

Response of tomato (*Solanum lycopersicum* L.) to non-selective herbicides in respect to weed control and yield attributing traits

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Tomato is one of the most important “protective foods” because of its special nutritive value and widespread production. Cultivation of this vegetable during spring-summer season suffers a considerable yield loss due to its competition with a large number of weeds for nutrients, moisture and space. Hand weeding is a common method of weed control adopted by farmers but comparatively this method is costlier and time consuming, whereas use of post emergent herbicides on the other hand keep the hardy uncontrolled weeds under control by arresting their growth through various kinds of deformities in foliage and growing point.

Excel Mera 71 is an ammonium salt of glyphosate 71% SG acts on the enzyme pathway and works by inhibiting the synthesis of amino acids essential for plant life and thus kills the weeds. Glyphosate 41% SL kills weeds slowly over a period of days or weeks because the chemical is transported throughout the plant and decomposes underground roots and rhizomes. However, Paraquat acts in the presence of light to desiccate the green parts of all plants with which it comes into contact. These herbicides are non-selective and to be used very carefully, however, they are very effective for controlling weeds within and between rows to provide good nutrition and water to well spaced tomato crop. Keeping in view of the above, the present investigation was carried out to discern the response of tomato var. *Kashi Vishesh* to various non-selective herbicides in comparison to hand weeding in terms of weed control and morphological and yield attributing characters.

The present investigation was carried out at Horticulture Research Complex, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur during 2011-12. The

experiment was laid out in randomized complete block design with three replications in 9 m² plot size. There were in all nine treatments. The tomato var. *Kashi Vishesh* was transplanted at spacing of 60 cm between and within rows. All other cultural practices were adopted as per the recommendation for tomato made by the Department of Horticulture, JNK.VV, Jabalpur. A dose of 120 kg N, 60 kg P₂O₅ and 80 kg K₂O/ha along with 20 tonnes FYM per hectare was applied. One-third nitrogen and entire quantity of P, K and FYM were applied prior to transplanting. Remaining dose of nitrogen was applied in two splits at 30 and 60 days after transplanting. The crop was sprayed with Chlorpyrifos and Trizophos alternate to keep the crop free from pest during crop growth period. The treatments of herbicidal spray were : T₁ – Excel Mera 71 (Ammonium salt of glyphosate 71% SG) @ 2.5 kg/ha, T₂ - Excel Mera 71 @ 3.0 kg/ha, T₃ - Excel Mera 71 @ 3.5 kg/ha, T₄ - Excel Mera 71 @ 6.0 kg/ha, T₅ - Excel Mera 71 @ 12.0 kg/ha, T₆ – Glyphosate 41% SL @ 3.0 lit/ha, T₇ – Paraquat dichloride 24% SL @ 2.5 lit/ha, T₈ – Hand Weeding at 30 and 60 days after transplanting and T₉ - Control. The herbicide treatments were selected on the basis of occurrence of annual and perennial weeds and were one time applied at 30 days after transplanting by knap-sack sprayer of fixed hood nozzle. The observations for weeds population were recorded before and at 4, 7, 10, 20, 30 and 45 days after herbicidal application by using quadrat of 1 m² size along with dry weight of weeds and weed control efficiency. Simultaneously, morphological and yield characters of tomato viz., plant height, number of primary branches per plant, days taken to first flowering, days taken to 50% flowering, number of fruits/plant, fruit weight, yield/hectare and TSS were also recorded. The statistical analysis of data was performed

as per method described by Panse and Sukhatme (1963).

Weed Density and Dry Weight of Weeds and Weed Control Efficiency:

The present investigation showed prevalence of various weeds in the experimental field of tomato. Perusal of Table 1 shows the prevalence of major weeds belonging to family Cyperaceae, Gramineae, Chenopodiaceae, Papiliniaceae, Euphorbiaceae, Asteraceae and Convolvulaceae. *Melilotus indica* had recorded maximum prevalence with 27.62% followed by *Chenopodium album* and *Cynodon dactylon*. Other weeds such as *Cyperus rotundus*, *Soncus arvensis* and *Phalaris minor* were also showed significant presence in the field. The overall observations showed the prevalence of both monocot and dicot weeds during the cropping season not only affected the growth but also gave significant impact on tomato yield. Such incidence of monocot and dicot weeds was also reported by Ghosh *et al.* (2001) and Patel *et al.* (2004). The application of herbicides had played a significant role in controlling these weeds (Tables 2 and 3). The minimum 25.00, 17.67 and 7.33 weed density of *Melilotus indica* were recorded

in the treatment T₅ Excel Mera 71 (12.0 kg/ha) at 4, 7 and 10 days after application, respectively, followed by T₂ Excel Mera 71 (3.0.kg/ha) at 4 and 7 days after application and T₄ Excel Mera 71 (6.0kg/ha) at 4, 7 and 10 days after application, respectively, as compared to other treatments. However, treatment T₀ (control) exhibited 31.67, 33.33 and 35.33 maximum weed density at 4, 7 and 10 days after application ,respectively. Whereas, the treatment T₈ (hand weeding) was found to have least weed density (0.0, 2.67 and 6.0 at 4, 7 and 10 days after application, respectively). At 20 days after application, the minimum zero weed density was recorded in treatment T₅ (Excel Mera 71 @ 12.0 kg/ha) followed by T₄ (Excel Mera 71 @ 6.0 kg/ha) (7.67), T₃ (Excel Mera 71 @ 3.5 kg/ha) (7.67) and T₂ (Excel Mera 71 @ 3.0 kg/ha) (9.00) as compared to other treatments. While at 45 days after application new weed emergence was seen but did not reach to the critical level. Overall T₄ (Excel Mera 71 @ 6.0 kg/ha) had proven the best with significantly lowest weed density and lowest dry weight (3.33 g/m²) of *Melilotus indica* (Table 4).

Table 1: Population of weeds and their relative percentage

S.No.	Group	Weed species	Weed count/m ²	Relative %
1	Dicot	<i>Melilotus indica</i>	31.70	27.62
2	Dicot	<i>Chenopodium album</i>	27.51	23.97
3	Monocot	<i>Cynodon dactylon</i> Pers.	23.03	20.08
4	Monocot/Dicot	<i>Cyperus rotundus</i> L., <i>Soncus arvensis</i> L. and <i>Phalaris minor</i>	32.52	28.33

Table 2: Effect of application of different herbicides and hand weeding on various weeds density in tomato field

Treatments	Weed density of <i>Melilotus indica</i>							Weed density of <i>Chenopodium album</i>						
	Before	4	7	10	20	30	45	Before	4	7	10	20	30	45
	application	DAA	DAA	DAA	DAA	DAA	DAA	application	DAA	DAA	DAA	DAA	DAA	DAA
T ₁	33.67	32.00	25.33	20.33	15.33	13.00	8.67	28.67	28.00	22.00	15.00	11.00	8.67	9.67
T ₂	31.33	25.33	18.67	13.67	9.00	6.67	3.33	26.67	22.00	15.00	9.67	6.33	4.33	5.33
T ₃	31.67	26.33	19.00	11.33	7.67	4.33	3.67	28.33	24.00	16.00	10.33	7.33	4.00	3.00
T ₄	32.33	28.00	20.67	11.67	7.67	0.00	1.67	28.33	24.33	17.67	11.67	6.00	0.00	2.33
T ₅	30.33	25.00	17.67	7.33	0.00	2.67	7.00	26.00	21.00	13.67	7.00	0.00	0.00	2.33
T ₆	33.33	29.67	23.00	19.00	10.00	0.00	3.00	28.67	24.33	16.67	10.67	6.67	1.67	2.67
T ₇	32.44	26.67	19.33	15.67	11.00	8.33	4.67	25.67	22.00	15.00	10.67	6.67	3.33	6.67
T ₈	30.67	0.00	2.67	6.00	8.67	0.00	6.67	26.33	0.00	1.67	5.33	8.67	0.00	6.00
T ₉	31.67	31.67	33.33	35.33	37.00	38.33	40.33	29.67	29.67	31.00	33.00	35.33	36.00	37.67
SEm±	-	1.14	1.14	1.14	1.06	0.92	1.02	-	1.04	1.17	1.17	1.19	0.95	0.91
C.D. at 5% level	-	3.42	3.43	3.04	3.19	2.77	3.07	-	3.11	3.53	4.30	3.56	2.86	2.74

T₁ Excel Mera 71(2.5kg/ha), T₂ Excel Mera 71(3.0kg/ha), T₃ Excel Mera 71(3.5kg/ha), T₄ Excel Mera 71(6.0kg/ha), T₅ Excel Mera 71(12.0kg/ha), T₆ Glyphosate 41%SL (3 lit/ha), T₇ Paraquat dichloride 24% SL (2.5lit/ha), T₈ Hand weeding and T₉ Control, DAA= Days after application.

Table 3: Effect of application of different herbicides and hand weeding on various weeds density in tomato field

Treatments	Weed density of <i>Cynodon dactylon</i>							Weed density of <i>Cyperus rotundus</i> , <i>Soncus arvensis</i> and <i>Phalaris minor</i>						
	Before	4	7	10	20	30	45	Before	4	7	10	20	30	45
	application	DAA	DAA	DAA	DAA	DAA	DAA	application	DAA	DAA	DAA	DAA	DAADAA	DAA
T ₁	25.67	22.33	18.00	13.00	9.67	7.00	5.00	35.67	33.67	28.67	22.00	18.33	15.00	11.33
T ₂	23.33	18.00	14.00	9.33	6.67	4.33	3.33	34.33	27.67	22.67	17.00	13.67	10.33	7.00
T ₃	24.67	21.67	18.00	12.33	9.33	5.67	3.67	31.00	27.67	22.33	15.67	12.00	9.00	6.67
T ₄	25.33	19.00	14.00	9.00	5.33	0.00	2.00	32.67	29.00	22.67	16.67	12.67	0.00	3.33
T ₅	23.33	18.00	12.00	6.33	0.00	1.33	4.33	34.67	26.00	18.33	12.00	7.00	0.00	4.00
T ₆	24.33	19.67	13.67	9.00	5.67	0.00	1.33	33.67	30.67	23.67	17.00	13.33	9.67	5.33
T ₇	22.67	18.33	11.00	7.33	4.00	2.33	1.67	32.33	25.67	19.33	13.33	10.00	7.00	4.00
T ₈	24.67	0.00	2.33	5.33	8.33	0.00	5.67	34.00	0.00	3.33	6.00	9.67	0.00	8.00
T ₉	26.00	26.33	27.33	29.33	32.00	33.00	33.67	35.00	36.00	38.00	39.00	40.00	41.00	41.67
SEm±	-	0.80	0.70	0.70	0.70	0.67	0.70	-	1.14	1.19	1.14	1.01	1.02	0.87
C.D. at 5%	-	2.41	2.11	2.08	2.12	2.02	2.11	-	3.42	3.58	3.43	3.05	3.07	2.62

T₁ Excel Mera 71(2.5kg/ha), T₂ Excel Mera 71(3.0kg/ha), T₃ Excel Mera 71(3.5kg/ha), T₄ Excel Mera 71(6.0kg/ha), T₅ Excel Mera 71(12.0kg/ha), T₆ Glyphosate 41%SL (3 lit/ha), T₇ Paraquat dichloride 24% SL (2.5lit/ha), T₈ Hand weeding and T₉ Control, DAA= Days after application.

Table 4: Effect of application of different herbicides and hand weeding on dry weight of various weeds (g/m²) and weed control efficiency

Treatments	Dry weight of <i>Melilotus indica</i> (g/m ²)		Dry weight of <i>Chenopodium album</i> (g/m ²)		Dry weight of <i>Cynodon dactylon</i> (g/m ²)		Dry weight of <i>Cyperus rotundus</i> , <i>Soncus arvensis</i> and <i>Phalaris minor</i>		Weed control efficiency (%)
	Before	45	Before	45	Before	45	Before	45	
	application	DAA	application	DAA	application	DAA	application	DAA	
T ₁	63.00	16.33	56.00	13.00	45.00	11.00	66.33	22.67	43.81
T ₂	49.00	7.33	45.33	6.67	37.00	6.33	58.33	15.00	57.90
T ₃	52.33	7.67	48.33	5.33	42.67	7.67	56.33	13.33	56.77
T ₄	55.67	3.33	47.33	3.67	38.33	4.00	57.00	7.00	60.10
T ₅	53.00	14.67	44.67	5.00	36.67	8.67	52.00	8.00	65.18
T ₆	58.00	6.67	49.00	5.67	40.33	2.33	61.00	10.33	56.61
T ₇	51.00	9.33	43.00	13.67	31.33	3.00	51.00	8.33	61.52
T ₈	60.00	13.33	48.67	11.67	37.67	11.33	68.33	15.33	78.95
T ₉	63.33	79.67	60.00	74.67	55.33	67.00	70.33	82.67	-
SEm±	2.18	2.15	1.92	1.84	1.65	1.54	1.98	1.68	-
C.D. at 5% level	6.54	6.45	5.78	5.52	4.96	4.63	5.95	5.03	-

T₁ Excel Mera 71(2.5kg/ha), T₂ Excel Mera 71(3.0kg/ha), T₃ Excel Mera 71(3.5kg/ha), T₄ Excel Mera 71(6.0kg/ha), T₅ Excel Mera 71(12.0kg/ha), T₆ Glyphosate 41%SL (3 lit/ha), T₇ Paraquat dichloride 24% SL (2.5lit/ha), T₈ Hand weeding and T₉ Control, DAA= Days after application.

Weed density of *Chenopodium album* also showed the similar trend. As after the application of herbicides, weed density was getting at minimum side. The treatment T₅ Excel Mera 71 (12.0 kg/ha) reduced the weed density to zero level at even 20 days after application followed by

T₄ Excel Mera 71 (6.0kg/ha) at 30 days after application (Table 2). Dry weight of *Chenopodium album* was lowest in treatment T₄ (3.67 g/m²) followed by T₅ (5.00 g/m²) (Table 4). Similar trend was again observed in weed density of *Cynodon dactylon*, where treatment T₅ showed

no weed at 20 days after application and treatment T₄ and T₆ showed no weed at 30 days after treatment (Table 3). The dry weight of *Cynodon dactylon* was also found lowest in treatment T₄ followed by T₆ (Table 4). Remaining weeds *Cyperus rotundus*, *Soncus arvensis* and *Phalaris minor* were also completely killed at 30 days after application in treatments T₄ and T₅ (Table 3). The dry weight of the weeds was also lowest in these treatments (Table 4). The maximum weed control efficiency of 65.18% was exhibited by treatment T₅ (Excel Mera 71 @12.0 kg/ha), followed by T₇ (Paraquat dichloride 24% SL @2.5 lit/ha) (61.52 %) and T₄ (Excel Mera 71 @ 6.0 kg/ha) (60.10 %). Treatment T₈ (hand weeding) recorded maximum (78.95 %) weed control efficiency (Table 4). Among all treatments, Excel Mera 71% SL @ 6 kg/ha (T₄) performance was superior. However, hand weeding (T₈) at 30 days after transplanting of tomato and again at 30 days after the first hand weeding made the field almost free from weeds thus resulted better control. Birgani *et al.* (2010) also reported the similar findings where post plant incorporation of herbicide reduced the number of weeds by 69% in tomato. The dry weight of weeds was also drastically reduced when observed at 45 days after application of herbicide. The dry weight of weeds is real indicator of any control measures adopted. The present results corroborated with the findings of Singh and Tripathi (1990) who studied the effects of herbicides on okra and associated weeds.

Plant Growth and Fruit Yield of Tomato: The morphological characters of tomato as influenced by various herbicides application are presented in Table 5. The treatment T₈ (hand weeding) had recorded maximum

plant height (66.07 cm) followed by T₄ (62.93 cm) and T₅ (61.80 cm), while minimum plant height (55.73 cm) was observed in treatment T₉ (Weedy check, control). The maximum number of primary branches per plant (10.13) was recorded under the treatment T₈ (hand weeding), which was closely followed by T₄ (Excel Mera 71, 6.0 kg/ha) and T₅ (Excel Mera 71, 12 kg/ha), whereas treatment T₉ (Weedy check, control) had shown minimum (8.30) primary branches per plant. Similarly, early days to 50 per cent flowering (58.33 days) was recorded under treatment, T₈ (hand weeding) followed by T₄ (Excel mera 71, 6.0 kg/ha) and T₅ (Excel mera 71, 12.0 kg/ha), while it was recorded late (61.67 days) in treatment T₉ (Weedy check, control).

On perusal of Table 5, it could be observed that number of fruits per plant was significantly maximum (38.80 fruits) in treatment T₈ (hand weeding) followed by T₄ (Excel Mera 71, 6.0 kg/ha) (35.67 fruits) and T₅ (Excel Mera 71, 12.0 kg/ha) (34.47 fruits per plant), while it was noticed minimum (22.97 fruit per plant) in treatment T₉ (weedy check, control). The fruit weight was found maximum (44.33 g) under the treatment T₈ (hand weeding), however, statistically it was at par to T₄ (Excel Mera 71, 6.0 kg/ha) (42.0 g). The minimum fruit weight (38.33 g) was recorded under the treatment T₉ (weedy check, control). Maximum (3.8⁰ Brix) TSS was measured under the treatments T₂, T₃ and T₈, while it was minimum (3.4⁰ Brix) in treatments T₆ and T₇. The fruit yield per plant was also significantly influenced by the different treatments. Treatment T₈ (hand weeding) exhibited maximum (1080.80 g) fruit yield per plant followed by T₄ (Excel Mera 71,6.0 kg/ha) (865.10 g /plant) and T₅ (Excel

Table 5: Effect of application of different herbicides and hand weeding on morphological characters of tomato

Treatments	Plant height	Primary branches per plant	Days to 1 st flowering	Days to 50% flowering	No. of fruits/plant	Fruit yield per plant (g)	Fruit yield per hectare (q)	TSS (°Brix)
T ₁ Excel Mera 71(2.5kg/ha)	56.60	8.27	51.40	61.00	25.37	695.90	231.88	3.5
T ₂ Excel Mera 71(3.0kg/ha)	58.47	8.40	51.20	60.33	25.53	700.40	232.55	3.8
T ₃ Excel Mera 71(3.5kg/ha)	58.73	8.83	49.80	60.33	25.07	722.90	240.77	3.8
T ₄ Excel Mera 71(6.0kg/ha)	62.93	9.87	46.27	58.33	35.67	865.10	288.10	3.6
T ₅ Excel Mera 71(12.0kg/ha)	61.80	9.80	48.27	58.33	34.47	855.05	284.97	3.7
T ₆ Glyphosate 41%SL (3 lit/ha)	59.47	8.87	49.40	59.33	26.07	755.05	250.66	3.4
T ₇ Paraquat dichloride 24% SL (2.5lit/ha)	61.13	9.33	48.80	60.33	24.37	760.65	254.55	3.4
T ₈ Hand weeding	66.07	10.13	44.53	58.33	38.80	1080.80	310.58	3.8
T ₉ Control	55.73	8.30	51.67	61.67	22.97	690.40	190.44	3.6
SEM±	0.24	0.26	0.36	0.30	1.137	9.34	3.44	0.25
C.D. at 5% level	0.72	0.20	1.08	0.91	3.41	28.02	10.32	-

Mera 71, 12.0 kg/ha) (855.05 g /plant), while minimum fruit yield/plant of 690.40 g /plant was obtained in treatment T₀ (weedy check, control). The maximum fruit yield (310.58 q/ha) was recorded in treatment T₈ (hand weeding) followed by T₄ (Excel Mera 71, 6.0 kg/ha) (288.10 q/ha) and T₅ (Excel Mera 71, 12.0 kg/ha) (284.97 q/ha), whereas the treatment T₉ (weedy check, control) had shown minimum fruit yield (190.44 q/ha). Santos *et al.* (2007) and Birgani *et al.* (2010) also observed the profitable control of weeds and increase in fruit yield of tomato with the application of pre-emergence, post-emergence herbicides and hand weeding operations.

On the basis of present findings it could be concluded that application of herbicides had significant impact on tomato growth and fruit yield parameters. The Excel Mera 71%SL @ 6 kg/ha not only gave the early flowering but had also significantly improved plant height, number of primary branches, number of fruits and fruit yield as compared to other herbicides. Nevertheless, 2 times hand weeding showed highest plant growth and fruit yield indicated that due to hand weeding there was no plant-weed competition and thus gave the best results. While herbicides killed weeds slowly and thereby, it showed some plant-weed competition.

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