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Weed parameters and weed indices as influenced by different weed management practices in *Bt* cotton

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Abstract
A field experiment was conducted during *kharif* seasons of 2022-23 and 2023-24 at college farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat). The soils of experimental unit were clay in texture. The data was analyzed using standard statistical techniques. Among different weed management practices, the minimum grass, sedge and broad-leaved weed density were recorded under Weed free check (HW at 20, 40 and 60 DAS) (T_9) followed by Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) during both years and pooled analysis. Similarly, Weed free check (HW at 20, 40 and 60 DAS) (T_9) was recorded minimum total weed density and weed dry weight. Whereas, higher weed control efficiency and lowest weed index were noticed under Weed free check (HW at 20, 40 and 60 DAS) (T_9). Nevertheless, herbicide efficiency index, weed management index, agronomic management index and integrated weed management index were recorded highest under Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) followed by Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3).

Keywords: Weed free check, Weed control efficiency, Herbicide efficiency index, Weed management index, Agronomic management index and Integrated weed management index

1. Introduction
Cotton (*Gossypium hirsutum* L.) is an important commercial fiber crop belonging to Malvaceae family grown under diverse conditions around the world. Cotton is popularly known as 'White gold' or 'King of fiber crops'. It is cultivated in tropical and sub-tropical regions in seventy-seven countries across the globe and one hundred five countries consume cotton. It provides main raw material for textile industry. Cotton is the most important global cash crop and controls economy of many nations. It provides gainful employment to several million people. Cotton textile industries are the engines of economic growth in both developed and developing countries. Fiber, food, feed, industrial products, and livelihood for a huge portion of population are some of the salient utilities of cotton crop. The seed oil of cotton is good for food and cosmetics. It is profitable for coffee filters, oil, plastics and rubber (Ayyadurai *et al*., 2013) [2].
Worldwide, cotton is cultivated over an area of about 32.41 million hectares with production and productivity of 24.51 million metric tonnes and 756 kg/ha, respectively. Among the major cotton exporting countries in the world, India occupied the fourth position with 0.51 million metric tonnes (USA-2.30 million metric tonnes, Brazil-1.97 million metric tonnes, CFA Zone-0.97 million metric tonnes). According to estimates of 2022-23, cotton occupied an area of 130.61 lakh hectares producing 311 lakh bales with a productivity of 447 kg/ha productivity (Anon., 2023) [1]. In India, there are nine major cotton growing states which fall under three zones *viz.*, the North Zone (Punjab, Haryana and Rajasthan), the Central Zone (Maharashtra, Madhya Pradesh and Gujarat), and the Southern Zone (Andhra Pradesh, Karnataka and Tamil Nadu). Among the states in India, Maharashtra ranks first in total area, whereas production and productivity are highest in Gujarat. Cotton cultivation in Gujarat covered an area of 25.49 lakh hectares with 87.12 lakh bales total production with a productivity of 581 kg/ha during 2022-23 (Anon., 2023) [1]. The important cotton growing districts in Gujarat are Amreli, Surendranagar, Rajkot, Bhavnagar, Morbi, Jamnagar, Botad, Ahmedabad, Bharuch, Vadodara and Chhota

Udepur. Cotton is a widely spaced and relatively slow growing crop during its early stages of growth and development, therefore, weeds can directly hinder cotton growth by competing for available resources such as solar radiation, moisture and nutrient uptake and may be releasing allelopathic or growth-suppressing chemicals. Weeds cause huge losses in cotton yield to the tune of 60% (Moolchand *et al*., 2012) [11]. The duration of weed presence with the crop and the time of weed emergence, generally affect weed-crop competition. The critical period of crop-weed competition occurs when both the weeds and crop are in the same vegetate stage of growth (Spasova *et al*., 2008) [19]. Weeds compete with crops for natural and applied resources besides being responsible for reducing quantity and quality of agricultural productivity (Rao *et al.*, 2015) [16]. However, the degree of damage through competition of weeds is related to the types of weed flora, densities and duration of weed-cotton competition.

In crops like cotton, weeds flourish even after critical period of crop weed competition due to longer crop duration and slow initial growth where it is difficult to achieve effective weed control with single application of herbicides (pre-emergence or post-emergence). Hence, in order to control weeds for a longer period of crop growth there is need to apply herbicides on sequential basis. Recent studies conducted by many workers clearly indicated that sequential application of herbicides will provide consistent weed control than single application (Singh *et al*., 2004) [18]. However, herbicides need to be matched with the weed problem for effective control. When chemical weed control is adopted with precision, it is more efficient, economical and controls the target plants without toxicity to the crop and man. Pre-emergence application controls the weeds either during their germination or immediately after germination. The use of pre-emergence herbicides requires sufficient moisture to controls weeds and it has a great future for irrigated cotton in India. The use of post-emergence herbicides in cotton can help to overcome the weed problems at later stages of crop growth. Hence, sequential application of different herbicides with different mode of action can be an option for long lasting weed control. Keeping this in view, the present experiment was carried out with the objective to weed parameters and weed indices as influenced by different weed management practices in *Bt* cotton

2. Materials and Methods

A field experiment was conducted during *kharif* seasons of 2022-23 and 2023-24 at college farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat). The soils of experimental unit were clay in texture, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium with slightly alkaline in reaction with normal electric conductivity. *Bt* cotton variety G.CO. Hy-10 (BG II) was sown with seed rate of 2.5 kg/ha. The seeds were sown manually with spacing of 120×45 cm.

The experiment consisted of twelve treatments laid out in a randomized block design with three replications and the treatments include *viz.*, T_1: Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS, T_2: Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS, T_3: Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS, T_4: Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS, T_5: Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS, T_6: Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS, T_7: Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS, T_8: Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS, T_9: Weed free check (HW at 20, 40 and 60 DAS) and T_{10}: Weedy check. Pre-emergence herbicides were applied within in 24 hours after sowing. Post-emergence herbicide was sprayed at 2-3 leaf stage of weeds with knapsack sprayer by using flat fan nozzle. Band application of herbicides were sprayed in between rows of crops. Sunnhemp crop sown along with crop and incorporated. The observations were noticed on density of grass, sedges and broad leaved weeds, total weed density, weed dry weight and weed indices *i.e.*, WCE, WI, HEI, WMI, AMI and IWMI. The number of weeds were counted. Data (weed density and weed dry weight) is presented per m^2 and subjected to statistical analysis after square root transformation with the following formula.

$$X = \sqrt{(x + 1)}$$

Where, X = transformed value.
x = original value.

$$WCE = \frac{WD_C \quad WD_T}{WD_C} \times 100$$

Where, WD_C = Dry matter production of weeds in unweeded control (g/m^2).
WD_T = Dry matter production of weeds in treatment (g/m^2).

$$WI = \frac{X - Y}{X} \times 100$$

Where, X = Yield from best treatment.
Y = Yield from the treatment for which weed index is to be worked.

$$HEI/TEI = \frac{Y_T - Y_C}{Y_T} \times \frac{WDM_C}{WDM_T}$$

Where, Y_T = Crop yield from treated plot WDMc = Weed dry matter in control.
Y_C = Crop yield from control plot WDM_T = Weed dry matter in treatment.

$$WMI = \frac{\text{Percent crop yield over control}}{\text{Percent control of weeds}}$$

$$AMI = \frac{\text{Percent crop yield over control} - \text{Percent control of weeds}}{\text{Percent control of weeds}}$$

$$IWMI = \frac{WMI - AMI}{2}$$

Where, WMI = Weed management index.
AMI = Agronomic management index.

3. Results and Discussion

3.1 Effect on species wise weed density

The data pertaining to species wise weed density (No./m^2) are furnished in Table 1 and graphically depicted in Fig 1.

The minimum grass weed density of 3.10/m^2 (2022-23), 3.16/m^2 (2023-24) and 3.13/m^2 (pooled) was recorded under Weed free check (HW at 20, 40 and 60 DAS) (T_9) followed by Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) (3.59, 3.74 and 3.67/m^2 during 2022-23, 2023-24 and in pooled analysis, respectively). The treatment Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) was at par with Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3) and Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2). Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4), Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5) and Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_6) these were at par with one another. These treatments followed by Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7) and it was at par with Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8). Weedy check (T_{10}) registered significantly higher grass weed density of 9.14/m^2, 12.71/m^2 and 11.07/m^2 during 2022-23, 2023-24 and in pooled analysis, respectively. Similar pattern of results was observed at harvest. Similar findings were noticed by Mahar *et al*. (2007) [8], Thorat *et al*. (2007) [21] and Patel *et al*. (2013) [14].

Similarly, lower sedge weed density of 1.60/m^2 (2022-23), 1.98/m^2 (2022-23) and 1.80/m^2 (pooled analysis) was recorded under Weed free check (HW at 20, 40 and 60 DAS) (T_9), which was followed by Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) and it was at par with Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3), Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2). Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4), Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5) and Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_6) were at par with one another. Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7) and Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8) were recorded significantly higher sedge weed density compared to other weed management practices. However, it was less compared to Weedy check (T_{10}) (6.24/m^2, 7.39/m^2 and 6.84/m^2 during 2022-23, 2023-24 and in pooled analysis, respectively). These results are corroborating the earlier findings of Ikram *et al*. (2012) [23], Patel *et al*. (2013) [14] and Veeraputhiran and Srinivasan (2015) [22].

However, Weed free check (HW at 20, 40 and 60 DAS) (T_9) observed significantly lower broad leaved weed density of 3.69/m^2 (2022-23), 3.82/m^2 (2023-24) and 3.75 /m^2 (pooled analysis). It was followed by Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) (4.27/m^2, 4.48/m^2 and 4.38/m^2 during 2022-23, 2023-24 and in pooled analysis, respectively), which was at par with Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3), Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2). Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4) was at par with Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5) and Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_6). These treatments followed by Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7) and Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8). Significantly higher broad leaved weed density *i.e.*, 12.69/m^2 (2022-23), 13.31/m^2 (2023-24) and 13.01/m^2 (pooled analysis) was recorded under Weedy check (T_{10}). These results were coincided with Malarkodi (2017) [9] and Tariq *et al.* (2018) [20].

3.2 Effect on total weed density (No./m^2)

The data pertaining to total weed density (No./m^2) are furnished in Table 2 and graphically depicted in 2. Weed free check (HW at 20, 40 and 60 DAS) (T_9) was registered significantly lower total weed density of 4.88/m^2 (2022-23), 5.15/m^2 (2023-24) and 5.01/m^2 (pooled analysis). Among the herbicidal treatments, Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) (5.92/m^2, 6.18/m^2 and 6.05/m^2 during 2022-23, 2023-24 and in pooled analysis, respectively) was best treatment, which was statistically at par with Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3), Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2) during both the years and in pooled analysis. These were followed by Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4), it was at par with Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5) and Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_6). Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7) and Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8) were lower weed density as compared to Weedy check (T_{10}) (16.78/m^2, 19.78/m^2 and 18.34/m^2 during 2022-23, 2023-24 and in pooled analysis, respectively). Effective control of weeds by different weed management practices at critical period of crop-weed competition led to lower total weed density. Similar results were reported by Prabhu *et al*. (2011) [15], Chetan (2013) [3], Nalini *et al*. (2013) [12] and Hariharasudhan *et al.* (2017) [5].

3.3 Effect on weed dry weight

The data pertaining to weed dry weight are furnished in Table 2 and graphically depicted in Fig 2. Different weed management practices significantly influenced weed dry weight in *Bt* cotton during both the years and in pooled analysis.

Significantly lower weed dry weight of 4.50 g/m^2 (2022-23), 4.64 g/m^2 (2023-24) and 4.57 g/m^2 (pooled) was observed under Weed free check (HW at 20, 40 and 60 DAS) (T_9). Among the herbicidal treatments, Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) *i.e.,* 5.30, 5.45 and 5.37 g/m^2 during 2022-23, 2023-24 and in pooled analysis, respectively was superior, which was found to be at par with Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3) and Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2) during both the years and in pooled analysis. These were

followed by Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4), it was at par with Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5) and Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_6). Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7) and Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8) were at par with one another. Higher weed dry weight *i.e.*, 13.42 g/m^2 (2022-23), 13.60 g/m^2 (2023-24) and 13.51 g/m^2 (pooled) was registered under Weedy check (T_{10}). These finding are in accordance with the earlier findings of Malik *et al.* (2012) [10], Hiremath *et al.* (2013a) [6] and Singh and Paikra (2014) [17] who also reported significantly lower weed dry weight under different weed management practices in *Bt* cotton.

3.4 Effect on weed indices

A perusal of data presented in Table 3 and depicted in Fig 2 revealed that Weed free check (HW at 20, 40 and 60 DAS) (T_9) was registered higher weed control efficiency *i.e.*, 89.25% (2022-23) and 88.86% (2023-24). This was followed by Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) > Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3) > Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2) > Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4) > Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5) > Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS(T_6) > Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7) > Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8).

The weed index is derived by comparing the yields of the treated and weed-free plots, resulting in a loss in crop production due to the presence of weeds in contrast to weed-free treatment, allowing the efficiency of the treatment to be assessed. Data pertained to weed index presented in Table 3. And graphically depicted in Fig. 3. Lowest weed index of 8.97 (2022-23) and 9.26 (2023-24) was noticed with Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1). This was followed by Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3), Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2), Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4), Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5), Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS(T_6), Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7), Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8). Highest weed index was recorded under Weedy check (T_{10}) (51.19 and 51.98 during 2022-23 and 2023-24, respectively). Lower weed index might be due to lower weed population and dry weight of weeds and high weed control efficiency which led to higher yield. These results are in accordance with Kurlekar and Khapse (1979) [9], Chinnusamy *et al.* (2013) [4] and Kalaisudarson and Srinivasaperumal (2019) and Nandagavi and Halikatti (2021) [13].

Data on herbicide efficiency index at various crop intervals was presented in Table 3 and clearly indicated that numerically highest treatment efficiency index was noticed under Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) (5.72 and 5.71 during 2022-23 and 2023-24, respectively). This was followed by Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3), Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2), Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4), Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5), Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS(T_6), Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7) and Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8).

The data pertaining to weed management index are furnished in Table 4. Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) of 1.02 (2022-23) and 1.05 (2023-24) was recorded higher weed management index. Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3) was next best treatment (0.92 and 0.91 during 2022-23 and 2023-24, respectively).This was followed by Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2), Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4), Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5), Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS(T_6), Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7). Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8) was recorded lower weed management index (0.43 and 0.43 during 2022-23 and 2023-24, respectively).

The data pertaining to agronomic management index are furnished in Table 4. Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) *i.e.*, -0.83 (2022-23) and -0.80 (2023-24) was recorded highest agronomic management index. Next effective treatment was Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3) (-0.83 and -0.85 during 2022-23 and 2023-24, respectively).This was followed by Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2), Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4), Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5), Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS(T_6), Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7). Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8) was recorded lowest agronomic management index (-1.05 and -1.05 during 2022-23 and 2023-24, respectively).

Data on integrated weed management index was presented in Table 4 and clearly indicated that Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) of 0.09 (2022-23) and 0.13 (2023-24) was recorded higher integrated weed management index. Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3) was next best treatment (0.02 and 0.01 during 2022-23 and 2023-24, respectively).This was followed by Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS (T_2), Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS (T_4), Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_5), Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS (T_6), Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS (T_7). Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS (T_8) recorded lower integrated weed management index (-0.31 and 0-0.31 during 2022-23 and 2023-24, respectively).

4. Conclusion

From above results and discussion, it could be concluded that, minimum weed density and weed dry weight were recorded under Weed free check (HW at 20, 40 and 60 DAS) (T_9) followed by Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1). At all stages of crop, higher weed density was registered under Weedy check (T_{10}).

Similarly, Weed free check (HW at 20, 40 and 60 DAS) (T_9) was recorded highest weed control efficiency followed by Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) and lowest weed index was noticed with Weed free check (HW at 20, 40 and 60 DAS) (T_9) followed by Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1). Weedy check (T_{10}) was recorded highest during both the years of experimentation.

Herbicide efficiency index, Weed management index, Agronomic management index and integrated weed management index were recorded highest under Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS (T_1) followed by Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS (T_3).

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Table 1: Density of different weed flora (No./m^2) as influenced by weed management practices in *Bt* cotton

Treatments		Density of grass weeds			Density of sedge weeds			Density of broad-leaved weeds		
		2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
T_1: Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS		3.59 (11.89)	3.74 (12.99)	3.67 (12.44)	2.43 (4.92)	2.47 (5.12)	2.45 (5.02)	4.27 (17.23)	4.48 (19.10)	4.38 (18.17)
T_2: Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS		3.85 (13.79)	3.98 (14.81)	3.91 (14.30)	2.71 (6.35)	2.76 (6.64)	2.74 (6.50)	4.50 (19.23)	4.84 (22.38)	4.67 (20.81)
T_3: Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS		3.73 (12.91)	3.87 (13.98)	3.80 (13.45)	2.54 (5.45)	2.75 (6.57)	2.65 (6.01)	4.35 (17.96)	4.62 (20.35)	4.49 (19.16)
T_4: Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS		4.34 (17.80)	4.53 (19.54)	4.44 (18.67)	3.47 (11.02)	3.23 (9.41)	3.35 (10.21)	5.08 (24.85)	5.54 (29.66)	5.32 (27.26)
T_5: Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS		4.42 (18.57)	4.62 (20.38)	4.52 (19.48)	3.70 (12.67)	3.34 (10.18)	3.52 (11.42)	5.32 (27.35)	5.68 (31.32)	5.51 (29.34)
T_6: Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS		4.52 (19.45)	4.91 (23.15)	4.72 (21.30)	4.01 (15.06)	3.47 (11.02)	3.75 (13.04)	5.71 (31.58)	5.92 (34.04)	5.81 (32.81)
T_7: Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS		5.00 (23.99)	5.51 (29.38)	5.26 (26.69)	5.27 (26.78)	3.90 (14.17)	4.63 (20.48)	6.25 (38.12)	6.58 (42.24)	6.42 (40.18)
T_8: Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS		5.07 (24.67)	5.62 (30.56)	5.35 (27.62)	5.33 (27.38)	3.96 (14.64)	4.69 (21.01)	6.43 (40.33)	6.79 (45.09)	6.61 (42.71)
T_9: Weed free check (HW at 20, 40 and 60 DAS)		3.10 (8.64)	3.16 (9.02)	3.13 (8.83)	1.60 (1.57)	1.98 (2.93)	1.80 (2.25)	3.69 (12.58)	3.82 (13.56)	3.75 (13.07)
T_{10}: Weedy check		9.14 (82.61)	12.71 (160.56)	11.07 (121.59)	6.24 (37.94)	7.39 (53.54)	6.84 (45.74)	12.69 (160.05)	13.31 (176.25)	13.01 (168.15)
SEm±		0.14	0.18	0.17	0.21	0.11	0.20	0.17	0.20	0.19
CD (P=0.05)		0.42	0.52	0.50	0.64	0.34	0.60	0.50	0.59	0.58
CV (%)		5.20	5.72	5.50	9.91	5.53	8.14	5.00	5.54	5.29
Year	SEm±	0.04			0.05			0.05		
	CD (P=0.05)	NS			NS			NS		
Interaction (Y x T)	SEm±	0.14			0.17			0.16		
	CD (P=0.05)	NS			NS			NS		

Table 2: Total weed density (No./m^2) and weed dry weight (g/m^2) as influenced by weed management practices in *Bt* cotton

Treatments		Total weed density (No./m^2)			Weed dry weight (g/m^2)		
		2022	2023	Pooled	2022	2023	Pooled
T_1: Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS		5.92 (34.04)	6.18 (37.20)	6.05 (35.62)	5.30 (27.09)	5.45 (28.69)	5.37 (27.89)
T_2: Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS		6.35 (39.37)	6.70 (43.83)	6.53 (41.60)	5.86 (33.34)	5.94 (34.33)	5.90 (33.84)
T_3: Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS		6.11 (36.33)	6.47 (40.91)	6.29 (38.62)	5.52 (29.47)	5.74 (31.90)	5.63 (30.68)
T_4: Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS		7.39 (53.68)	7.72 (58.60)	7.56 (56.14)	6.61 (42.69)	6.75 (44.60)	6.68 (43.65)
T_5: Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS		7.72 (58.59)	7.93 (61.88)	7.83 (60.24)	6.72 (44.16)	6.84 (45.73)	6.78 (44.94)
T_6: Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS		8.19 (66.09	8.32 (68.21)	8.26 (67.15)	6.85 (45.92)	6.99 (47.93)	6.92 (46.92)
T_7: Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS		9.48 (88.89)	9.32 (85.79)	9.40 (87.34)	7.61 (56.91)	7.79 (59.69)	7.70 (58.30)
T_8: Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS		9.66 (92.38)	9.55 (90.29)	9.61 (91.34)	7.75 (59.06)	7.87 (60.95)	7.81 (60.01)
T_9: Weed free check (HW at 20, 40 and 60 DAS)		4.88 (22.79)	5.15 (25.51)	5.01 (24.15)	4.50 (19.25)	4.64 (20.50	4.57 (19.88)
T_{10}: Weedy check		16.78 (280.60)	19.78 (390.36)	18.34 (335.48)	13.42 (179.10)	13.60 (184.09)	13.51 (181.60)
SEm±		0.30	0.32	0.28	0.24	0.25	0.23
CD (P=0.05)		0.90	0.95	0.85	0.70	0.75	0.69
CV (%)		6.28	6.33	6.31	5.81	6.10	5.96
Year	SEm±	0.08			0.07		
	CD (P=0.05)	NS			NS		
Interaction (Y x T)	SEm±	0.26			0.21		
	CD (P=0.05)	NS			NS		

Table 3: Weed indices as influenced by weed management practices in *Bt* cotton

Treatments	WCE (%)		WI		HEI	
	2022	2023	2022	2023	2022	2023
T_1: Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS	84.87	84.42	8.97	9.26	5.72	5.71
T_2: Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS	81.39	81.35	14.47	16.29	4.04	3.98
T_3: Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS	83.55	82.67	10.12	13.38	5.11	4.64
T_4: Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop- ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS	76.16	75.77	23.90	25.02	2.35	2.32
T_5: Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS	75.34	75.16	24.24	25.71	2.24	2.20
T_6: Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS	74.36	73.97	27.43	28.06	1.90	1.91
T_7: Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS	68.22	67.58	36.32	37.15	0.96	0.95
T_8: Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS	67.02	66.89	37.10	38.20	0.88	0.87
T_9: Weed free check (HW at 20, 40 and 60 DAS)	89.25	88.86	0.00	0.00	-	-
T_{10}: Weedy check	0.00	0.00	51.19	51.98	-	-

WCE: Weed Control Efficiency, **WI:** Weed Index, **HEI:** Herbicide Efficiency Index

Table 4: Weed indices as influenced by weed management practices in *Bt* cotton

Treatments	WMI		AMI		IWMI	
	2022	2023	2022	2023	2022	2023
T_1: Pendimethalin 30 EC 1000 g/ha PE *fb* HW at 30 and 60 DAS	1.02	1.05	-0.83	-0.80	0.09	0.13
T_2: Pendimethalin 38.7 CS 1000 g/ha PPI *fb* HW at 30 and 60 DAS	0.92	0.91	-0.88	-0.88	0.02	0.01
T_3: Pyrithiobac sodium 10 EC 75 g/ha PE *fb* HW at 30 and 60 DAS	1.01	0.97	-0.83	-0.85	0.09	0.06
T_4: Pendimethalin 30 EC 1000 g/ha PE *fb* Pyrithiobac sodium + Quizalofop- ethyl 10 MEC (Premix) 125 g/ha at 30 DAS *fb* HW at 60 DAS	0.73	0.74	-0.96	-0.95	-0.12	-0.11
T_5: Pendimethalin 30 EC 1000 g/ha PE *fb* Paraquat dichloride 24% SL 500 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS	0.73	0.73	-0.95	-0.96	-0.11	-0.11
T_6: Pendimethalin 30 EC 1000 g/ha PE *fb* Glufosinate ammonium 13.5% SL 450 g/ha PoE (directed spray) + HW in row at 30 and 60 DAS	0.65	0.67	-1.00	-0.98	-0.17	-0.15
T_7: Pyrithiobac sodium + Quizalofop-ethyl 10 MEC (Premix) 125 g/ha at 20 DAS *fb* HW at 40 DAS	0.45	0.46	-1.06	-1.04	-0.31	-0.29
T_8: Pendimethalin 30 EC 1000 g/ha PE (band application) + Sunnhemp as smother crop (inter-row) harvested and mulched at 35-40 DAS	0.43	0.43	-1.05	-1.05	-0.31	-0.31
T_9: Weed free check (HW at 20, 40 and 60 DAS)	-	-	-	-	-	-
T_{10}: Weedy check	-	-	-	-	-	-

WMI: Weed Management Index, **AMI:** Agronomic Management Index, **IWMI:** Integrated Weed Management Index

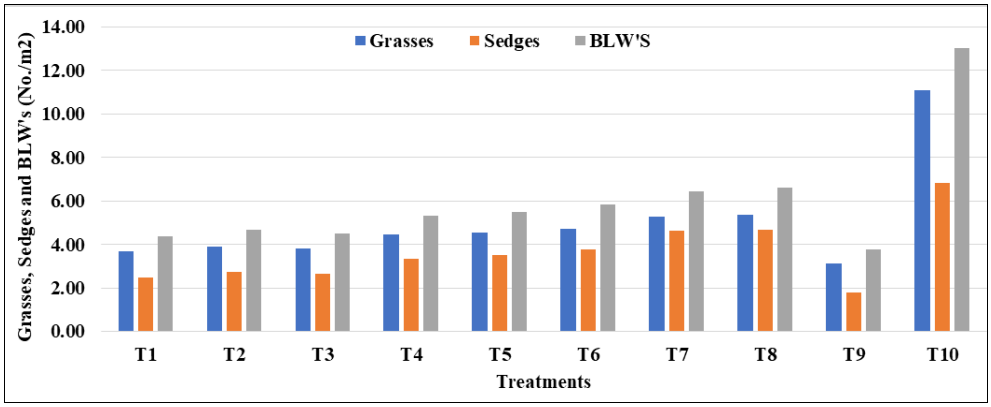

Fig 1: Density of different weed flora (No./m^2) as influenced by weed management practices in *Bt* cotton

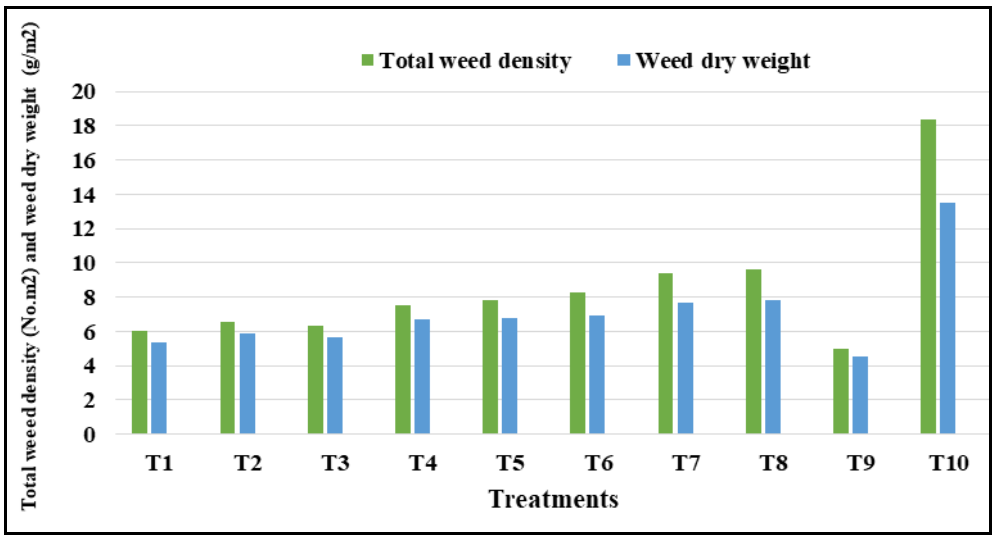

Fig 2: Total weed density (No./m^2) and weed dry weight (g/m^2) as influenced by weed management practices in *Bt* cotton

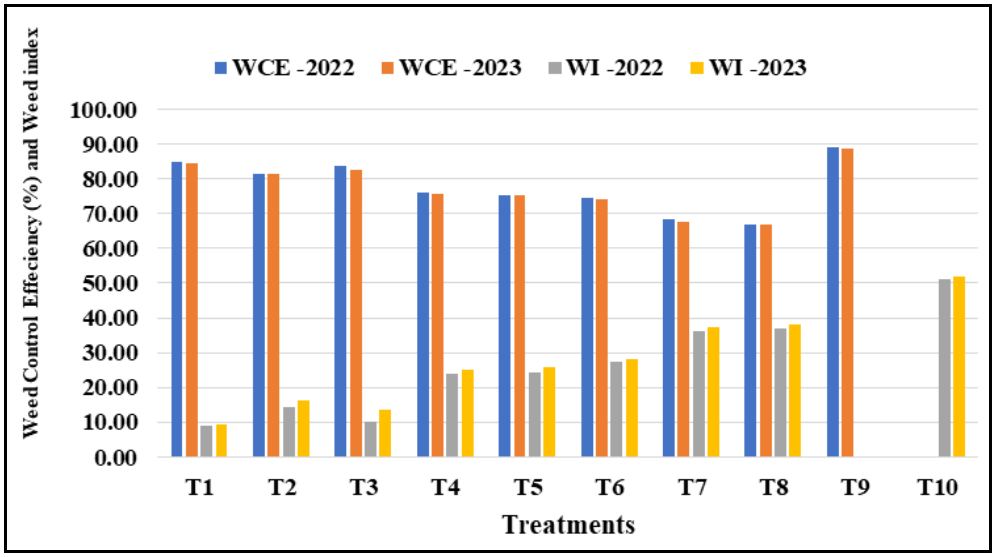

Fig 3: Weed Control Effeciency (%) and Weed index as influenced by weed management practices in *Bt* cotton

6. References

1. Anonymous. Agricultural statistics at a glance. Ministry of Agriculture & Farmers' Welfare. Directorate of Economics & Statistics, DAC and FW; c2023.
2. Ayyadurai P, Poonguzhalan R, Gokila J. Effect of crop weeds competition in cotton (*Gossypium hirsutum* L.). Agriculture Review. 2013;2(34):157-161.
3. Chetan KS. Sequential application of pre and post emergence herbicides for weed control in Bt cotton. M.Sc thesis. University of Agricultural Sciences, Dharwad; c2013.
4. Chinnusamy N, Chinnusamy C, Ravisankar D. Weed management in herbicide tolerant transgenic cotton (*Gossypium hirsutum* L.,). International Journal of Agricultural Science and Research. 2013;3(2):277-284.
5. Hariharasudhan V, Chinnusamy C, Prabhakaran NK. Optimum time of sowing and weed management methods on weeds interference and productivity and profitability of

Bt cotton hybrid in western zone of Tamil Nadu. International Journal of Chemical Studies. 2017;5(3):793-796.
6. Hiremath R, Yadahalli GS, Chittapur BM, Siddapur AD, Yadahalli VG, Koppalkar BRG, *et al*. Efficacy of chemical weed management in Bt cotton (*Gossypium hirsutum* L.). Acta Biological Indica. 2013;2(2):425-429.
7. Kurlekar VG, Khuspe VS. Studies on weed control in cotton (H-4). Indian Journal of Agronomy. 1979;24(4):377-382.
8. Mahar GM, Oad FC, Buriro UA, Solangi GS. Effect of post-emergence herbicide on the yield of up-land cotton. Asian Journal of Plant Sciences. 2007;6(8):1282-1286.
9. Malarkodi N. Integrated weed management effect on weeds and seed cotton Yield. International Journal of Environment and Agriculture Biotechnology. 2017;2(2):2387-2390.
10. Malik RS, Ashok Y, Hasija RC, Hooda VS. Efficacy of new herbicide against weeds in cotton. Environment and Ecology. 2012;30(3A):673-679.
11. Moolchand C, Sairam V, Prabhu Kumar S. Evaluation of integrated weed management practices in rainfed cotton (*Gossipium hirsutum* L.) at farmer's field. International Symposium on Global Cotton Technologies vis-a-vis Climate Change held at CCS Haryana Agricultural University, Hissar. 2012;10(12):274-276.
12. Nalini K, Muthukrishan P, Chinnusamy C, Janaki P. Response of soil microflora in herbicide residue of winter irrigated cotton. Crop Research. 2013;45(3):268-271.
13. Nandagavi RA, Halikatti SI. Bioefficacy of sequential application of herbicides in cotton. Journal of Pharmacognosy and Phytochemistry. 2021;10(1):2078-2083.
14. Patel JG, Raj VC, Kumar V, Sutaria CM, Usadadiya VP. Integrated weed management in Bt cotton. International Journal of Agriculture Innovations and Research. 2013;2(2):149-151.
15. Prabhu G, Halepyati A, Pujari BT, Desai BK. Weed management in Bt cotton (*Gossypium hirsutum* L.) under irrigation. Karnataka Journal of Agricultural Sciences. 2011;25(2):183-186.
16. Rao AN, Wani SP, Ramesha M, Ladha JK. Weeds and weed management of rice in Karnataka State, India. Weed Technology. 2015;29(1):1-17.
17. Singh M, Paikra PR. Bio-efficacy of post-emergence herbicides in transplanted rice of Chhattisgarh plains. The Bioscan. Journal. 2014;9(3):973-976.
18. Singh T, Bhatia RK, Singh S, Mehra SP. Bio-efficacy of glufosinate ammonium for weed control in American cotton. Indian Journal Weed Science. 2004;36(3&4):306-307.
19. Spasova D, Mitrev S, Spasova J, Atanasova B. Critical periods of weed competition in cotton. International scientific conference; c2008 Jun 5-6.
20. Tariq M, Afzal MN, Ahmad M, Qayyum A, Khan MA. Performance of pre and post-emergence herbicides for weed control in cotton (*Gossypium hirsutum* L.). Pakistan Journal of Weed Science Research. 2018;24(2):276-289.
21. Thorat VB, Paturde JT, Dongarwar UR, Karunakar AP, Mandhare SK. Evaluation of post emergence herbicides for weed control in cotton. Annals of Plant Physiology. 2007;21(2):171-174.
22. Veeraputhiran R, Srinivasan G. Post-emergence herbicides effect on weeds, yield and economics of Bt cotton. Indian Journal of Weed Science. 2015;47(4):379-382.
23. Schrijvers EM, Verhaaren BF, Koudstaal PJ, Hofman A, Ikram MA, Breteler MM, *et al*. Is dementia incidence declining? Trends in dementia incidence since 1990 in the Rotterdam Study. Neurology. 2012 May 8;78(19):1456-1463.