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Full Length Research Paper

Assessment of soil quality parameters and yield of rainfed Bt. Cotton as influenced by application of herbicides in Vertisols

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The present study pertains to the effect of different herbicides viz. Pendimethalin @ 1.0 kg ai ha^{-1} as a pre emergence herbicide, Pyrithiobacksodium @ 62.5 g ai ha^{-1}, Quazolfopethyl @ 40 g ai ha^{-1}, Fenoxyprop @ 12 g ai ha^{-1} as a post emergence herbicide (25 DAS) and management practices on physico-chemical, biological properties, seed cotton, dry matter yield and soil fertility status. The results revealed that organic carbon content (8.0 g kg^{-1}), soil porosity (48 per cent) and cation exchange capacity (63.66 cmol (p^{+}) kg^{-1}) was significantly higher in the plots treated with 3 hoeings and 3 hand weedings as compared to all other herbicide treatments applied as a pre and post emergence. Almost similar trend was observed in the seed cotton yield (1868 kg ha^{-1}), dry matter yield (2835 kg ha^{-1}), available N (184.90 kg ha^{-1}), available P (11.70 kg ha^{-1}) and available K (666.20 kg ha^{-1}). The practice of 3 hoeing and 3 hand weedings showed the highest efficiency in weed control and thus reflected in higher yields when maintaining soil fertility status.

Key words: Soil quality, herbicides, seed cotton yield, soil fertility, microbial count.

INTRODUCTION

Cotton is one of the most important commercial fibre crop playing a key role in the economic and social affairs of the world. It is grown chiefly for its fibre which is use in the manufacture of cloths, making of threads and extraction of oil from cotton seed. In cotton, weeds compete for nutrient, moisture and sunlight. The weed free maintenance of 60 – 70 days after emergence of crop is necessary for better yield in cotton (Deshpande et al., 2006). In cotton, yield losses due to weed competition may go up to 70 – 89 per cent and presently, non availability of labour is arising as a burning issue in agriculture. The adoption of herbicide is the cheaper and best alternative towards the weed control and ultimately for harvesting higher yields (Idapugandi et al., 2005). At the same time, it is worthwhile to study the residual and any toxic effect that persist in the soil and causes the soil health problems in long term due to the application of herbicides. The increased use of pesticides and herbicides in agricultural soils causes the contamination of the soil with toxic chemicals. When pesticides are applied, the possibilities exist that these chemicals may exert certain effects on non-target organisms, including soil microorganisms (Simon-Sylvestre G, Fournier JC 1979). The microbial biomass plays an important role in the soil ecosystem where they fulfill a crucial role in nutrient cycling and decomposition**.** During the past four decades, a large number of herbicides have been introduced as pre and post-emergence weed killers in many countries of the world. Soil quality is often defined as the capacity to sustain in terms of biological production, maintain the environmental quality, and promotes plant and animal health (Karlen et al., 1997)**.** It is assessed using seven soil quality parameters that measure physical, chemical and biological functions of the soil. Changes in soil quality can be both positive and negative. Many herbicides are lethal to beneficial soil organisms like *mycorrhizae* and nitrogen-fixing bacteria (Sebiomo et al., 2011). The death of beneficial microorganisms will result in ecological imbalance and overgrowth of other injurious bacteria and fungi (Farenhost, 2003). Traditional methods of weed control could not be performed in time due to uncertainty of rains, unworkable soil conditions and higher cost. No

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systematic information is available on the effects of herbicide application in relation to soil properties and yield of Bt cotton under rainfed condition in vertisols and associated black soils. Hence, the present investigation was undertaken to study the soil quality parameters and yield of rainfed Bt cotton as influenced by application of herbicides.

MATERIALS AND METHODS

The experiment was carried out on rainfed Bt. cotton during *kharif* - 2012 at Parbhani, on the farm of All India Co-ordinated Research Project on Weed Science, Marathwada Krishi Vidaypeeth, Parbhani**.** The soil of the experimental field was deep black (58.00 per cent clay) of fine montmorilonitic hyper thermic family of *Tyipc Haplusterts*. Initial soil characteristics (0 - 0.20 m depth) of the experimental field were: pH 7.92, electrical conductivity 0.18 dSm^{-1}, organic carbon 6.5 g kg^{-1}, calcium carbonate 30 g kg^{-1}, available N 175 kg ha^{-1}, availabale P 10.11 kg ha^{-1}. The bacterial, fungal and actinomycetes counts were 60.30 cfu x 10^{-7}, 22.66 cfu x 10^{-4} and 50.43 cfu x 10^{-5}, respectively. The experiment included 08 treatments viz. T_1 - POE-Pyrithiobacksodium @ 62.5 g ai ha^{-1}, T_2 - POE-Quazolfopethyl @ 40 g ai ha^{-1}, T_3 - POE-Fenoxyprop @ 12 g ai ha^{-1}, T_4 - POE-Chlorimuron ethyl @ 12 g ai ha^{-1}, T_5 - PE- Pendimethalin @ 1.0 kg ai ha^{-1}, T_6 - 03 Hoeing and 03 Hand Weeding, T_7 - Weedy check and T_8 - POE-Quazolfopethyl @ 40 g ai ha^{-1} + Chlorimuron ethyl @ 12 g ai ha^{-1}, each replicated three times in a randomized block design. The JBCH – 01 Bt cotton was dibbled on 2nd week of June, 2012 at a spacing of 120 x 30 cm. The plot size was 7.2 x 4.2 m^2. The fertilizers used were urea (46 per cent N), single super phosphate (16 per cent P_2O_5) and murate of potash (60 per cent K_2O). All P, K and 1/3 of the N were applied as basal dressing and the remainder of N was top-dressed in two equal splits at 1 and 2 months after sowing. The pre-emergence herbicide (pendimethalin) was applied on second day after sowing and post-emergence herbicides were applied on 30th days after sowing of cotton crop. Hand weeding was done on 20, 45 and 60 days after sowing in hand weeding treatment plots. Soil samples (0 – 0.2 m) were collected from 0 to 110 days after sowing at each 20 days interval and at harvesting stage of crop. The collected soil samples were thoroughly mixed, air dried and ground in wooden pestle and morter passes through 2 mm sieve. After harvest, soil samples were analysed for pH and electrical conductivity in 1 : 2.5 soil : water suspension (Jackson, 1973); organic carbon by the Walkley and Black (1934) method; calcium carbonate by rapid titration method (Jackson, 1973); available N by $KMnO_4$ oxidized N (Subbiah and Asijia, 1956); available P by Olsen method (Olsen et al., 1954); available K and CEC by extraction with 1 N ammonium acetate (NH_4OAc) solution at pH 7.0 (Jackson, 1973) and microbial properties were determined by serial dilution methods described by Pramer and Schmidp (1964). The seed cotton yield was computed on 12 per cent moisture content and dry matter is on the oven dry basis. The experimental data were statistically analysed as per the method described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Soil quality parameters

Organic carbon

A perusal of the data in Table 1 showed that, organic carbon content of the soil after harvest of cotton did not show any visible trend under different treatments. However, increased organic carbon content was observed in treatment receiving 03 hoeing and 03 hand weedings (T 6) over rest of the treatments. This increase might be attributed to the overall improvement in soil physical condition. These results are in accordance with the findings of Aipokpodion et al. (2010).

Soil porosity

After harvest of cotton, the treatment receiving 03 hoeing and 03 hand weedings (T 6) exhibited significantly higher porosity (48 per cent) as compared to other herbicide treatments (Table 1). Lowest porosity was recorded in treatment T 2 (POE – Quazolfop ethyl @ 40 g. a. i. ha^{-1}. Improvement in soil porosity is due to increase in water stable aggregates and higher organic carbon, which resulted in more space and good soil aggregation. Sheeba and Kumaraswamy (2001) observed improvement in porosity with increase in organic matter content.

Cation exchange capacity

Cation exchange capacity at the harvest of cotton ranged from 42.64 (T 8) to 63.66 cmol (P^+) kg ha^{-1} (T 6). The use of 03 hoeing and 03 hand weedings (T 6) significantly improved the cation exchange capacity of soil over T 8 (POE – Quazolfop ethyl @ 40 + Chlorimuron ethyl g. a. i. /ha^{-1}). Similar findings were also reported by Patel et al. (2008).

Microbial count

The data in Table 2, 3 and 4 indicated that, the lowest microbial count (Bacteria, Fungi and Actinomycetes) was observed in all the treatments of herbicide application over initial values. However, treatment receiving 03 hoeing and

Table 1. Effect of herbicide application on organic carbon, soil porosity and CEC of soil.

Treatments	Organic Carbon (g kg^{-1})	Soil porosity (%)	CEC [cmol (p^+) kg^{-1}]
T_1:POE-pyrithioback sodium@ 62.5 g a.i. ha^{-1}	7.8	37	61.28
T_2:POE-Quazolfop ethyl @ 40 g a.i. ha^{-1}.	7.6	33	58.78
T_3:POE-Fenoxyprop @ 12g a.i. ha^{-1}	7.6	35	56.96
T_4:POE-Chlorimuron ethyl @ 12 g a.i. ha^{-1}	7.7	33	47.56
T_5:PE-Pendimethalin @ 1.0 kg a.i. ha^{-1}	7.7	40	59.41
T_6: 3 Hoeing and 3 Hand weeding	8.0	48	63.66
T_7:Weedy check	7.2	35	54.04
T_8:POE-Quazolfop ethyl + Chlorimuron ethyl	7.6	36	42.64
Initial values	6.5	-	54.00
SE ±	0.20	2.17	0.88
CD at 5%	NS	6.59	2.68

a.i. : active ingredient, DAS : days after sowing, @: at the rate, g : gram.

Table 2. Effect of herbicide application on bacterial count of soil (cfu x 10^{-7}) .

Treatment	30DAS	50DAS	70DAS	90DAS	110DAS	Harvesting
T_1:POE-pyrithioback sodium@ 62.5 g a.i. ha^{-1}	23.00	46.66	52.00	53.00	53.33	53.66
T_2:POE-Quazolfop ethyl @ 40 g a.i. ha^{-1}.	19.00	37.66	41.33	43.33	44.66	45.00
T_3:POE-Fenoxyprop @ 12g a.i. ha^{-1}	21.66	36.33	40.33	41.33	43.00	42.00
T_4:POE-Chlorimuron ethyl @ 12 g a.i. ha^{-1}	17.66	30.0	34.33	38.00	39.00	39.00
T_5:PE-Pendimethalin @ 1.0 kg a.i. ha^{-1}	55.00	55.33	59.33	56.66	59.66	61.66
T_6:3 Hoeing and 3 Hand weeding	65.00	63.66	65.66	65.66	66.33	62.00
T_7:Weedy check	63.00	68.66	66.66	63.66	63.33	63.00
T_8:POE-Quazolfop ethyl + Chlorimuron ethyl	11.33	31.66	35.00	35.66	35.33	36.33
Initial values	60.33					
SE ±	3.0	4.0	3.77	4.78	4.83	4.13
CD at 5%	9.2	12.15	11.45	14.52	14.67	12.54

03 hand weedings (T 6) recorded highest microbial count over all other treatments. The microbial count was seen in increasing trend after third week and onwards of the treatments where the application of herbicides was undertaken. This might be due to microbes use herbicide as a source of carbon. These results are in conformity with the earlier findings reported by Sebiomo et. al. (2011).

Quality parameters

The quality parameters of cotton seed were not affected significantly due to various herbicidal treatments. The quality parameters viz. oil (16.98 per cent) and protein (23.00 per cent) was maximum with treatment 03 hoeing and 03 hand weedings (T 6) followed by treatment of application of Pyrithioback sodium @ 62.5 g. a. i. / ha^{-1} (T 1). Mukhtar Ahmad et al. (2000) reported that, the different herbicides and their doses shown non-significant differences on quality parameters.

Seed cotton yield

The highest seed cotton yield in different weed management practices was observed in treatment T_6 (3

Table 3. Effect of herbicide application on fungal count of soil (cfu x 10^{-4}).

Treatment	30DAS	50DAS	70DAS	90DAS	110DAS	Harvesting
T_1:POE-pyrithioback sodium@ 62.5 g a.i. ha^{-1}	16.00	20.33	21.33	24.33	19.33	20.33
T_2:POE-Quazolfop ethyl @ 40 g a.i. ha^{-1}.	14.00	19.33	19.00	18.33	19.00	19.66
T_3:POE-Fenoxyprop @ 12g a.i. ha^{-1}	12.66	17.33	18.66	17.33	18.33	18.33
T_4:POE-Chlorimuron ethyl @ 12 g a.i. ha^{-1}	7.00	16.00	16.33	16.33	18.00	18.00
T_5:PE-Pendimethalin @ 1.0 kg a.i. ha^{-1}	28.33	28.33	29.66	26.66	20.33	20.33
T_6:3 Hoeing and 3 Hand weeding	28.66	26.00	25.00	26.66	24.66	25.00
T_7:Weedy check	26.66	27.66	27.00	27.00	16.00	24.33
T_8:POE-Quazolfop ethyl + Chlorimuron ethyl	5.66	15.33	16.00	16.00	17.33	17.00
Initial Value	22.66					
SE $\pm$	1.73	1.73	1.81	1.75	1.80	1.46
CD at 5%	5.26	5.26	5.51	5.41	5.48	4.43

Table 4. Effect of herbicide application on actinomycetes count of soil (cfu x 10^{-5}).

Treatment	30DAS	50DAS	70DAS	90DAS	110DAS	Harvesting
T_1:POE-pyrithioback sodium@ 62.5 g a.i. ha^{-1}	22.6	45.6	48.0	47.6	47.3	50.33
T_2:POE-Quazolfop ethyl @ 40 g a.i. ha^{-1}.	21.3	41.3	42.6	40.0	44.0	43.33
T_3:POE-Fenoxyprop @ 12g a.i. ha^{-1}	20.3	40.0	39.0	37.3	41.0	41.33
T_4:POE-Chlorimuron ethyl @ 12 g a.i. ha^{-1}	13.6	37.6	38.3	36.0	38.6	40.33
T_5:PE-Pendimethalin @ 1.0 kg a.i. ha^{-1}	39.0	47.0	47.6	48.6	49.3	54.66
T_6:3 Hoeing and 3 Hand weeding	55.6	53.0	51.6	49.6	52.0	51.66
T_7:Weedy check	52.3	55.6	52.6	51.6	51.6	52.66
T_8:POE-Quazolfop ethyl + Chlorimuron ethyl	11.0	36.0	38.0	42.0	37.3	38.66
Initial value	50.43					
SE $\pm$	2.21	3.38	2.6	2.3	2.8	3.22
CD at 5%	6.72	10.27	8.0	7.02	8.5	9.79

Hoeings and 3 Hand Weedings) and proved significantly superior over all other practices. The yield data (Table 5) revealed that the maximum seed cotton yield (1868 kg ha^{-1}) was noticed in treatment T_6 (3 Hoeings + 3 Hand weeding) and minimum (315 kg ha^{-1}) in treatment T_8 (POE – Quazolfop ethyl + Chlorimuron ethyl). In weed control treatments, due to poor resurgence and regrowth, the weeds were unable to compete with the crop at different growth stages, which consequently resulted in better expression of yield components. The treatments T_6 (3 had weedings and 3 hoeings) recorded significantly higher dry matter yield due to effective control of both early and late emerging weeds providing a season long control of weeds offering lesser competition for nutrients, sunlight and water by the crop. Deshpande et al. (2006) was also found maximum Bt. seed cotton yield with 3 hand weeding and 3 hoeings. Post emergence herbicide pyrithioback sodium @ 62.5 g a.i. ha^{-1} was found effective in Bt cotton as compared to rest of pre and post emergence herbicides, indicating one of the best alternative option for timely weed management.

Table 5. Effect of application of herbicide on seed Bt cotton yield and dry matter yield.

Treatments	Seed Bt cotton yield (kg ha^{-1})	Dry matter yield (kg ha^{-1})
T_1:POE-pyrithioback sodium@ 62.5 g a.i. ha^{-1}	1480	2234
T_2:POE-Quazolfop ethyl @ 40 g a.i. ha^{-1}	1079	1581
T_3:POE-Fenoxyprop @ 12g a.i. ha^{-1}	875	1312
T_4:POE-Chlorimuron ethyl @ 12 g a.i. ha^{-1}	344	518
T_5:PE-Pendimethalin @ 1.0 kg a.i. ha^{-1}	1238	1857
T_6:3 Hoeing and 3 Hand weeding	1868	2835
T_7:Weedy check	544	767
T_8:POE-Quazolfop ethyl + Chlorimuron ethyl	315	457
SE $\pm$	43.74	51.25
CD at 5%	132.70	155.47

Table 6. Effect of herbicide on available N, P_2O_5, K_2O status in soil after harvest.

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
T_1:POE-pyrithioback sodium@ 62.5 g a.i. ha^{-1}	178.7	10.50	658.9
T_2:POE-Quazolfop ethyl @ 40 g a.i. ha^{-1}.	166.1	9.92	640.2
T_3:POE-Fenoxyprop @ 12g a.i. ha^{-1}	163.0	9.16	628.7
T_4:POE-Chlorimuron ethyl @ 12 g a.i. ha^{-1}	149.8	7.59	568.3
T_5:PE-Pendimethalin @ 1.0 kg a.i. ha^{-1}	172.4	10.43	646.5
T_6:3 Hoeing and 3 Hand weeding	184.9	11.70	666.2
T_7:Weedy check	156.7	8.81	595.0
T_8:POE-Quazolfop ethyl + Chlorimuron ethyl	143	7.06	551.6
SE $\pm$	1.96	0.91	12.94
CD at 5%	5.95	2.78	39.27
Initial value	175.20	5.19	624.64

Soil fertility status

Available nutrient in the soil after harvest were affected significantly due to different weed management methods. Significant variation in available N, P_2O_5 and K_2O in the soil was observed and was in increasing trend (Table 6) where the practice of 3 hand weeding and 3 hoeings were applied, which reflected in availability of these nutrients to plant in adequate amount, time and remained in soil in substantial quantity after fulfilling the crop requirement that ultimately improved soil fertility. The results are in conformity with the findings of Debnath et al. (2002).

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