Original Research Article

WEED POPULATION DYNAMICS UNDER ORGANIC, BIO-DYNAMIC, CONVENTIONAL Bt AND NON-Bt COTTON (*Gossypium hirsutum*)

ABSTRACT

Aim: In order to compare the weed seed bank and population dynamics under organic, biodynamic, Bt-conventional, and non-Bt conventional management systems of cotton (Gossypium hirsutum), a field experiment was carried out.

Study design: Randomized Block Design (RBD)

Place and Duration of Study:bioRe-FiBL research trails, bioRe Association, Kasrawad, Khurgone, Madhya Pradesh during the *kharif* season of 2020-21.

Methodology: : Five distinct crop management techniques were used in the field experiment, each duplicated four times, and the experiment was set up using a randomized block design. The treatments were distributed at random to different plots. The five management treatments were Absolute Control (no fertilizers), Conventional management of non-Bt cotton, Conventional management of Bt cotton, and Organic management of cotton. For the duration of the experiment, four 1 m × 1 m (1 m^2) quadrants were randomly placed on each experimental plot's four sides, and different biometric observations were recorded from each quadrant according to its treatment. For the purpose of collecting the necessary observations, two of these quadrants were regularly weeded every 20 days, while the other two were left unweeded for the duration of the experiment.

Results: The dominant weed species includes *Panicum dichotomiflorum, Cyperus rotundus, Paspalum dilatatum, Euphorbia hirta, Acalypha indica* and*Digeria arvensis.Poaceae* was the dominant family in terms of composition. There was very less variation in the weed flora between the treatments. Significantly higher weed seed bank, weed species, weed count and weed dry matter were observed in Organic and Biodynamic cotton than in the Conventional cotton. Weed control efficiency was found to be maximum in the Conventional cotton compared to the Organic and Biodynamic cotton.

Conclusion: From the experiment, it can be concluded that the Conventional cotton especially Conventional management Bt Cotton was found to be most efficient among all the treatments. However, the Organic cotton was observed with high number of overall plant species and best in conserving the plant species biodiversity.

KEY WORDS: *Bio-dynamic, Bt, Conventional, Cotton, Organic, Weed*

Comment [r1]: quadrats

Comment [r2]: density

Comment [r3]: dry weight or dry biomass

INTRODUCTION

For India's sustainable economy and the life of the cotton farming community, cotton is a significant crop. It is grown on around 126.07 lakh hectares in the nation and 336.3 lakh hectares worldwide. India thus occupies around 37.5% of the world's cotton acreage and provides 20% (or 5.45

million MT) of the 25.69 million MT of cotton produced globally [1]. One of the crops that is grown most extensively in India is cotton, which has a challenging impact on the environment and natural resources. After Bt cotton was introduced, its acreage increased from 3.8 mha in 2006-2007 to 10 mha in 2009-2010 and is currently around 12 mha [2]. Heavy tillage, inter-~~cultivation~~ row techniques, and extensive use of ~~fertilisers~~fertilizers, insecticides, and herbicides are all part of cotton farming. Intensive cotton growing practices have a number of negative side effects on the environment and farmers [3]. The greatest threat to the biodiversity of rural regions is the intensification of agriculture, which is mostly caused by simpler crop rotation, high levels of fertilizer application, and plant protection products.The primary cause of the decline in biodiversity is the widespread use of herbicides in traditional farming systems. This has led to a significant increase in interest in growing organic cotton, which uses all environmentally friendly, sustainable farming methods and preserves biodiversity. With the addition of eight specialised preparations, biodynamic farming exhibits roughly similar methods. The early 1920s saw the emergence of the biodynamic farming movement in Europe. [4]

Being a long duration widely spaced and initially slow-growing crop, cotton is vulnerable to a serious weed infestation [5].The seed cotton yields were negatively impacted by intense weed competition during the early growing stages of the crop [6].About 70% of the weedy check's losses in seed cotton output are attributable to this[7]. Weed competition in the cotton crop was estimated to be the cause of 40 to 85% of the production losses. [8]. Weed population dynamics mainly includes; weed seed bank in the soil, germination, seed production and dispersal [9]. It is impossible to control weed population in a field without the right understanding of their dynamics [10]. In order to resolve these issues, in this experiment we compared the weeds that arise and their population dynamics in the field conditions of all the five treatments i.e., organic, biodynamic, conventional Bt, conventional non-Bt farming systems of cotton and the control.

MATERIALS AND METHODS

The present investigation on “Weed Population Dynamics under Organic, Bio-dynamic, Conventional Bt and Non-Bt Management of Cotton” was conducted at bioRe-FiBL research trails, bioRe Association, Kasrawad, Khurgone, Madhya Pradesh State, India in the Nimar Valley at 22.83°N 75.45°E and at about 200 - 300 m above mean sea level, during *kharif* season of 2020-21. The climate is semi-arid, with an average annual precipitation of 800 mm in a single peak monsoon season, usually lasts from mid-June to September. Temperature ranges from 15 - 49°C and is highest in May/June and lowest in December/January. Relative humidity attains maximum value (70-90 %) during the south-west monsoon and minimum value (20-30 %) during summer months. The present experimental field was under the FiBL Sys-Com project, which has established a long-term experiment (LTE) in which different farming systems were compared over a period of 10 – 20 years, since 2007. Cotton, soybean and wheat production were compared in a two-year crop rotation.

The experiment was laid out in randomized block design with five different crop management practices for field experiment, each replicated four times. The treatments were allocated randomly to various plots. Treatments were (i) organic, (ii) biodynamic, (iii) conventional, (iv) conventional with genetically modified Bt cotton and (v) control (Table 1). These representations illustrate local agricultural systems and the predominant issues facing farmers, agricultural groups, and politicians. For the duration of the experiment, four 1 m × 1 m (1 m^2) quadra~~n~~ts were randomly placed on each experimental plot's four sides, and different biometric observations were recorded from each quadrant according to its treatment. For the purpose of collecting the necessary observations, two of these quadrants were regularly weeded every 20 days, while the other two were left unweeded for the duration of the experiment.

The current test site is located in a vertisol-rich area. The soil has a low level of nitrogen (159.3 kg ha^{-1}) that is readily accessible, a medium level of phosphorus (15.5 kg ha^{-1}) and organic carbon (0.71%), a high level of potassium (672.4 kg ha^{-1}) that is readily available, and a somewhat alkaline reaction (7.75). Cotton cultivars 'Narmada shakti silver' (non-Bt) and 'Rasi-659' (Bt) were ~~employed~~ sown in the trial, and they were seeded at a seed rate of 0.128 kg $plot^{-1}$ (5 kg ha^{-1}) with a spacing of 106 × 53 cm. The amount of each weed present in each quadrant, its kind, and the emergence of weed seeds, the germination of fresh weed seeds from the soil were all noted. The weeds removed were first air dried and kept in an oven at 65°C till the constant dry weight was obtained. Thus, the dry weight of the weeds was recorded. Weed control efficiency was also calculated by taking the percentage ratio of the difference between the dry ~~matter~~ weight of weeds in control (untreatedd) plots and treated plots to the dry matterweight of weeds in control plots. All ~~observations~~ data were statistically analysed by 'Analysis of Variance' method[11] and 'F-test of significance' was used for testing the 'null hypothesis'.

Comment [r4]: what is the procedure for evaluation of weed seed bank?

RESULTS AND DISCUSSION

The summary of the findings and the discussion related to the present investigation as influenced by different treatments was as follows.

Weed flora and details

A total of 20 weed species were observed in the experiment (Table 2). The results showed that the soil weed seed bank contains many different species. However, a very few weed species had a major share in terms of composition i.e., 6 weed species including *Panicum dichotomiflorum, Cyperus rotundus, Paspalum dilatatum, Euphorbia hirta, Acalypha indica and Digeria arvensis* ~~occupies~~ occupied (80-90) % of the total composition. Grundy and Jones also reported the same trend of dominance by few species [12]. In the experiment, percentage of monocot weeds observed was highest in the treatment Conventional Bt and percentage of dicot weeds was highest in the treatment Organic. The dominant weeds observed were *Paspalum dilatatum* in Organic, *Cyperus rotundus* in Biodynamic and Control, *Panicum dichotomiflorum* in Conventional non-Bt and Conventional Bt.

Comment [r5]: author name of species must be mention in whole manuscript.

Comment [r6]: date of reference?!

Major weed families in the experiment include *Poaceae, Cyperaceae, Euphorbiaceae, Fabaceae* and *Asteraceae*. *Poaceae* was the dominant family in terms of composition. Weeds under *Poaceae* were about (40-50) % of the total weeds infested in field. The perennial nature and the vegetative propagation of the certain members of *Poaceae* were also may be responsible for the dominance in the crop field. The dominance of the weeds belonging to the family *Poaceae* was also reported by Nazar [13]and Memon [14]. The weed flora observed in the experiment was not exactly similar with the weed flora observed in other places of cotton cultivation. Weed flora differs widely in their diversity depending upon environmental and soil conditions of the area of cultivation [15]. However, few similar weed species were also present with some other findings. Similar monocot weed flora was observed by Jain in the cotton growing tracts of Madhya Pradesh. [16]

In terms of species richness ~~other than~~except the Control, Organic treatment was recorded higher species as compared to the other treatments. This might be due to the high weed cover above the ground. Organic field shows greater weed species richness and higher species diversity [17],[18],[19]. Most of the weed species observed were annual herbs and grasses which are about 75 % of the total weed species ~~types~~. Tena *et al.* also reported that the 80% of the species found in the cotton were erect, annual herbs and grasses [20]. Perennials occupied only 25% of the total weed species types, but (40-60) % of the total weed composition. As the perennial weeds are difficult to control due to the vegetative reproduction and special mechanisms they adapt, they might be were reported to have more composition despite of the lower number of species. The results showed that the cotton field was infested by all the three categories of weeds, which included grasses, sedges and broad-leaved weeds. However, the composition and the number of weed species were not homogeneous.

Monocot weed count

The highest monocot weed count other than control was observed in Organic and Biodynamic treatments compared to the conventional treatments in the field experiment (Table 3). This might be due to the higher soil weed seed bank and the non-chemical management of weeds in the organic and biodynamic treatments.

Dicot weed count

At most of the intervals, the dicot weed count is found to be non-significant among all the treatments in the experiment (Table 3). However, in terms of numerical values other than control it is highest in the Organic and Biodynamic treatments compared to the conventional treatments.

Comment [r7]: Density?

Total weed count

In the field experiment other than Control, the highest weed count was observed in Organic among all the treatments at all the intervals (Table 4). This might be due to the higher soil weed seed bank and the non-chemical management of weeds. Adam and Beata (2018) explained that the studies had shown significantly higher species diversity and abundance of above-ground and soil seed bank weeds in organic than in conventional farms. The mean total weed count difference between the organic and biodynamic treatments was found to be non-significant. There will be no statistically significant differences in weed population due to biodynamic sprays [21]. Weed population was similar with organic and biodynamic management. The conventional treatments were shown less weed ~~count~~ density compared to organic and there was no significant difference found in between the Conventional non-Bt and Conventional Bt. This was might be due to the wider availability of effective weed control methods in the conventional methods[22].

Dry ~~matter~~ weight of weeds (g)

In the field experiment, the weed dry matter was found to be highest in the Organic and Biodynamic treatments respectively with no significant difference (Table 4). This might be due to the more weed population and the non-chemical management strategies adapted. Poudel in tomatoes and maize reported with highest weed biomass at harvest in organic treatment [23]. The lowest weed dry weight was observed in the both of the conventional treatments with no significant difference. This might be due to the low weed population and the integrated weed management strategies adapted. Karkanis*et al.*also observed in leek (*Allium porrum* L.) with lowest weed biomass in the conventional treatments. [24]

Weed Control Efficiency (%)

The highest weed control efficiency in the field experiment was found in Conventional Bt at 30 DAS, 90 DAS, 120 DAS and Conventional non-Bt at 60 DAS and at harvest (Table 4). This might be due to the efficient integrated weed control strategies adapted in the crop field. Due the integrated practices of weed control, the weed population and dry weight were also found to be very less compared to the weedy check (control). Whereas the lowest weed control efficiency was found in the treatment Organic followed by Biodynamic at all intervals. As the weed population and the dry weight were highest in the case of these treatments, the above results were obtained. From this, we can explain that the Conventional treatments and conventional method of weed control was more efficient compared to the organic treatments and the organic methods of weed control.

CONCLUSION

From the above findings, it can be concluded that there was very less variation in the weed flora between the treatments. Significantly higher weed seed bank, weed species diversity, weed ~~count~~ density and weed dry ~~matter~~ weight were observed in the Organic and Biodynamic cotton than in the Conventional cotton. Weed control efficiency was found to be maximum in the Conventional cotton

compared to the Organic and Biodynamic cotton. The Conventional management of Bt Cotton was found to be most efficient among all the treatments. However, the Organic cotton was observed with high number of overall plant species and best in conserving the plant species biodiversity.

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Table 1: Comparison of the five treatments (different management systems of cotton)

S no	Particular	Organic	Biodynamic	Conventional Non-Bt	Conventional Bt	Control
1	**Genetic material**	Non-Bt	Non-Bt	Non-Bt	Bt	Non-Bt
2	**Fertilization**	Organic manures	Organic manures	Synthetic fertilizers	Synthetic fertilizers	-

3	**Green manuring**	Yes	Yes	No	No	No
4	**Weed management**	Manual	Manual	IWM*****	IWM	-
5	**Plant protection**	Organic pesticides	Organic pesticides	IPM******	IPM	-
6	**Irrigation**	Yes	Yes	Yes	Yes	Yes
7	**Others**	-	Biodynamic preparations are used	-	-	-

(*****IWM: Integrated Weed Management; ******IPM: Integrated Pest Management)

Table 2. Percentage of each weed of crop as influenced by different treatments

S No	Weeds	Crop				
		T1-ORG	**T2-BD**	**T3-Cnv-NBt**	**T4-Cnv-Bt**	**T5-CTRL**
	Monocot weeds	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
1	*Panicum dichotomiflorum*	17.02	19.50	28.50	27.33	20.00
2	*Cyperus rotundus*	15.30	26.70	15.33	22.50	26.75
3	*Commelinaforskaoliivahl*	0.50	0.05	-	-	0.75

Comment [r8]: The names of the authors of the species should be mentioned

4	*Paspalum dilatatum*	33.18	22.25	25.60	21.92	21.25
5	*Echinochloacolonum*	-	-	0.07	-	0.25
	Dicot weeds					
1	*Cocculus hirsutus*	0.75	-	-	-	0.50
2	*Euphorbia hirta*	5.55	5.33	5.50	4.75	3.03
3	*Convolvulus arvensis*	0.50	1.10	-	-	0.26
4	*Cassia tora L.*	0.75	0.66	-	-	2.50
5	*Mimosa pudica*	0.07	-	-	-	0.10
6	*Physalis minima*	1.13	0.85	1.35	0.95	1.25
7	*Portulaca oleracea*	2.75	2.66	2.50	2.35	2.25
8	*Phyllanthus niruri*	1.50	1.35	1.65	1.60	1.25
9	*Acalypha indica*	5.25	5.75	6.15	5.50	4.40
10	*Melilotus albus*	0.50	-	-	-	0.30
11	*Digeria arvensis*	6.45	5.50	6.25	5.95	6.50
12	*Anagalis arvensis*	3.80	3.75	2.60	3.00	3.50
13	*Sphaeranthus indicus*	1.60	1.95	2.35	2.15	1.75
14	*Tridax procumbens*	1.20	0.85	-	-	0.75
15	*Corchorus fascicularis*	2.20	1.75	2.15	2.00	2.66

(ORG=Organic, BD=Bio-dynamic, Cnv-NBt=Conventional non-Bt, Cnv-Bt=Conventional Bt, CTRL= Control)

Table 3. Monocot (grasses) and dicot (broadleaved) weeds ~~count~~ density per m^2 of crop as influenced by different treatments

Treatment Details	Monocot weed count per m^2					Dicot weed count per m^2				
	30 DAS*	60 DAS	90 DAS	120 DAS	At Harvest	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
T_1- Organic farming cotton	8.61 (73.89)	7.73 (59.42)	5.96 (35.12)	5.11 (25.71)	2.15 (4.11)	5.99 (35.8)	3.45 (11.41)	3.48 (11.75)	2.81 (7.41)	2.24 (4.54)
T_2- Bio-dynamic farming cotton	8.14 (66.16)	7.31 (53.21)	5.91 (34.45)	5.06 (25.19)	2.11 (3.97)	5.24 (28.59)	4.08 (16.39)	3.46 (11.67)	2.79 (7.43)	2.21 (4.41)
T_3- Conventional farming non-Bt cotton	6.85 (46.51)	6.74 (45.05)	5.31 (27.71)	4.89 (23.54)	1.94 (3.27)	4.68 (22.86)	3.92 (15.40)	3.41 (11.52)	2.36 (5.31)	1.98 (3.46)
T_4- Conventional farming Bt cotton	7.13 (50.69)	6.52 (42.12)	5.53 (30.25)	4.75 (22.22)	1.94 (3.28)	4.42 (19.37)	4.06 (16.03)	2.95 (8.44)	2.37 (5.27)	1.99 (3.53)
T_5- Absolute Control (without fertilizers)	9.12 (82.82)	7.30 (52.90)	6.34 (39.78)	5.45 (29.25)	2.28 (4.70)	5.99 (35.49)	4.8 (22.67)	3.23 (9.80)	2.79 (7.31)	2.28 (4.70)
SE(m)±	0.28	0.23	0.13	0.12	0.05	0.51	0.22	0.23	0.2	0.07
CD at 5 %	0.86	0.71	0.4	0.37	0.15	NS	0.68	NS	NS	0.22
GM	7.97 (64.01)	7.12 (50.54)	5.81 (33.46)	5.06 (25.18)	2.08 (3.87)	5.27 (28.42)	4.06 (16.38)	3.31 (10.64)	2.62 (6.55)	2.14 (4.13)

(Data are subjected to square root transformation √(x+0.5) and original data are presented in parenthesis.)

*DAS= Days after sowing

Table 4. Total weed count and dry matter of weeds per m^2 of crop as influenced by different treatments

Treatment Details	Total weed count per m^2					Dry matter of weeds per m^2 (g)				
	30 DAS*	60 DAS	90 DAS	120 DAS	At Harvest	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
T_1- Organic farming cotton	10.48 (109.7)	8.44 (70.84)	6.88 (46.87)	5.79 (33.12)	3.02 (8.65)	4.76 (22.2)	2.86 (7.67)	2.19 (4.31)	1.29 (1.18)	1.09 (0.70)
T_2- Bio-dynamic farming cotton	9.75 (94.75)	8.36 (69.6)	6.82 (46.13)	5.74 (32.62)	2.97 (8.37)	4.70 (21.65)	2.8 (7.37)	2.12 (3.99)	1.27 (1.11)	1.09 (0.68)
T_3- Conventional farming non-Bt cotton	8.32 (69.37)	7.8 (60.45)	6.29 (39.12)	5.4 (28.85)	2.68 (6.72)	4.03 (15.79)	2.31 (4.87)	1.81 (2.79)	1.13 (0.79)	0.95 (0.40)
T_4- Conventional farming Bt cotton	8.37 (70.06)	7.65 (58.15)	6.25 (38.69)	5.27 (27.50)	2.69 (6.81)	4.00 (15.57)	2.36 (5.06)	1.79 (2.73)	1.14 (0.79)	0.95 (0.40)
T_5- Absolute Control (without fertilizers)	10.89 (118.3)	8.7 (75.56)	7.09 (49.73)	6.09 (36.56)	3.14 (9.41)	5.34 (28.02)	3.09 (9.05)	2.39 (5.20)	1.37 (1.39)	1.16 (0.84)
SE(m)±	0.34	0.24	0.16	0.17	0.08	0.07	0.06	0.04	0.03	0.02
CD at 5 %	1.06	0.75	0.48	0.52	0.25	0.22	0.18	0.13	0.09	0.05
GM	9.56 (92.44)	8.19 (66.92)	6.66 (44.10)	5.66 (31.73)	2.90 (7.99)	4.57 (20.64)	2.68 (2.80)	2.06 (3.80)	1.24 (1.05)	1.05 (0.61)

(Data are subjected to square root transformation √(x+0.5) and original data are presented in parenthesis.)

*DAS= Days after sowing

Table 5. Weed Control Efficiency (%) of crop as influenced by different treatments

Treatment Details	Weed Control Efficiency (%)				
	30 DAS*	60 DAS	90 DAS	120 DAS	At Harvest
T_1- Organic farming cotton	20.76	14.66	17.06	15.61	16.82
T_2- Bio-dynamic farming cotton	22.76	18.03	23.27	19.49	18.75
T_3- Conventional farming non-Bt cotton	43.66	45.51	46.36	42.77	51.94
T_4- Conventional farming Bt cotton	44.43	43.39	47.40	42.92	52.51
T_5- Absolute Control (without fertilizers)	-	-	-	-	-

*DAS= Days after sowing