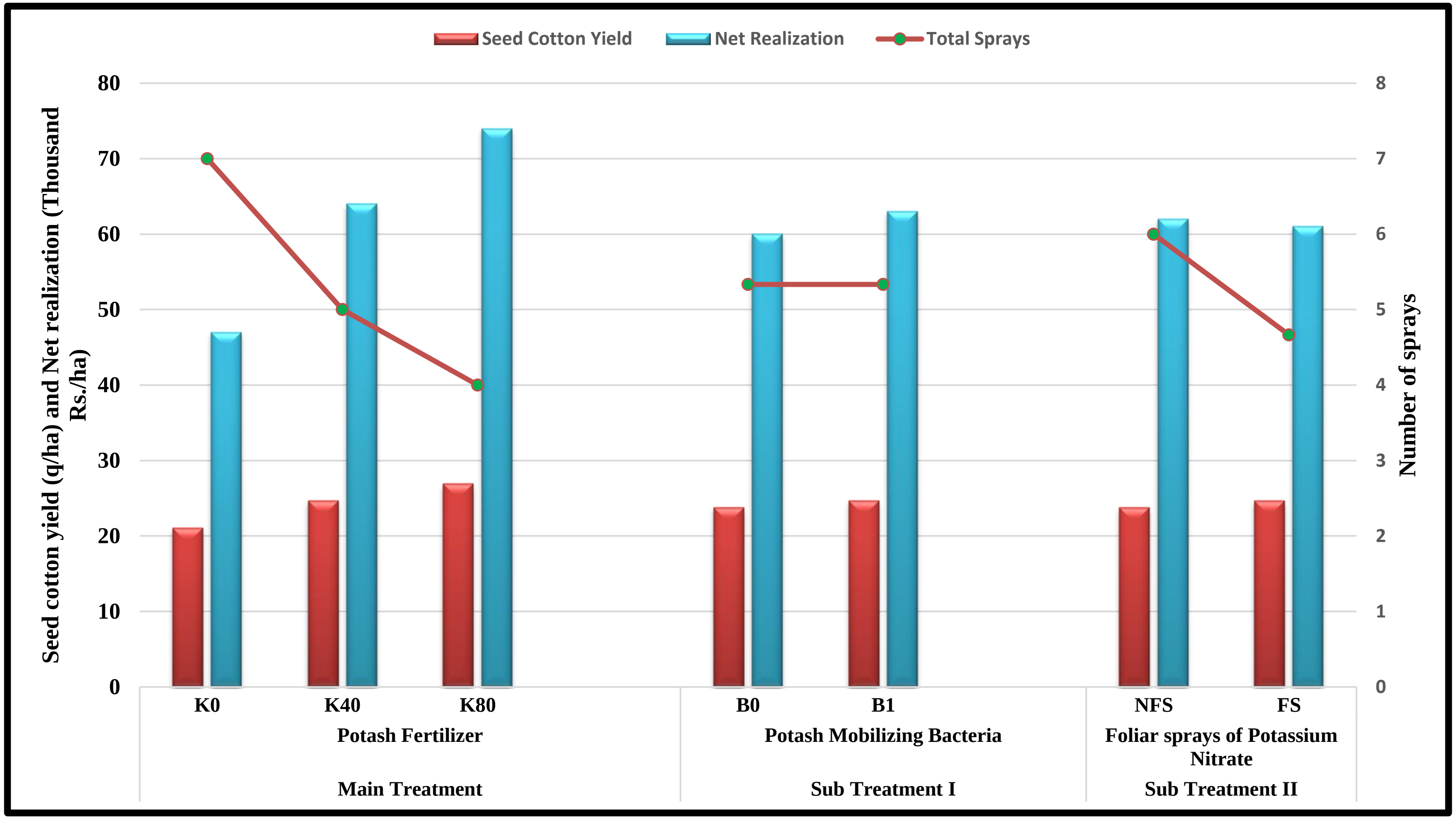

Fig. 1. Number of sprays for insect pest management, seed cotton yield and net realization of main and sub treatments

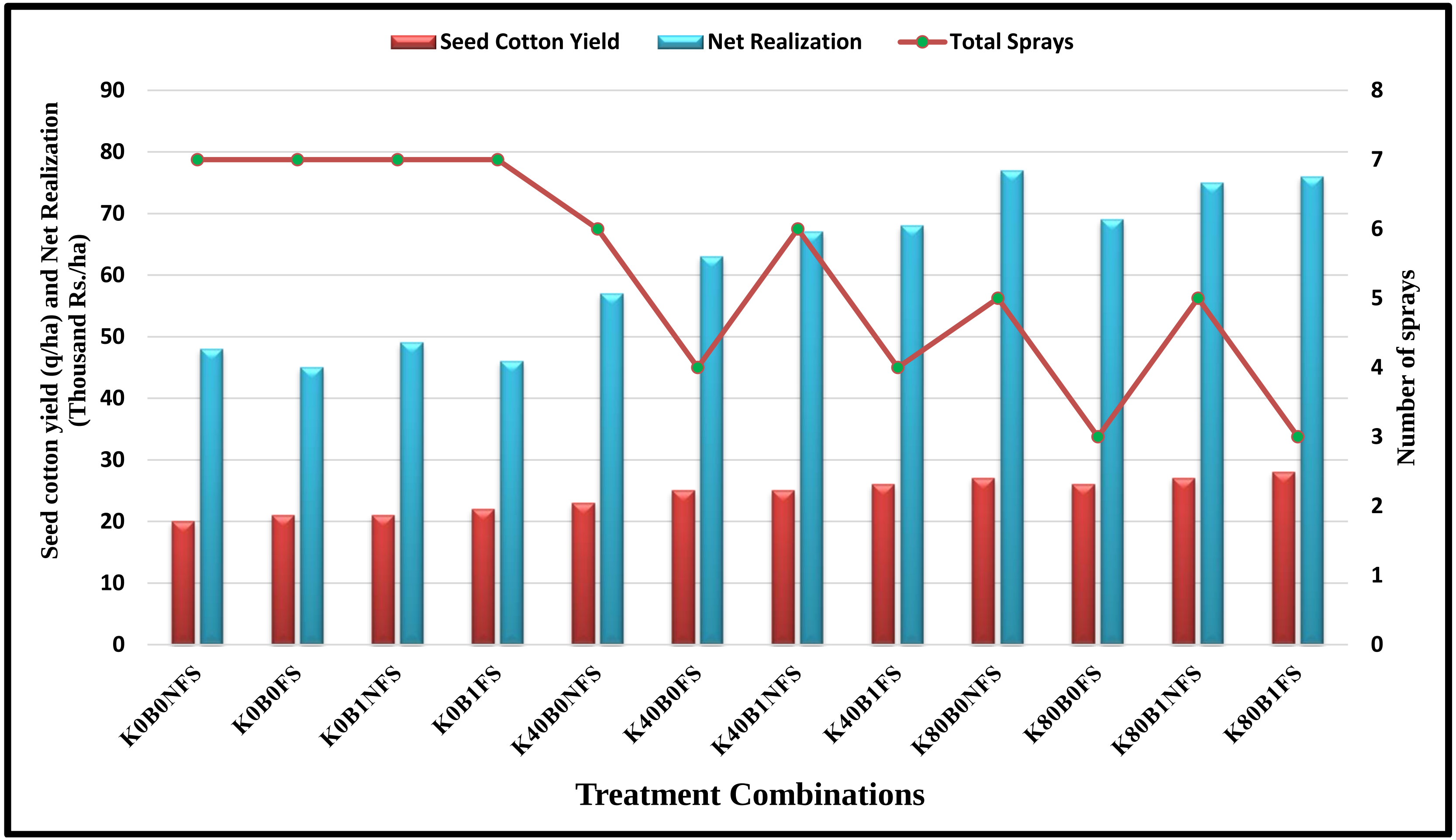

Fig. 2. Number of sprays for insect pest management, seed cotton yield and net realization in various treatment combinations

The application of potash mobilizing bacteria showed the longer availability of potassium to the plant as the K content in stalk was above mean value in the applied plots. In Gujarat, the available K status showed 100% area under high K in 1976 which reduced to 65% in 2002 [14]. Bhambhaneeya *et al*. (2017) studied the soil available nutrient status and their indexing in cotton growing areas of south Gujarat and reported high status of K (>280 kg ha^{-1}) both in irrigated and rain fed regions in selected samples [11].

The positive role of K application on growth parameters and yield and abiotic stress specifically light intensity was also reported [15,16]. Application of hormone and micro-nutrient did not affect the population of thrips, jassid, whitefly and bollworms [17]. With respect to synthetic and organic source of nutrition, some workers did not find any marked effect on whitefly, jassid, thrips and spotted bollworms whereas less infestation of all three bollworms and sucking pests was noticed in organic source of nutrition [18-20]. Balanced nutrition/fertilization with NPK content gave ideal growth of the plants and reduced the insect pest damage especially of sucking pests (leafhopper, aphid and whitefly by eliciting plant defence to biotic stress [21-24]. Under agronomic requirements of Bt hybrids,Nehra (2015) found increased in the seed cotton yield by 1.87 q ha^{-1} with the application of potassic fertilizer @30 kg ha^{-1} at sowing than without potash [25]. Increasing fertilizer levels (NPK), though associated with increase in yield, on the other hand it increased the bollworm infestations and damage especially on non Bt hybrids [26].

Amtmann *et al.* (2008) opined that the effect of K nutrition on pest and disease resistance in plants required genetic approach to establish causal relationship between pest susceptibility/resistance along with in-depth studies on enzymatic and signaling pathway [27]. The indirect effect of fertilization practices acting through changes in the nutrient composition of the crop have been reported to influence plant resistance to many insect pests. Among major nutrients, potassium uptake in the cotton plants reached maximum during mid-bloom and declined rapidly as the boll matures which under biotic stress or its deficiency affected number of physiological and biochemical processes that lead to susceptibility to insect pests and disease [28,29].

Correlation of bollworm incidence and expression of genes: The surviving larval population of PBW recovered from green bolls was above ETL during different periods whereas the larval populations of SBW and ABW recovered from green bolls of the 5 plants were found below ETL (Table 15). Attempt was made to correlate the larval recovery of bollworms (PBW, ABW and SBW) with the expression of *Cry1Ac* and *Cry2Ab2*δ-endotoxin in boll rind irrespective of main and sub-treatments as the expression was found above critical level of toxins required and reported by earlier workers. The larval incidence of pink bollworm (larvae/10 green bolls) showed no significant correlations with expression of *Cry1Ac* endotoxin in tissue of boll rinds sampled during 90, 105 and 120 DAS while the larval population at 90 DAS (2.08±0.51 larvae/10 green bolls) and 120 DAS (2.78±0.52 larvae/10 green bolls) showed significant negative correlation with *Cry2Ab2* expression in tissue of boll rinds (81.79±7.57 and 87.86±9.07 µg $g^{-1}$of fresh tissue at 90 and 120 DAS, respectively). In case of SBW, the incidence larvae/5 plants (118 DAS) showed significant positive correlations with expression of *Cry1Ac* endotoxin in tissue of boll rinds sampled during 120 DAS (3.01±0.20 µg g^{-1} of fresh tissue), though, the population of SBW remained below ETL in all treatment combinations. While with *Cry2Ab2*, the larval populations of SBW (111 and 118 DAS) did not show any significant correlations. In case of ABW, the incidence of larvae/5 plants (111 and 118 DAS) showed no significant correlations with expression of *Cry1Ac* endotoxin in tissue of boll rinds sampled during 105 and 120 DAS. However, the larval populations (0.28±0.42 larva/5 plants) at 118 DAS showed significant negative correlation with *Cry2Ab2* expression in tissue of boll rinds at 120 (87.86±9.07 µg g^{-1} of fresh tissue). Adamczyk *et al.* (2001) found inverse correlations of survivorship and development rate of *Helicoverpa zea* and *Spodoptera frugiperda* with the d-endotoxin concentrations in plant parts of commercial cotton (DP451B/RR&NuCOTN 33B) and opined that this difference affected the dynamics and resistance build up [30]. Prabhuraj *et al.* (2011) opined that the survival of *Helicoverpa armigera* on Bt cotton collected from Raichur district of Karnataka when fed on Bt cotton in their F1 generations was equal to that of the control supported the school of thought that there was gradual development of resistant in individuals as expression of genes in hybrids were proven and approved while commercialization [31]. Naik *et al.* (2011)

reported higher mortality of early larval instars of American bollworm fed on leaves and squares of all the Bt event hybrids was higher than the later instars [32]. Bansudey *et al.* (2014) found variability in performance of commercial hybrids and reported that *Cry1Ac* concentration was found to be significantly highest (12.22 µgg^{-1}) in MRC 7351 BG II and UPLHH 2 Fusion Bt and *Cry2Ab2* in Dhanwan BG II (489.2 ìg g^{-1}) whereas the highest mortality (96.66%) of *Helicoverpa* larvae was observed in ACH 11 BG II and TCHH-4 BG II hybrids and of *Spodoptera* larvae (76.66%) in ACH 11 BG II, Kaveri Jackpot BG II and TCHH – 4 BG II [33]. Naik *et al.* (2018) reported the annual PBW larval recovery from Bt cotton was 28.85 to 72.49% during 2014 to 2017. Further they reported that the LC_{50} of *Cry1Ac* for pink bollworm increased from mean of 0.300 to 6.938 µg ml^{-1} and of *Cry2Ab2* from mean of 0.014 to 12.51 µg ml^{-1}during 2013 to 2017 in Central and Southern India [8].

Seed cotton yield and economics: The data revealed that there was significant difference in seed cotton yield in K_2O application and no K_2O application. The seed cotton yield was highest (2692.90 kg ha^{-1}) in K_2O application @80 kg ha^{-1}and was statistically at par to K_2O application @ 40 kg ha^{-1}(2471.45 kg ha^{-1}) as against seed cotton yield of 2103.90 kg ha^{-1}in no K_2O application.The seed cotton yield was found significantly maximum (2469.13 kg ha^{-1}) in KMB application than no KMB application (2376.37 kg ha^{-1}). The potash solubilizing/mobilizing bacteria increase the availability of nutrients near the rhizosphere which ultimately lead to better absorption and the K provides resistance to disease and pests and prevents premature senescence which ultimately enhances the yield indirectly. Inoculation of potassium solubilizing bacteria, *Bacillus mucilaginosus* has been reported to significantly increase the yield of cotton [34]. The increase in yield of cotton by 50-94 percent when Azotobacterin and silica bacterin were applied simultaneously [35].

There was no significant difference in seed cotton yield in sub treatments of foliar sprays of potassium nitrate (2465.70 kg ha^{-1}) and no foliar sprays 2379.80 kg ha^{-1}), though the value was higher in the foliar sprays. Saravanan *et al.* (2011) studied Polyfeed+Multi K recorded the highest seed cotton yield of 2758 kg ha^{-1} [36]. Sekhon and Singh (2013) observed foliar spray of fertilizers containing N and K nutrients helped to maintain boll development resulted in improvement in seed cotton yield [37]. Nehra (2015) reported that foliar application of KNO_3 @3% gave the highest seed cotton yield [25]. Kumar *et al.*(2017) found that the application of K @60 kg ha^{-1} along with two foliar spray of 1% KNO_3 significantly produced higher yield [38]. Magare *et al.* (2018) reported that application of 37.5 kg K_2O ha^{-1} along with recommended dose of fertilizer (50:25:0 NPK kg ha^{-1}) recorded significantly higher seed cotton yield (14.64 q ha^{-1}) [24]. Interactions (KB, KF, BF and KBF) were found not significant indicating consistent performance of respective combination of main and sub treatments.

4. CONCLUSION

The K_2O application @80 kg ha^{-1} in the form of Murate of Potash fertilizer with the application of potash mobilizing bacteria (KMB) @2.5 litre ha^{-1} (as basal application at 15 days after sowing) and foliar sprays of potassium nitrate (KNO_3) @3% at squaring, flowering and boll development stages recorded highest profitable seed cotton yield, requires two ETL based spray for sucking pests and only one spray for bollworms particularly for pink bollworm.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that there was no usage of generative ai technologies like (ChatGPT, COPILOT, etc.).

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AVAILABILITY OF DATA AND MATERIALS

All data generated during this study are included in this published article.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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