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Krishnaveni A
Department of Environmental Sciences, Agricultural College and Research Institute, Vazhavachanur, Tamil Nadu, India

C Sivakumar
Department of Agronomy, Agricultural College and Research Institute, Vazhavachanur, Tamil Nadu, India

N Tamilselvan
Department of Agronomy, Agricultural College and Research Institute, Vazhavachanur, Tamil Nadu, India

MN Budhar
Professor and Head, Regional Research Station, Paiyur, Tamil Nadu Agricultural University Tamil Nadu, India

M Pandiyan
Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Vazhavachanur, Tamil Nadu, India

Corresponding Author:
Krishnaveni A
Department of Environmental Sciences, Agricultural College and Research Institute, Vazhavachanur, Tamil Nadu, India

Effect of non-chemical and chemical method of weed management in tomato (*Lycopersicon esculentum* L.)

Krishnaveni A, C Sivakumar, N Tamilselvan, MN Budhar and M Pandiyan

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Abstract
The effective and eco-friendly way of weed management in tomato is essential for safer produce and clean environment. Accordingly, the experiment was conducted with chemical and non-chemical methods of weed management in tomato. The experiment consisted of nine treatments viz., four herbicides with and without hand weeding on 45 DAT viz., pendimethalin 1.00kg a.i. ha^{-1}, oxyflourfen 0.125kg a.i./ha, metribuzin 0.50kg a.i. ha^{-1}, fluchloralin 1.00kg a.i. ha^{-1} compared against non-chemical methods viz., the black polythene mulch (8µ) was laid out at one day before transplanting, manual weeding and weedy check (control).Different weed control treatments significantly influenced the mean fruit yield. The yield increase in pre-emergence application of herbicide, pre emergence application of herbicide followed by hand weeding (IWM), polythene mulching, and twice manual weeding on 25 and 45 DAT were 45.8%, 75.8, 140.6 and 66.5% over weedy check. Thus, the polythene mulching was better than other methods of weed control. The maximum fruit yield of 24.78 t ha-^{1} was recorded under polythene mulching. The integrated weed management (IWM) involving pre emergence application of herbicide followed by hand weeding resulted in higher tomato yield of 18.32 t ha-^{1} than pre emergence application of herbicide, manual weeding and weedy check. The non-chemical like black polythene mulching resulted the higher net income of Rs.88258 ha-^{1} with BC ratio of 3.48 than other weed control methods. Hence, black polythene mulching may be recommended for effective control of weeds besides improving the fruit yield of tomato. In the absence of black polythene mulch due to non-availability, the integrated weed management practice of pre emergence application of herbicides followed by hand weeding on 45 DAT found to be better than other weed control measures.

Keywords: Tomato, weed control methods, polythene mulch, pre emergence herbicides, yield attributes, yield, economics

Introduction
Tomato is a prime and essential vegetable for cooking with high minerals, antioxidants, vitamins C, E and red pigmented proteins like lycopene, carotenoids and also constitutes the medicinal properties for cancer and cardiovascular due to its phenolic compounds (Adalid *et al*., 2004) [1]. It is one of most important and largest vegetable crop grown in three seasons at north western agro climatic zone of Tamil Nadu. Among the biological constraints, weed interference is the most serious problem in the successful cultivation and to achieve potential yield of tomato. The weed species reduces the yield of the main crop through competition for nutrients, sunlight, water and space, which ultimately reduces the growth and development of standing crop and also reduces the yield (Abbasi *et al.*, 2013) [2]. The favorable weather conditions, wider spacing, frequent irrigations, excess fertilizers and also the ineffective weed management operations promote the luxuriant growth of weeds. The weed competition reduces the yield to the tune of 42 to 71 per cent when weeds compete with the crop from 15 to 45 days after transplanting. To avoid the wasteful loss, control of weeds in time is imperative. Although manual weeding controls the weeds effectively, it is difficult, time consuming and costly. There are safe and non-phototoxic herbicides available for tomato. Singh and Tripathi (1988) [3] found that pre and post emergence application of metribuzin @0.35 and 0.50kg ai/ha respectively produced the tomato yield on par with hand weeding. Govindra *et al*., (1986) [4] reported that the yield reduction was 57% reduction in tomato crop due to weed density in control when compared one hand weeding followed by herbicide application in tomato.

Walker and Buchanan (1982) [5] reported that the approach like integrated weed management system using chemical and non-chemical or cultural weed control give efficient weed control and crop yield compared to either chemical or non-chemical alone. Marana *et al*., (1986) [6] found that the weeds reduced fruit yield by 70 per cent based on the stage and duration of weed competition and critical period of weed competition to be 30-40 days after sowing and first four weeks Shad bolt & Holm (1956) [7]. The herbicides have the potential for 100 per cent controlling of weeds in the field. But, they are expensive and require particular device for spray. Mulching is new and important non-chemical weed management method for crops. Mulches cover the soil surface with which creates high biological activity and also conserve the soil moisture. The mulching process increases high temperature in the soil, which favors root development and also earlier crop harvest (Lament 1993) [8]. Cerdeira *et al.* (2012) [9] reported that live plant mulches has the allelopathic potential in managing the weeds. The soil structure, organic matter, mineral, soil bioactivity and yields were improved due to straw mulching. Further, the sawdust, rice straw and cogon grass mulching reduced the weed populations in organic farming system Abouziena *et al*. 2008 [10]; Sinkeviciviene *et al*. 2009 [11]; and Coolong 2012 [12] The weeding by conventional manual is very effective, but time consuming, expensive, and also injuries o crop roots (Khurana *et al*. 1993) [13]. Hence, weed control is one of the puissant factors in the productivity of tomato. In recent years, due to weed shift in all types of lands and soils, a complex of weeds poses the problem from transplanting to harvest. Therefore, the present investigation was undertaken with a view to evaluate the performance of chemical and non-chemical methods of weed control on yield and economics in tomato.

Materials and Methods

Field experiments were conducted at Regional Research Station (TNAU), Paiyur-635 112, Krishnagiri, and Tamil Nadu under irrigated condition in tomato (PKM 1) in randomized block design with three replications. The soil was sandy loam, haring N: 182kg ha^{-1}P: 15kg ha^{-1} and K: 254kg ha^{-1} with pH 7.2. The experiment consisted of nine treatments viz., chemical method of weed control by pre emergence application of herbicides alone and with hand weeding on 45 DAT through pendimethalin 1.00kg ai ha^{-1} (T_1, T_5), oxyflurofen 0.125kg ai ha^{-1} (T_2, T_6), metribuzin 0.50kg ai/ha (T_3, T_7) and fluchloralin 1.00kg ai ha^{-1} (T_4, T_8) compared against non-chemical methods viz., black polythene mulch (8µ) (T9), manual weeding on 25 and 45 DAT (T_{10}) and weedy check (control-T_{11}). The pre emergence herbicides were sprayed on 3 DAT and the spacing adopted was 60 x 45 cm. The black polythene mulch (8µ) was laid out at one day before transplanting and the tomato seedlings were planted by making holes in the polythene sheet at 60 x 45cm apart.

Treatment Details

S. No.	Treatment details
T2	Oxyflourfen 0.125 kg a.i./ha
T3	Metribuzin 0.50 kg a.i./ha
T4	Fluchloralin 1.00 kg a.i./ha
T5	Pendimethalin 1.00 kg a.i./ha fb hand weeding on 45 DAT
T6	Oxyflourfen 0.125 kg a.i./ha fb hand weeding on 45 DAT
T7	Metribuzin 0.50 kg a.i./ha fb hand weeding on 45 DAT
T8	Fluchloralin 1.00 kg a.i./ha fb hand weeding on 45 DAT
T9	Black polythene mulch 50µ
T10	Hand weeding twice (25 and 45 DAT)
T11	Unweeded control

Details of the variety

Variety	PKM-1 (Periyakulam)
Spacing (cm)	60 x 45cm
Plot size (m)	2.40 x 5.85
Design	RBD
Replicate	Three

The edges of polythene sheet were held on the bunds of each plot with soil. The recommended fertilizer @150:100:50kg NPK $ha^{-1}$was applied as urea (46% N), single super phosphate (16%) and muriate of potash (60% k) in all treatments except in polythene mulch plot, the full dose of phosphorus and potassium was applied as basal at the time of transplanting. Nitrogen was applied in two splits viz., 50% at the time of transplanting and remaining dose at 25 DAT. The full dose of all fertilizes were applied basally before the spread of polythene mulch. The rainfall received from planting to flowering in second and third experiment was excess which affected the crop growth and ultimately led to poor yield. The data recorded on weed population and dry weight have been transformed using log values and analyzed.

Results and Discussion

Weed flora (per cent)

The major weed flora of the experimental site included sedges viz., *Cyperus rotundus* (44.9%), broad leaved weeds viz., *Parthenium hysterophorus* (23.0%), *Portulaca oleraceae* (8.0%), *Trianthema portulacastrum* (5.3%), *Amaranthus viridis* (0.8%), *Boerhaiva diffusa* (0.6%) and grassy weeds viz., *Dactyloctenium aegyptium* (6.4%), *Brachiaria mutica* (3.0%) *Chloris barbata* (1.3%), and *Euphorbia geniculata* (0.1%) was the most problematic.

Weed population ($m^{-2)}$ and dry weight

Application of herbicides with and without hand weeding and mulching of black polythene sheet significantly reduced the weed population and dry weight over the weedy check and hand weeding twice in all the stages of crop growth (Table.1). Black polythene mulch had resulted in minimum weed number and weed dry weight at all the stages of observation. The black polythene mulch suppressed the weed growth due to prevention of sunlight to reach the soil surface to cause emergence and growth of weeds. Thus, the weed population and weed dry weight was minimum in black polythene mulched plots at 25, 45 and 70 days after transplanting. The lower weed dry weight

recorded due to few numbers of weeds might be due to emergence of these weeds through the planting holes of tomato seedlings.

Likewise, the pre emergence application of herbicides viz., pendimethalin 1.00kg ai/ha, oryflourfen 0.125kg ai/ha, metribuzin 0.50kg ai/ha and fluchloratin 1.00kg ai/ha also resulted in lower weed population and biomass at 25 DAT compared to hand weeding at 25 DAT and weedy check. This might be due to the inhibition of weed seed germination by herbicidal action. The hand weeding twice at 25 and 45 DAT recorded higher number of weeds and biomass at 25 DAT compared to 45 and 70 DAT. This is due to weeding done at 25 and 45 DAT resulted in less weed free environment for 20 days interval till the next weeding done at 45 DAT compared to pre emergence application of herbicides alone and weedy check. The weed population and dry weight of weeds was lesser at 70 DAT in the pre emergence application of herbicides followed by hand weeding at 45 DAT and hand weeding twice at 25 and 45 DAT compared to pre emergence application of herbicides alone. This is due to less weed free environment from transplanting to 70 DAT created by herbicidal action and manual weeding reported that weed density was very low in black plastic mulched plots similar to that of hand weeding**.** Monks *et al.,* (1997) [14] also reported in the similar way that the some mulches hand weeding resulted effective weed control in crops.

Table 1: Weed population and dry weight at different growth stages of tomato as influenced by weed control treatments in tomato

Treatment	First experiment (Jan-May, 2013)						Second experiment (July-Dec 2014)						Third experiment (Jan-May, 2015)					
	Weed population (No/sqm)			Weed dry weight (g/sqm)			Weed population (No/sqm)			Weed dry weight (g/sqm)			Weed population (No/sqm)			Weed dry weight (g/sqm)		
	25 DAT	45 DAT	70 DAT	25 DAT	45 DAT	70 DAT	25 DAT	45 DAT	70 DAT	25 DAT	45 DAT	70 DAT	25 DAT	45 DAT	70 DAT	25 DAT	45 DAT	70 DAT
T_1	87.3 (1.937)	121.3 (2.071)	144.7 (2.153)	12.80 (1.094)	21.2 (1.323)	27.7 (1.436)	78.7 (1.890)	143.3 (2.154)	180.7 (2.167)	47.12 (1.550)	172.6 (2.234)	184.3 (2.265)	43.3 (1.625)	66.0 (1.753)	74.0 (1.856)	10.88 (1.034)	35.6 (1.462)	41.6 (1.527)
T_2	91.3 (1.941)	108.0 (2.009)	121.3 (2.070)	15.67 (1.078)	21.7 (1.272)	30.0 (1.416)	71.3 (1.844)	140.7 (2.139)	175.3 (2.243)	49.56 (1.580)	178.9 (2.248)	204.0 (2.280)	54.7 (1.729)	65.3 (1.793)	71.3 (1.846)	13.86 (1.085)	33.9 (1.448)	47.4 (1.404)
T_3	79.3 (1.878)	118.7 (2.069)	132.0 (2.118)	13.27 (0.920)	19.1 (1.183)	28.7 (1.379)	76.0 (1.878)	156.0 (2.185)	176.0 (2.237)	40.69 (1.554)	167.6 (2.220)	186.4 (2.256)	54.7 (1.725)	61.3 (1.768)	73.3 (1.855)	13.96 (1.083)	42.8 (1.473)	43.6 (1.623)
T_4	78.0 (1.848)	113.3 (2.046)	129.0 (2.106)	13.47 (1.104)	23.2 (1.321)	29.8 (1.436)	80.3 (1.903)	155.3 (2.189)	171.3 (2.215)	44.47 (1.624)	169.7 (2.214)	201.8 (2.304)	56.7 (1.737)	69.3 (1.828)	78.7 (1.884)	13.17 (1.113)	42.1 (1.539)	45.1 (1.635)
T_5	97.3 (1.971)	114.0 (2.056)	58.0 (1.751)	16.33 (1.173)	27.7 (1.424)	3.9 (0.530)	88.7 (1.942)	148.7 (2.161)	106.7 (2.026)	47.14 (1.609)	148.5 (2.166)	77.9 (1.881)	50.0 (1.699)	69.3 (1.834)	64.0 (1.804)	15.25 (1.156)	39.1 (1.481)	22.3 (1.331)
T_6	86.7 (1.931)	117.3 (2.061)	70.0 (1.836)	18.00 (1.110)	27.1 (1.367)	4.3 (0.590)	82.7 (1.902)	153.3 (2.164)	111.3 (2.042)	40.25 (1.575)	179.0 (2.193)	89.0 (1.931)	67.3 (1.826)	67.3 (1.817)	63.3 (1.791)	16.24 (1.210)	38.8 (1.588)	25.2 (1.302)
T_7	79.3 (1.898)	106.7 (2.028)	66.7 (1.821)	10.07 (0.987)	18.9 (1.264)	4.9 (0.652)	85.3 (1.900)	164.7 (2.162)	118.7 (2.072)	40.17 (1.603)	154.5 (2.187)	87.7 (1.909)	60.7 (1.782)	60.0 (1.777)	62.7 (1.780)	14.78 (1.165)	32.5 (1.503)	20.2 (1.269)
T_8	93.3 (1.957)	115.3 (2.062)	72.7 (1.859)	10.87 (1.030)	14.3 (1.153)	5.7 (0.734)	83.3 (1.865)	153.3 (2.154)	109.3 (2.028)	44.80 (1.649)	161.0 (2.206)	91.4 (1.925)	68.7 (1.836)	68.0 (1.832)	52.0 (1.692)	15.09 (1.176)	40.7 (1.585)	26.3 (1.345)
T_9	8.7 (0.884)	13.3 (1.111)	19.0 (1.270)	0.03 (-1.59)	0.70 (-0.14)	2.1 (0.313)	4.3 (0.619)	11.3 (1.043)	12.0 (1.062)	0.11 (0.000)	1.6 (0.202)	2.0 (0.307)	9.0 (0.937)	12.0 (1.075)	18.0 (1.253)	0.07 (-1.180)	1.0 (0.008)	2.1 (0.312)
T_{10}	127.3 (2.087)	31.3 (1.492)	43.3 (1.616)	23.73 (1.373)	2.5 (0.395)	16.0 (1.179)	92.7 (1.965)	99.3 (1.994)	90.0 (1.948)	60.78 (1.771)	110.0 (1.912)	68.6 (1.823)	98.7 (1.971)	86.0 (1.908)	62.0 (1.772)	17.95 (1.223)	59.3 (1.735)	50.4 (1.697)
T_{11}	144.7 (2.156)	172.0 (2.233)	222.0 (2.343)	30.93 (1.489)	41.7 (1.620)	21.2 (1.298)	127.3 (2.104)	224.7 (2.349)	247.0 (2.387)	65.76 (1.811)	183.0 (2.258)	224.7 (2.351)	121.3 (2.080)	133.3 (2.125)	149.3 (2.162)	26.80 (1.410)	85.4 (1.929)	103.3 (2.009)
CD 5%	39.5 (0.209)	40.5 (0.170)	38.9 (0.180)	11.5 (0.419)	11.8 (0.287)	16.3 (0.403)	37.9 (0.192)	65.2 (0.205)	94.6 (0.240)	27.9 (0.326)	78.7 (0.307)	65.9 (0.209)	29.3 (0.189)	37.0 (0.243)	34.2 (0.203)	9.5 (0.295)	36.0 (0.414)	38.8 (0.452)

Figures in parentheses are log transformed values DAT: Days after transplanting, fb: followed by

Fruit number

The different weed control treatments had significantly influenced the fruit number in all experiments (Table. 2). The maximum number of fruits per plant was observed in black polythene mulching. Pre emergence application of herbicides followed by hand weeding (IWM) and hand weeding twice were enhanced the fruits number per plant than pre emergence application of herbicides alone. Higher number of fruits in black polythene mulch, hand weeding twice and pre emergence application of herbicides followed by hand weeding were due to better utilization of nutrients, moisture and sunlight by the tomato plants due to lower weed crop competition. Severe weed infestation under unweeded control smothered the crop by depriving the light source and suppressed growth and yield parameters of the crop. Continuous shading of the crop by higher weed population suppressed the tomato growth. Kandasamy (2000) [15]. Reported that black polythene mulch effectively reduced the weed growth and improved the fruit numbers and yield of tomato.

Fruit yield

Application of herbicide, hand weeding twice and black polythene mulching significantly influenced the fruit yield over the weedy check. Maximum fruit yield of 40.19, 12.90 and 21.24 t ha^{-1} in three seasons respectively) was recorded under black polythene mulching. This might be due to temperature in activation of weed seeds by continuous higher soil temperature and weakening of existing vegetative propagates which lead to better weed control and reduction of their number and dry weight. Also, it regulated the micro climate and altered the plant-root environment which facilitated improved nutrient uptake of crop and resulted in increased yield attributes (fruit number) and yield. In all three experiments integrated weed management of herbicide application followed by hand weeding and hand weeding twice resulted in higher tomato yield than pre emergence application of herbicide alone. This is due to effective inhibition of weed seed germination and limited growth of early emerged weeds as well as inhibition of regeneration of vegetative propagated weeds at the early and later stages of crop growth which reduced the crop weed competition which resulted for better yield. The weeds in weedy check caused poor crop growth and lowest yield of 15.13 t ha^{-1}, 5.93 and 9.04 t ha^{-1} in three seasons respectively. Single plant yield was always decreased due to weed plant densities (Mudarres *et al*., 1998) [16] and also less row spacing in crops (Sobkowicz & Tendziagolska, 2005) [17].

In general, weed control treatment increased the fruit yield to the tune of 50 to 166, 30 to 118.1 and 33 to 135% in first,

second and third experiment respectively over weedy check. Black polythene mulching, hand weeding twice, integrated weed management (herbicide +hand weeding) and herbicide application alone increased the fruit yield by 165.7, 96.0, and 80.4 to 97.6 and 50.2 to 56.4%, 117.5, 71.8 to 92.2%, 64.7% and 30.3 to 64.4% 134.9, 33.2, 56.3 to 74.3 and 33.3 to 53.8% in first, second and third experiment respectively over weedy plots. The mean fruit yield in each replication for three experiments were analyzed statistically and the results were presented in Table.2. The methods of weed control viz., chemical control, black polythene mulching and hand weeding had marked increase in yield over weedy check. The yield increase in chemical control viz., pre-emergence application of herbicide, pre emergence application of herbicide followed by hand weeding (IWM), polythene mulching, hand weeding twice were 45.8%, 75.8, 140.6 and 66.5% over weedy check. Thus, the polythene mulching was better than other methods of weed control. Yield losses in crops occur due to biomass and density of weeds (Mamolos & Kalburtji, 2001) [18].

The maximum fruit yield of 24.78 ha^{-1} was recorded under polythene mulching. Integrated weed management involving pre emergence application of herbicide followed by hand weeding resulted in higher tomato yield (17.60 to 18.32 t ha^{-1}) than pre emergence application of herbicide, hand weeding and weedy check. However, hand weeding twice (17.15 t ha^{-1}) and pre emergence application of herbicide resulted in 14.79 to 15.15 t ha^{-1} increased the yield over weedy check (10.03 t ha^{-1}). In general, no marked difference was recorded among the difference herbicides used. The mean yield increased by the application of herbicide through pre or post emergence with pendimethalin, oxyflurofen, metribuzin and fluchloralin were 16.69 t ha^{-1}, 16.31, 16.72, and 16.52 t ha^{-1} respectively. Thus, all the herbicides proved equally good in controlling the weeds. The weed population has limited availability of soil resources to the crops which ultimately lowered the fruit yields in spite in less row spaced crops (Sobkowicz & Tendziagolska, 2005) [19] and rice straw mulches increased the fruit numbers (Awodoyin *et al*. 2007) [20]

In general, the methods of weed control viz., chemical control; black polythene mulching and hand weeding had marked increase in yield over weedy check. The yield increase in chemical control viz., pre-emergence application of herbicide, post emergence application of herbicide followed by hand weeding (IWM), polythene mulching, hand weeding twice were 45.8%, 75.8, 140.6 and 66.5% over weedy check. Thus, the polythene mulching was better than other methods of weed control (Table -3).

Different weed control treatments significantly influenced the fruit yield significantly higher fruit yield (24.78 t/ha) was recorded under polythene mulching. This might be due to temperature inactivation of weed seeds by continuous higher soil temperature and weakening of existing vegetative propagates which lead to better weed control and reduction of their number and dry weight. Also, it regulated the micro climate and altered the plant-root environment which facilitated improved nutrient uptake of crop and resulted in increased yield attributes and yield. Integrated weed management involving pre emergence application of herbicide followed by hand weeding resulted in higher tomato yield (17.60 to 18.32 t/ha) than pre emergence application of herbicide, hand weeding and weedy check. This is due to effective inhibition of weed seed germination and limited growth of early emerged weeds as well as inhibition of regeneration of vegetative propagated weeds at the early and later stages of crop growth which reduced the crop weed competition and better yield. However, hand weeding twice (17.15 t/ha) and pre emergence application of herbicide (14.79 to 15.15 t/ha) increased the yield over weedy check (10.03 t/ha).

Table 2: Yield attributes, yield and economics of tomato (PKM 1) as influenced by weed control treatments

Treatment	First experiment (Jan-May, 2007)				Second experiment (Jul -Dec, 2007)				Third experiment (Jan-May, 2008)				Pooled analysis		
	Fruits/ plant (No)	Fruit yield t/ha	Net income (Rs/ha)	BC ratio	Fruits/ plant (No)	Fruit yield t/ha	Net income (Rs/ha)	BC ratio	Fruits/ plant (No)	Fruit yield t/ha	Net income (Rs/ha)	BC ratio	Fruit yield t/ha	Net income (Rs/ha)	BC ratio
T1	17.1	23.66	83806	3.43	7.3	9.75	41269	2.20	10.47	12.05	25758	1.75	15.15	41269	2.20
T2	17.6	23.42	82951	3.43	6.9	9.33	40896	2.20	10.46	12.28	27241	1.80	15.01	40896	2.20
T3	17.6	22.91	80319	3.35	6.7	8.98	41381	2.21	10.69	13.48	33168	1.97	15.12	41381	2.21
T4	17.5	22.72	79447	3.33	6.0	7.73	39783	2.16	10.71	13.91	35406	2.04	14.79	39783	2.16
T5	20.0	28.37	106358	4.00	8.7	10.53	55626	2.57	11.71	15.76	43335	2.22	18.22	55626	2.57
T6	20.7	27.29	101300	3.88	8.2	11.40	52867	2.50	11.05	14.13	35477	2.01	17.60	52867	2.50
T7	22.7	29.90	114288	4.24	8.1	10.30	56385	2.60	11.87	14.77	38602	2.10	18.32	56385	2.60
T8	21.4	29.38	111745	4.18	8.1	10.19	56024	2.59	12.04	15.14	40520	2.15	18.24	56024	2.59
T9	28.2	40.19	165328	5.64	11.0	12.90	88258	3.48	15.13	21.24	70568	2.98	24.78	88258	3.48
T10	21.3	29.65	113071	4.22	7.9	9.77	50583	2.44	9.99	12.04	25018	1.71	17.15	50583	2.44
T11	14.1	15.13	42461	2.28	4.3	5.93	16983	1.51	7.53	9.04	12013	1.36	10.03	16983	1.51
CD 5%	5.49	5.73	NA	NA	2.2	2.80	NA	NA	2.57	4.36	NA	NA	2.76	NA	NA

Table 3: Influence of weed control treatments on yield of tomato (pooled analysis).

Tr. No	Treatment details	Fruit yield t/ha
T1	Pendimethalin 1.00kg a.i./ha	15.15
T2	Oxyflourfen 0.125kg a.i./ha	15.01
T3	Metribuzin 0.50kg a.i./ha	15.12
T4	Fluchloralin 1.00kg a.i./ha	14.79
T5	Pendimethalin 1.00kg a.i./ha fb hand weeding on 45 DAT	18.22
T6	Oxyflourfen 0.125kg a.i./ha fb hand weeding on 45 DAT	17.60
T7	Metribuzin 0.50kg a.i./ha fb hand weeding on 45 DAT	18.32
T8	Fluchloralin 1.00kg a.i./ha fb hand weeding on 45 DAT	18.24
T9	Black polythene mulch 50µ	24.78
T10	Hand weeding twice (25 and 45 DAT)	17.15
T11	Unweeded control	10.03
	CD 5%	2.76

In general, no marked difference was recorded among the different herbicides used. The mean fruit yield increase by the pre emergence application of herbicide with pendimethalin, oxyflurofen, metribuzin and fluchloralin were 16.69 t/ha, 16.31, 16.72, and 16.52 t/ha respectively. Thus, all the herbicides proved equally good in controlling the weeds

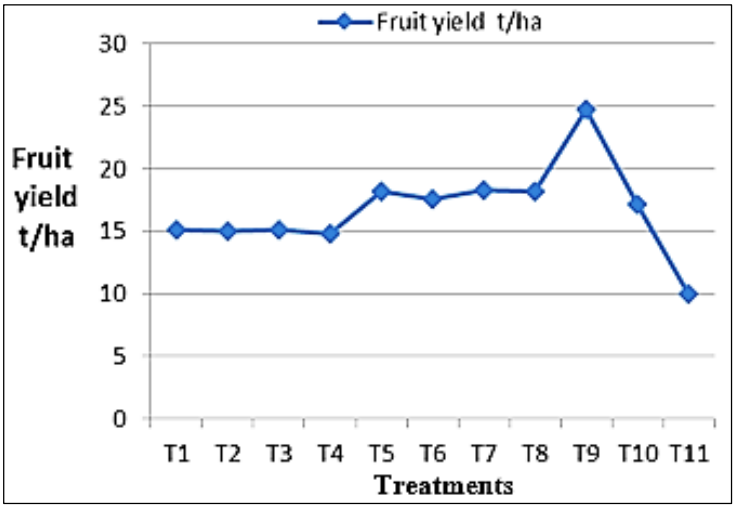

Fig 1: Influence of weed control treatments on yield of tomato (pooled analysis).

Effect of treatments on Economics (Table 4)

Different weed control methods had marked influence on cost of cultivation, net income and BC ratio. The black polythene mulching (50µ/8µ) found to realize higher net income and BC ratio than other weed control treatments. Thus, black polythene mulching resulted in higher net income (Rs.88258/ha) and BC ratio (3.48) than pre or post emergence application of herbicides and hand weeding. The next best method of weed control was integrated weed management constituting pre emergence application of herbicides followed by hand weeding on 45 DAT which resulted higher net income (Rs.52867 to Rs.56385) and BC ratio (2.50 to 2.60) than pre emergence application of herbicide (Rs.39783 to Rs.41381/ha with 2.16 to 2.21) and hand weeding (Rs.50583/ha with 2.44). Among the herbicides, difference in net income and BC ratio was little and all the herbicides proved to be the best in realizing the high profitability. However, metribuzin 0.50kg ai/ha resulted higher mean net income and BC ratio (Rs.48888/ha and 2.41) followed by pendimethalin 1.00kg ai/ha (Rs.48848/ha and 2.39), fluchloralin 1.00kg ai/ha (Rs.479041/ha and 2.38) and oxyflunfen 0.125kg ai/ha (Rs.46902/ha and 2.35).

Table 4: Gross income, net income and BC ratio as influenced by weed control treatments in irrigated tomato (PKM 1) (Pooled analysis).

Tr. No	Treatment details	Gross income RS/ha	Net income RS/ha	BC ratio
T1	Pendimethalin 1.00kg a.i./ha	75756	41269	2.20
T2	Oxyflourfen 0.125kg a.i./ha	75051	40896	2.20
T3	Metribuzin 0.50kg a.i./ha	75616	41381	2.21
T4	Fluchloralin 1.00kg a.i./ha	73940	39783	2.16
T5	Pendimethalin 1.00kg a.i./ha fb hand weeding on 45 DAT	91113	55626	2.57
T6	Oxyflourfen 0.125kg a.i./ha fb hand weeding on 45 DAT	88022	52867	2.50
T7	Metribuzin 0.50 kg a.i./ha fb hand weeding on 45 DAT	91620	56385	2.60
T8	Fluchloralin 1.00 kg a.i./ha fb hand weeding on 45 DAT	91181	56024	2.59
T9	Black polythene mulch 50µ	123875	88258	3.48
T10	Hand weeding twice (25 and 45 DAT)	85750	50583	2.44
T11	Unweeded control	50150	16983	1.51
	CD 5%	NA	NA	NA

Cost of produces

Black polythene sheet Rs/Kg	100	Pendimethalin Rs/Lit	400
Tomato fruits average price Rs/Kg	5	Oxyflurofen Rs/Lit	1856
N Rs/Kg	11.96	Metribuzin Rs/Kg	1500
P Rs/Kg	25.00	Flucholralin Rs/Lit	450
K Rs/Kg	8.33		

Summary

- Number of fruits per plant was higher in black polythene mulching followed by integrated weed management of application of herbicides followed by hand weeding than other weed control methods. The mean yield increase in chemical control viz., pre-emergence application of herbicide, pre emergence application of herbicide followed by hand weeding (IWM), polythene mulching, hand weeding twice were 45.8%, 75.8, 140.6 and 66.5% over weedy check. Thus, the polythene mulching was better than other methods of weed control. Higher mean fruit yield (24.78 t/ha) was recorded under polythene mulching. Integrated weed management involving pre emergence application of herbicide followed by hand weeding resulted in higher tomato yield (17.60 to 18.32 t/ha) than pre emergence application of herbicide, hand weeding and weedy check.
- No marked difference was recorded among the different herbicides used. The mean yield increase by the application of herbicide through pre emergence or pre emergence with pendimethalin, oxyflurofen, metribuzin and fluchloralin were 16.69 t/ha, 16.31, 16.72, 16.52 t/ha respectively. Thus, all the herbicides proved equally good in controlling the weeds. Black polythene mulching resulted higher net income (Rs.88, 258/ha) and BC ratio (3.48) than pre emergence application of herbicides and hand weeding. The next best method of weed control was integrated weed management constituting pre emergence application of herbicides followed by hand weeding on 45 DAT which resulted higher net income (Rs.52,867 to Rs.56385) and BC ratio (2.50 to 2.60). Black polythene mulching effectively reduced the weed growth and improved the crop growth, yield parameters and fruit yield of tomato (PKM 1). Considering the economic indices (net income and BC ratio), black polythene mulching followed by integrated weed management practices of pre emergence application of herbicides followed by one hand weeding found to be better than other weed control methods due to better weed control at relatively lower cost of cultivation and better fruit yield. Though black polythene mulching resulted in best weed control and recorded higher yield, the higher initial cost can be alleviated due to absence of hoeing and weeding, no application cost for top dressing the fertilizers. Thus, it may prove useful for hi-tech and export oriented tomato production. No marked differences were recorded in terms of yield and income due to different herbicides used. However, on the basis of little differences in net income, the recommendation may be followed in the order of metribuzin or pendimethalin or fluchloralin or oxflurofen. Though no study was made on the impact of thickness of polythene sheet on growth and yield, the lower (8μ) and higher thickness (50μ) are suitable for first (kharif) and second (Rabi) seasons respectively for better establishment and higher stand.

Conclusion

The tomato crop is an economical crop and also widely adopted by farmers due to its short duration and economical value in offseason time. There are many methods for controlling the weeds in tomato crops. But, the physical method like mulching with the black polythene sheet was found to better in weed control and shown the maximum fruit yield compared to chemical treatments and also no residual effect like phytotoxicity to the plants. The integrated weed management treatments resulted better fruit yield than the single herbicide alone. The black polythene mulching (50μ/8μ) may be recommended for irrigated tomato for effective control of weeds besides improving the yield attributes and fruit yield of tomato. In the absence of black polythene mulch, the integrated weed management practice of pre emergence application of herbicides viz., Metribuzin 0.50 kg a.i./ha or Pendimethalin 1.00 kg a.i./ha, or Fluchloralin 1.00 kg a.i./ha or Oxyflourfen 0.125 kg a.i./ha, followed by hand weeding on 45 DAT found to be better than other weed control measures for better weed control and fruit yield of tomato. The result indicated that the most cost effective method of weed management was mulching with black polythene sheets before transplanting the seedlings in the main field. The tomato farmers should be encouraged to the ecofriendly ways of weed management practice like mulching with plant residues, dried grass, and black polythene sheets are very effective to cut down on the cost of cultivation of crop and also to get toxic free produce. Application of herbicide alone is not recommended to the crop because it pollutes the soil. In another way, the herbicide treated plots should be combined with manual weeding and mulching to make favorable conditions for crop growth and development with higher yield.

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