Effect of Calcium and Magnesium on Flowering and Fruiting of Tomato (*Lycopersicon esculentum Mill*)

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Abstract: **The influence of $CaCl_2$ and Mg on growth, yield, and quality of tomato was investigated in Uasin Gishu (in Chepkoilel) and Bungoma counties, between June-October 2016, and March-July 2017. The experiment was laid out with a randomized complete block design. $CaCl_2$+Mg foliar (1.5% and 2.0%) solutions was applied as foliar sprays in combination with soil application of CaO and NPK fertilizer on three tomato varieties-Cal-J, Riogrande and Nyati. Data were recorded for days to 50% flowering, the highest number flowers per cluster, fruits per plant, yield, fruit weight, fruit firmness, and total soluble solid content of the fruit. The application of $CaCl_2$+Mg at 2% in T12 (30Kg P/ha+4tons/ha+2% calcium and magnesium)significantly increased the days to 50%flowering, number of flowers, and the number of fruits per plant. Foliar application of $CaCl_2$ (2.0%) + CaO (4t/ha) resulted in the minimum number of days to 50% flowering (18.67 in Chepkoilel and 22 in Bungoma), the highest number of flower clusters (Bungoma 51.67 and 52.33 in Chepkoilel), the highest number of flowers (Bungoma 239.67 and Chepkoilel 201.33), highest number of fruits per plant (Bungoma 99.67 and Chepkoilel 96.33), and highest yield (Bungoma 10.55t/ha and Chepkoilel 9.63t/ha).**

Key words: **Calcium chloride, foliar application, tomato**

I. INTRODUCTION

Tomato *(Lycopersicon esculentum Mill)* is one of the most widely grown, and used vegetable crops. In Bungoma and Chepkoilel, maize crop is the most popular produced. However, recent years has seen these farmers have to face several challenges, including drastic price reduction, outbreak of pests and diseases (e.g. Maize Lethal Necrosis Disease), exhaustion of cultivated soils (Kuete, 2008; Okalebo et al., 2002; Gillermou and Kamga, 2004). Therefore,it becomes urgent to search for alternative income-generating products. In this context, seasonal cultures such as vegetables and fruits are gaining more and more interest. This has seen a rise in tomato growing farmers in a paradigm shift and diversifying their farming production systems. Tomatoes are one of the preferred income generation crops by the smallholder farmers because it can be cultivated during the rainy season as well as dry season(Taiz and Zeiger, 2006).Therefore, farmers can harvest tomato fruits twice a year (Uwizeyimana, 2009).Since nutrition plays a major role in tomato production(Kinet and Peet, 1997; Boss et al., 2004;Zook et al., 1987), the yield potential and quality can be improved by maintaining proper fertilizer application(Mohammad *et al*., 2014; Evans, 1993). For improving plant growth and development, balanced, and nutrient rich (both micro and macronutrients) fertilizers are essential. Like other nutrients, calcium and magnesium have a pronounced effect on the production and quality of tomato. Calcium ion (Ca^{2+}) is involved in a wide range of processes in plants including, responses to infections (Zook et al., 1987), flower induction (Friedman et al., 1989), fruit yield (Hao and Papadopoulos, 2004), and conservation (Park et al., 2005). Magnesiumions activate enzymes that catalyze processes such as respiration, photosynthesis, synthesis of DNA and RNA and is part of the ring structure of the chlorophyll molecule (Taiz and Zeiger, 2006). The deficiency of Ca and Mg affects tomato growth and development, yield, and quality of the harvested fruit. In order to provide a corrective measure tothis problem in tomato production, this research work was undertaken with the aim; to investigate the response of different tomato varieties to different rates of Ca^{2+}/ Mg^{3+} fertilizer + Lime + NPK fertilizer on; growth, flowering, and yield.

II. METHODOLOGY

The study was conducted at Chepkoilel, in the University of Eldoret, and in Bungoma during 2016-2017. A total of 117 experimental plots measuring 6.25m^2 were used. Recommended doses of nitrogen (CAN) and phosphorus were used as NPK (23:23:23) fertilizer at the rate of 30kg P/ha. Ca in the form of lime (CaO) using the broadcast method, was applied at three different rates (2t/ha, 3t/ha, and 4t/ha) before transplanting.

Treatment combinations were as follows:

Table 1: Treatment combinations

TRT CODE	Composition of treatments	TRT ABBREVIATION
T0	N:P:K(23:23:23) at rate of 30Kg P/ha	N:P:K
T1	T0 + Soil application of lime(CaO) at 50 Kg/ha (2tons/ha)	N:P:K+2t CaO
T2	T0 + Soil application of lime(CaO) at 75Kg/ha(3tons/ha)	N:P:K+3t CaO
T3	T0 + Soil application of lime(CaO) at 100Kg/ha(4tons/ha)	N:P:K+4t CaO
T4	T1 + 1% combination of foliar fertilizer of calcium and magnesium	N:P:K+2t CaO+1%CaMg
T5	T2 + 1% combination of foliar fertilizer of calcium and magnesium	N:P:K+3t CaO+1%CaMg
T6	T3 + 1% combination of foliar fertilizer of calcium and magnesium	N:P:K+4t CaO+1%CaMg

T7	T1 + 1.5% combination of foliar fertilizer of calcium and magnesium	N:P:K+2t CaO+1.5%CaMg
T8	T2 + 1.5% combination of foliar fertilizer of calcium and magnesium	N:P:K+3t CaO+1.5%CaMg
T9	T3 + 1.5% combination of foliar fertilizer of calcium and magnesium	N:P:K+4t CaO+1.5%CaMg
T10	T1 + 2% combination of foliar fertilizer of calcium and magnesium	N:P:K+2t CaO+2%CaMg
T11	T2 + 2% combination of foliar fertilizer of calcium and magnesium	N:P:K+3t CaO+2%CaMg
T12	T3 + 2% combination of foliar fertilizer of calcium and magnesium	N:P:K+4t CaO+2%CaMg

Three varieties of tomato seedlings such as-Cal J, Riogrande (Rio), and Nyati seedlings were transplanted from a nursery bed at four weeks after sowing, at a recommended spacing of 60cmby 60cm between plants and rows with sixteen (16) seedlings per plot. Control tomato plants received only N: P: K at a ratio of 23:23:23. Nitrogen fertilizer was applied at a recommended rate of 250kg N/ha, as CAN. This was applied in three split doses; at planting (75Kg N/ha), vegetative (100Kg N/ha), and fruiting (75Kg N/ha) stages. Tomato plants were staked, watered, and all other agronomic practices were done as per requirement. Phosphorus was applied at 30kg P/ha. Ca and mg foliar fertilizer was sprayed as foliar on the aerial parts of tomato plants once in 2 weeks from 2 weeks after transplanting until the first harvesting period. The experiment was laid in a RCBD with three replications. Data was collected on the number of days to 50% flowering, flower clusters, number of flowers, and fruit yield.Data obtained was subjected to ANOVA and General Linear Model (GLM) using SAS statistical package. Means were separated by New Duncan Multiple Range Tests (NDMRT). Relationships between crop yields and the treatments were drawn.

III. RESULTS

Number of Days to 50% Flowering in Bungoma and Chepkoilel

In Chepkoilel, treatment T11 had 23.55 days to 50% flowering. This was the lowest recorded number of days to 50% flowering among treatments (Table 2). Treatments T11, T12, T10, and T9 recorded significantly low ($p \leq 0.001$) number of days to 50% flowering (23.55b,22.00a, 23.89b and 24.89c respectively) in comparison to other treatments. Treatment T0 recorded significantly high ($p \leq 0.001$) number of days to 50% flowering (38.00j) (Table 2).

The two varieties Cal-J, and Riogrande recorded the lowest mean number of days to 50% flowering, at 29.23a and 29.74b days respectively (Table 2). In general, Cal-J recorded the lowest number of days to 50% flowering (29.23 days) followed by Riogrande (29.74 days). Nyati realized the highest number of days to 50% flowering (32.34 days) (Table 2).

In Bungoma, treatment T12 recorded the lowest number of days to 50% flowering, with a mean of 18.67a days (Table 2). This was followed closely by treatments T11 and T10 with a means of 20.33b and 21.00c days to 50% flowering respectively (Table 2). Treatment T0 recorded the highest number of days to 50% at 36.00l days (Table 4.2).

Variety Cal-J recorded the lowest number of days to 50% flowering at 17, under treatment T12(Table 4.2). This was followed by Riogrande having 18 days to 50% flowering. Nyati variety recorded the lowest number of days to 50% flowering at 21 days under T12(Table 4.2). The highest number of days to 50% flowering among the varieties tested was under Nyati, with 40 days under treatment T0 (N:P:K)(Table 4.2).

Table 2: Days to 50 % flowering in Bungoma and Chepkoilel

Treatments		Bungoma					Chepkoilel				
		Tomato Varieties					Tomato Varieties				
		Cal-J	Nyati	Riogrande	Mean Variety	Tukeys$_{(.05)}$	Cal-J	Nyati	Riogrande	Mean Variety	Tukeys$_{(.05)}$
T0	N:P:K	36	41	37	38.00	J	34	40	34	36.00	L
T1	N:P:K+2t Cao	35	37	35	35.78	H	29	33	29	30.33	H
T10	N:P:K+2t Cao+2%Camg	25	25	22	23.89	B	22	22	19	21.00	C
T11	N:P:K+3t Cao+2%Camg	21	25	21	22.00	A	19	23	19	20.33	B
T12	N:P:K+4t Cao+2%Camg	22	26	22	23.55	B	17	21	18	18.67	A
T2	N:P:K+3t Cao	35	37	37	36.44	I	32	34	34	33.33	K
T3	N:P:K+4t Cao	34	35	34	34.11	G	32	34	32	32.67	J
T4	N:P:K+2t Cao+1%Camg	32	36	32	33.22	Ef	31	32	31	31.33	I

T5	N:P:K+3t Cao+1%Camg	32	36	32	33.55	F	29	33	29	30.33	H
T6	N:P:K+4t Cao+1%Camg	30	36	33	33.00	E	27	33	30	30.00	G
T7	N:P:K+2t Cao+1.5%Camg	27	31	27	28.48	D	25	27	26	26.00	F
T8	N:P:K+3t Cao+1.5%Camg	28	30	29	28.78	D	24	28	24	25.33	E
T9	N:P:K+4t Cao+1.5%Camg	25	26	24	24.89	C	22	23	21	22.00	D
	Mean Treatment	29.23a	32.34c	29.74b	30.44		29.46a	26.62c	27.49b	27.49	
	Probability	<0.001***	<0.001***	0.325ns			<0.001***	<0.001***	0.179ns		
		Var	Trt	Var*Trt			Var	Trt	Var*Trt		
	S.E	0.309	0.644	1.115			0.300	0.600	1.100		
	S.E.D	0.437	0.911	1.577			0.400	0.900	1.500		
	Lsd	0.861	1.792	3.103			0.800	1.700	3.000		
	%C.V	11.0					11.8				

VAR-Variety; TRT-Treatment; *** Significant at p≤0.001; ** significant at p≤0.01; * significant at p≤0.05; ns- not significant; Different letters within columns indicate statistical significance (P < 0.05)

Number of Flowers in Bungoma and Chepkoilel

Treatments T12, T11, and T9 recorded significantly high means of number of flowers. The three had 239.67, 211.67 and 204.00 flowers respectively among the tested varieties (Table 3).However, Riogrande variety yielded significantly higher (p≤0.05) means of flowers above the Cal-J and Nyati varieties (191.31c, 168.62b and 166.31a respectively) (Table 3).

Treatment T12 and T11 had a high significant effect (p≤0.001) on number of flowers in Bungoma (Table 3). The number of flowers was significantly lowest (p≤0.05) under treatment T0 (Table 3).

Analysis of variance showed high significant effect (p≤0.001) by varieties and treatments on number of flowers (Table 3). Under number of flower clusters in Chepkoilel, T12, T11 and T10 treatments scored highest with 52.33k, 47.67j and 47.67i respectively in Chepkoilel (Table 3). Riogrande variety stood out from the rest with a mean of 43.15 flower clusters respectively (Table 4**).**

Table 3: Number of flowers in Bungoma and Chepkoilel

Treatments		Bungoma					Chepkoilel				
		Tomato Varieties					Tomato Varieties				
		Cal-J	Nyati	Riogrande	Mean Variety	$Tukeys_{(.05)}$	Cal-J	Nyati	Riogrande	Mean Variety	$Tukeys_{(.05)}$
T0	N:P:K	129	125	127	127.00	a	109	114	131	118.00	a
T1	N:P:K+2t CaO	133	161	133	142.33	b	121	147	157	141.67	c
T10	N:P:K+2t CaO+2%CaMg	158	130	184	157.33	d	179	199	214	197.33	l
T11	N:P:K+3t CaO+2%CaMg	216	189	230	211.67	l	174	185	219	192.67	k
T12	N:P:K+4t CaO+2%CaMg	226	224	269	239.67	m	189	184	231	201.33	m
T2	N:P:K+3t CaO	139	129	186	151.33	c	128	139	120	129.00	b
T3	N:P:K+4t CaO	145	195	182	174.00	h	147	123	181	150.33	e
T4	N:P:K+2t CaO+1%CaMg	179	144	155	159.33	e	140	187	202	176.33	h
T5	N:P:K+3t CaO+1%CaMg	163	152	193	169.33	f	153	156	128	145.67	d
T6	N:P:K+4t	162	167	207	178.67	i	177	162	188	175.67	g

	CaO+1%CaMg										
T7	N:P:K+2t CaO+1.5%CaMg	164	176	175	171.67	g	158	190	205	184.33	i
T8	N:P:K+3t CaO+1.5%CaMg	194	178	210	194.00	j	159	171	170	166.67	f
T9	N:P:K+4t CaO+1.5%CaMg	184	192	236	204.00	k	184	164	225	191.00	j
	MEAN Treatment	168.62b	166.31a	191.31c	178.64		155.23a	163.15b	182.38c	166.92	
	Probability	<.001***	<.001***	<.001***			<.001***	<.001***	<.001***		
		VAR	TRT	VAR*TRT			VAR	TRT	VAR*TRT		
	S.E	4.900	10.200	17.700			4.900	10.100	17.600		
	S.E.D	7.000	14.500	25.100			6.900	14.300	24.800		
	LSD	13.700	28.500	49.400			13.600	28.200	48.900		
	%C.V	30.4					12.4				

VAR-Variety; TRT-Treatment; *** Significant at p≤0.001; ** significant at p≤0.01; * significant at p≤0.05; ns- not significant; Different letters within columns indicate statistical significance (P < 0.05)

Analysis of variance showed a highly significant (p≤0.05) effect of both treatments and varieties on the number of tomato flowers. The interaction between varieties and treatments also had a high significant effect (p≤0.05) on the number of tomato flowers (Table 3).

Number of Flower Clusters in Bungoma and Chepkoilel

Treatments T12, T11 and T10 had the significant high (p≤0.05) number of flower clusters (52.33, 44.67 and 42.67 flower clusters respectively) in Bungoma (Table 4). Riogrande, Cal-J and Nyati had 47.00c, 41.15b and 41.08a flower clusters respectively (Table 4).

Riogrande variety had a high significant effect (p≤0.05) on the number of flower clusters (Table 4). This was highest among the varieties with 46.98b, followed by Cal-J and Nyati (41.16b and 40.95a respectively) (Table 4).

There was a high significant effect (p≤0.001) of both varieties and treatments on the number of flower clusters in Bungoma (Table 4).

Table 4: Number of flower Clusters in Bungoma and Chepkoilel

Treatments		Bungoma					Chepkoilel				
		Tomato Varieties					Tomato Varieties				
		Cal-J	Nyati	Riogrande	Mean Variety	$Tukeys_{(.05)}$	Cal-J	Nyati	Riogrande	Mean Variety	$Tukeys_{(.05)}$
T0	N:P:K	31	34	34	33.00	a	24	25	31	26.67	a
T1	N:P:K+2t CaO	41	34	40	38.33	c	28	35	35	32.67	b
T10	N:P:K+2t CaO+2%CaMg	46	45	33	41.33	e	42	38	54	44.67	i
T11	N:P:K+3t CaO+2%CaMg	46	49	54	49.67	j	46	46	51	47.67	j
T12	N:P:K+4t CaO+2%CaMg	47	43	65	51.67	l	44	51	62	52.33	k
T2	N:P:K+3t CaO	39	33	36	36.00	b	43	33	30	35.33	c
T3	N:P:K+4t CaO	31	40	49	40.00	d	28	37	46	37.00	d
T4	N:P:K+2t CaO+1%CaMg	44	38	46	42.67	f	43	31	37	37.00	d
T5	N:P:K+3t CaO+1%CaMg	46	36	42	41.33	e	43	30	33	35.33	c
T6	N:P:K+4t CaO+1%CaMg	32	44	53	43.00	g	29	41	50	40.00	e
T7	N:P:K+2t CaO+1.5%CaMg	45	41	49	45.00	h	41	42	43	42.00	g
T8	N:P:K+3t CaO+1.5%CaMg	46	43	53	47.33	i	43	40	39	40.67	f
T9	N:P:K+4t CaO+1.5%CaMg	41	54	57	50.67	k	38	40	50	42.67	h

	MEAN Treatment	41.15b	41.08a	47.00c	43.75		37.08b	37.62a	43.15c	39.54	
	Probability	<.001***	<.001***	<.001***			<.001***	<.001***	<.001***		
		VAR	TRT	VAR*TRT			VAR	TRT	VAR*TRT		
	S.E	1.200	2.500	4.300			1.360	2.600	4.720		
	S.E.D	1.700	3.500	6.000			2.013	3.619	6.561		
	LSD	3.300	6.900	11.900			3.300	6.800	11.800		
	%C.V	18.9					12.3				

VAR-Variety; TRT-Treatment; *** Significant at p≤0.001; ** significant at p≤0.01; * significant at p≤0.05; ns- not significant; Different letters within columns indicate statistical significance (P < 0.05)

There was a significant difference (p≤0.05) between Cal-J and Nyati varieties in Chepkoilel, having37.08b and 37.62a flower clusters respectively (Table 4).Riogrande had significantly high (p≤0.05) number of flower clusters among the three tested varieties (Table 4.4). Both varieties, treatments and variety by treatment interaction, had a high significant effect (p≤0.05)on number of flower clusters in Chepkoilel site (Table4).

Number of Fruits in Bungoma and Chepkoilel

Treatment T0 recorded significantly low (p≤0.05) number of fruits amongst the treatments. Treatment T12 had a significant (p≤0.05) effect on the total number of fruits in Bungoma(Table 5).

Variety Riogrande recorded the highest average number of fruits (89.62c fruits) in Bungoma (Table 5). Cal-J variety had the lowest number of fruits (66.00b fruits). Treatments T12, T9 and T11 recorded the highest number of fruits (99.67m, 93.00l and 92.33k fruits) amongst the treatments (Table 5).

Analysis of variance revealed varieties and the thirteen treatments had a high significant effect (p≤0.001) on the resulting number of fruits in Bungoma (Table 5). There was a significant difference (p≤0.05)between Riogrande, Cal-J and Nyati varieties in the number of fruits harvested in Chepkoilel site.

Table 5: Number of fruits in Bungoma and Chepkoilel

		Bungoma					Chepkoilel				
		Tomato Varieties					Tomato Varieties				
	TREATMENT	Cal-J	Nyati	Riogrande	MEAN	$TUKEYS_{(.05)}$	Cal-J	Nyati	Riogrande	MEAN	$TUKEYS_{(.05)}$
T0	N:P:K	38	62	66	55.33	a	51	43	56	50.00	a
T1	N:P:K+2t CaO	52	75	85	70.67	b	64	63	78	68.33	b
T10	N:P:K+2t CaO+2%CaMg	76	91	94	87.00	i	80	89	84	84.33	j
T11	N:P:K+3t CaO+2%CaMg	82	104	91	92.33	k	87	97	95	93.00	l
T12	N:P:K+4t CaO+2%CaMg	86	104	109	99.67	m	96	91	102	96.33	m
T2	N:P:K+3t CaO	56	78	81	71.67	c	69	65	74	69.33	c
T3	N:P:K+4t CaO	63	95	93	83.67	h	83	86	81	83.33	h
T4	N:P:K+2t CaO+1%CaMg	61	82	87	76.67	e	71	73	80	74.67	e
T5	N:P:K+3t CaO+1%CaMg	56	82	82	73.33	d	73	70	75	72.67	d
T6	N:P:K+4t CaO+1%CaMg	77	95	97	89.67	j	78	88	86	84.00	i
T7	N:P:K+2t CaO+1.5%CaMg	68	91	90	83.00	g	70	84	83	79.00	f
T8	N:P:K+3t CaO+1.5%CaMg	62	94	88	81.33	f	82	80	87	83.00	g
T9	N:P:K+4t CaO+1.5%CaMg	81	96	102	93.00	l	84	90	90	88.00	k
	MEAN	66.00a	88.38b	89.62c	81.33		76.00a	78.38b	82.38c	81.74	
	Probability	0.253ns	0.028*	0.713ns			0.085ns	<0.001***	0.569ns		
		VAR	TRT	VAR*TRT			VAR	TRT	VAR*TRT		

	S.E	2.200	4.600	7.900			2.000	4.300	7.400		
	S.E.D	3.100	6.500	11.200			2.900	6.000	10.400		
	LSD	6.100	12.700	22.000			5.700	11.800	20.500		
	%C.V	24.3					18.0				

VAR-Variety; TRT-Treatment; *** Significant at p≤0.001; ** significant at p≤0.01; * significant at p≤0.05; ns- not significant;Different letters within columns indicate statistical significance (P < 0.05)

Treatment T12, T11 and T9 had the highest means of number of fruits (96.33m, 93.00l and 88.00k fruits respectively) in Chepkoilel site (Table 5). Riogrande variety scored the highest means of number of fruits (82.38c) amongst varieties, followed by Nyati (78.38b) and Cal-J (76.00a) (Table 5). Treatment T0 scored significantly low (p≤0.05) number of fruits (50.00a) in Chepkoilel (Table 5).

Analysis of variance showed no significant (p≤0.05) difference between varieties in the number of harvested fruits in Chepkoilel (Table 5). All the tested 13 treatments had a high significant effect (p≤0.05) on number of fruits inChepkoilel site (Table 5).

Tomato Fruit Yield (t/ha) in Bungoma and Chepkoilel

The highest yield in Bungoma was under treatments T12 with a yield of 10.55mt/ha (Table 6). The treatments T11, T10 and T9 recorded a yield of 10.03l, 9.42k and 9.29j t/ha respectively (Table 6). The varieties differed significantly (p≤0.05) in tomato fruit yield levels too. Riogrande recorded the highest yield (8.930c t/ha), followed by Nyati (7.783b t/ha) and Cal-J (7.665a t/ha) (Table 6).

In Bungoma, treatment T0 had a significantly low (p≤0.05) tomato yield in Bungoma, in comparison to the twelve other treatments (Table 6). T0 recorded the lowest mean tomato fruit yield of 4.53a t/ha (Table 6).

Analysis of variance revealed a significant difference (p≤0.05) between the three tested varieties (Table 6). Also, treatment T12 was significantly different (p≤0.05) from all the other treatments in Bungoma, with a yield of 10.551e (Table 6).

Treatments T12, T11 and T10 recorded the highest yield in Chepkoilel, having 9.63m, 9.46l and 8.65k t/ha respectively (Table 6).

Among the varieties tested, Riogrande had a significantly high (p≤0.05) mean tomato fruit yield. This had an average yield of 8.49c t/ha, followed by Nyati (7.23b t/ha) and Cal-J that had the lowest mean (6.31a t/ha) (Table 6).

There was a significant difference (p≤0.05) between the three tested varieties in terms of the yield recorded (Table 6). Cal-J had a significantly low (p≤0.05) yield of 8.490 t/ha (Table 6).

Analysis of variance showed that varieties and treatments had a high significant (p≤0.05) on yield of tomato (Table 6). The interaction of variety and treatments too showed a significant effect (p≤0.05) on tomato yield in Chepkoilel (Table 6).

Table 6: Fruit yield (t/ha) in Bungoma and Chepkoilel

		Bungoma					Chepkoilel				
		Tomato Varieties					Tomato Varieties				
	Treatment	Cal-J	Nyati	Riogrande	MEAN	$Tukeys_{(.05)}$	Cal-J	Nyati	Riogrande	MEAN	$Tukeys_{(.05)}$
T0	N:P:K	4.63	4.31	4.64	4.53	a	2.72	3.18	4.43	3.44	a
T1	N:P:K+2t CaO	5.56	6.85	7.46	6.62	c	3.96	5.13	6.75	5.28	b
T10	N:P:K+2t CaO+2%CaMg	9.04	9.09	10.13	9.42	k	8.10	8.25	9.61	8.65	k
T11	N:P:K+3t CaO+2%CaMg	9.03	9.63	11.43	10.03	l	7.80	9.92	10.65	9.46	l
T12	N:P:K+4t CaO+2%CaMg	8.92	10.93	11.8	10.55	m	8.71	8.80	11.37	9.63	m
T2	N:P:K+3t CaO	6.56	6.03	6.36	6.32	b	5.16	6.17	7.68	6.34	c
T3	N:P:K+4t CaO	7.09	6.67	7.04	6.93	d	5.70	6.49	7.85	6.68	d
T4	N:P:K+2t CaO+1%CaMg	7.52	7.53	9.27	8.11	f	6.63	7.47	7.05	7.05	f
T5	N:P:K+3t CaO+1%CaMg	7.44	6.84	7.7	7.33	e	5.94	7.14	7.80	6.96	e
T6	N:P:K+4t CaO+1%CaMg	8.4	6.95	9.89	8.41	g	6.72	7.78	7.91	7.47	g
T7	N:P:K+2t CaO+1.5%CaMg	8.67	7.74	10.21	8.87	h	6.81	7.91	8.23	7.65	h
T8	N:P:K+3t CaO+1.5%CaMg	7.93	9.87	9.89	9.23	i	6.64	7.55	10.58	8.26	i

T9	N:P:K+4t CaO+1.5%CaMg	8.88	8.73	10.26	9.29	j	7.08	8.24	10.47	8.60	j
	MEAN	7.665a	7.783b	8.930c	8.13		6.31a	7.23b	8.49c	7.34	
	Probability	<0.001***	<0.001***	0.093ns			<0.001***	<0.001***	0.024*		
		VAR	TRT	VAR*TRT			VAR	TRT	VAR*TRT		
	S.E	0.217	0.452	0.784			0.180	0.374	0.648		
	S.E.D	0.307	0.64	1.108			0.254	0.529	0.917		
	LSD	0.605	1.259	2.181			0.500	1.041	1.804		
	%C.V	18.9					16.5				

VAR-Variety; TRT-Treatment; *** Significant at $p \le 0.001$; ** significant at $p \le 0.01$; * significant at $p \le 0.05$; ns- not significant; Different letters within columns indicate statistical significance ($P < 0.05$)

IV. DISCUSSION

Number of Days to 50% Flowering

Treatment T11 led to a reduction in the number of days to 50% flowering in Bungoma. However, treatment T12 (NPK + Soil application of lime (CaO) at 4tons/ha + 2% combination of foliar fertilizer of calcium and magnesium) led to a reduction in the number of days to 50% flowering in Chepkoilel. These treatments meant that there is a possibility of produced tomato flowers and hence fruits, at a minimum number of days to 50% flowering. In comparison to no-lime application (treatment T0), liming had a significant influence on the time of flowering in tomato crops in both Bungoma and Chepkoilel sites. Additionally, foliar application (2% combination of foliar fertilizer of calcium and magnesium) ensured a quick uptake of both calcium and magnesium. The calcium and magnesium uptake of the tomato crop induced and hastened early floral induction. The results are consistent with previous study by Boss et al., (2004) who reported that, nutrients and moisture availability along with variety affects the flowering time of tomatoes.

Similar. Varieties grown differed in number of days to 50% flowering because of their genetic make-up. Tomato is the model of autonomous flowering plants, i.e. plants that do not require particular environments to initiate reproductive structures (Picchioni et al., 2018; Plieth, 2019; Kinet and Peet, 1997).

In a study using tomato, all mutants that were found to be affected in their flowering time are late flowering, with a few early-flowering mutants have been mentioned, but there was no precise description of these plants (Evans, 1993; Kinet and Peet, 1997; Boss et al., 2004). Thus, there is no doubt that the search for genes implicated in the regulation of flowering time in tomato will not only contribute to a better understanding of the mechanisms regulating floral transition in this crop, especially in different varieties. This explains the difference in varieties in number of days to 50% flowering, with Nyati attaining this earlier than Riogrande and Cal-J (Table 2). The different weather pattern is the reason of the difference in the days to 50% flowering, between Chepkoilel which was lowest than in Bungoma.

Number of Flowers

In both sites, plants treated with NPK + Soil application of lime (CaO) at 4tons/ha + 2% combination of foliar fertilizer of calcium and magnesium (T12) resulted into the highest number of flowers. Calcium application resulted into increase in number of flowers in Bungoma as compared to Chepkoilel. The different weather patterns, with Chepkoilel receiving low rainfall in mm could have led to the difference in the total number of flowers. Among varieties, Riogrande stood out from the other two (Nyati and Cal-J) as having the highest number of flowers.

Calcium and magnesium ions play a major role in the regulation of the flowering in tomato plants. The result coincides with findings from *Pharbitis nil* (Friedman *et al*., 1989). Here, it was reported that Ca^{2+} was involved in the photoperiodic flower induction process at different rates in the different species. The research confirms the findings ofPicchioni *et al*., 2018 and Plieth, 2019, who revealed that Ca had a superior effect on plant vegetative characters. Similarly,Barlow et al., (2018) also found that both Magnesium and Calcium enhanced the vegetative growth of plants. Alternatively, Mohammad et al. (2014), revealed that calcium and magnesium had no significant effect on plant vegetative characters. Moreover, Friedman *et al*., (1989) reported that endogenous calcium levels may be a limiting factor to flowering (Friedman *et al*., 1989). This may be related to the difference in the number of flowers between the three varieties tested. The foliar application levels affected the number of flowers, with the highest concentration realizing an increased number of flowers. This is in line with the study by Kobayashi *et al*. (2006), who suggested for the first time that Mg^{2+} plays an important role in flower induction. A higher concentration of calcium and magnesium increased number of flowers in both Bungoma and Chepkoilel. This was evident with 2% combination of foliar fertilizer of calcium and magnesium recording highest number of flowers in combination with other treatments above 1.0% foliar fertilizer concentration. This actually coincides with the findings of Upadhyay and Patra (2011), who reported that the effect of calcium and magnesium to be significantly higher in respect of growth parameters including plant height, number of flowers, width of flower, and fresh weight (g) of flower.

Number of Flower Clusters

Calcium and magnesium application gave the highest means of flower clusters both in Chepkoilel and Bungoma. The increased number of flower clusters above the levels in Chepkoilel site is attributed to the difference in the weather patterns between the two sites . Variety Riogrande had the highest means of flower clusters in both sites. This could be due to the genetic make-up of the variety that was favored in terms of flower cluster development in the two sites. Calcium plus magnesium nutrients played a major role in influencing the flower cluster development. Similar result was also evident from a study by Kobayashi *et al*. (2006) working on magnesium fortified manure effect on tomato. This is evident in the reduced number of flower clusters under the T0 treatment (N: P: K 23:23:23) without lime and foliar application.

Number of Fruits

Calcium and magnesium application resulted into increased number of tomato fruits. Treatments of calcium and magnesium influenced an increase in number of fruits in Chepkoilel and Bungoma. This is in line with studies bySaure, (2015) and, Sjutand Bangerth, (2019) who reported an increase in number of fruits after application of magnesium and copper rich foliar fertilizers on tomato tree. Calcium and magnesium also play a major role in chlorophyll development (Mohammad *et al*., 2014). The increased chlorophyll content in resulting into increased photosynthesis and cell metabolism. This coupled with nutrient uptake from the soil leads to increased plant nutrient content culminating into an increased number of fruits. This enhances good development, including pollen germination and growth of enzyme activators. Lack of calcium and magnesium results to flower abscission leading to poor or less fruit development (Aghofack-Nguemezi*et.;al* 2014).

Tomato Yield

Calcium and magnesium foliar application improved tomato fruit yield in Bungoma and Chepkoilel. This was in comparison between the high yielding treatment verses the lowest yield (Table 6). The treatment realized a change in soil pH, through lime application at 4t/ha. The improved soil pH resulted into improved soil nutrient status, with available phosphorus levels improving. The result is a well-developed plant due to the balanced availability of essential growth nutrients. The good growth and development resulted in a good crop establishment. As calcium and magnesium levels increased through both soil and foliar application improved several growth parameters, and yield definitely improved in Bungoma and Chepkoilel. Regular dose of NPK along with higher dose of Ca and mg as foliar application enhance growth parameters and finally increased yield. The treatment actually increased the physiological relationship between calcium and magnesium while improving the yield (Gillaspy et al.,2016; Barlow et al., 2018; Sjutand Bangerth, 2019; Sperry et al., 2016). Higher yields in both sites were witnessed as a result of calcium and magnesium application.This was consistent with findings of several studies; Rab and Haq (2012), Mohammad et al., (2014),Sjutand Bangerth, (2019) and Sperry et al., 2016), who reported that the application of calcium significantly affected the yield as it increased fruits per plant, fruits per cluster, fruits per plant, and fruit weight. This was also confirmed by Sjutand Bangerth, (2019), whose study revealed the highest fruit weight as a result of Calcium treatment application. However, Chapagain and Wiesman (2004) and Johnstone (2008)reported that there was no significant effect of different treatments of Calcium/Magnesium on fruit yield. Therefore in summary, both Calcium and Magnesium are involved in various cellular functions such as activation of enzymes, photosynthesis and carbohydrate metabolism hence high yields. Their deficiency may lead to poor fruit growth and yield. Different weather conditions, the genetic make-up of the tested varieties among other factors, could have been the ultimate cause for the difference in the tomato yield among the three tested varieties. The difference in the number of fruits among varieties could be attributed to the different genetic make-up of these varieties.

V. CONCLUSION

Calcium foliar feeding provides a fast, on-the-spot supplementary nutrition to ensure high, top quality yields. Preharvest Ca^{2+}/mg^{3+}foliar application at 2% coupled with 4t/ha of lime (CaO) increased number of flowers, flower clusters, number of fruits, and subsequent yields. From this study it can be concluded that Calcium and Magnesium fertilizers play important role in improving growth and yield of tomato crop. It improves tomato growth and development as well as yield. Application of calcium and magnesium fertilizer can increase tomato yield in Chepkoilel and Bungoma area in natural soil and weather conditions.

VI. RECOMMENDATIONS

The study recommends treatment NPK (at 30Kg P/ha) + lime (CaO) at 4tons/ha + 2% combination of foliar fertilizer of calcium and magnesium (Ca^{2+}/Mg^{3+}) for tomato production in Bungoma and Uasin Gishu counties.

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