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Microflora Population in Rhizosphere and Yield of Potato as Influenced by Weed Management Practices

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A field experiment was conducted at Bidhan Chandra Krishi Viswavidyalaya, during *rabi* seasons for two years (2008-10) to assess the microflora population in the *rhizosphere* of potato as influenced by weed management practices. Pre-emergence application of oxyfluorfen @ 300 g a.i. ha$_{-1}$ recorded minimum weed population as well as biomass. Potato tuber yield was maximum in oxyfluorfen @ 300 g a.i. ha$_{-1}$ (35.032 t ha$_{-1}$) which is statistically at par with oxyfluorfen @ 200 g a.i. ha$_{-1}$ (34.706 t ha$_{-1}$). Excluding atrazine @ 1000 g ha$_{-1}$ and pendimethalin @ 1500 g ha$_{-1}$, no phytotoxicity in potato plants was observed in the herbicidal treatments. No detrimental effect on soil micro-flora (total bacteria, actinobacteria and fungi) was observed in the long-term though herbicides decreased the micro-flora population initially.

Key words: Weed management, Herbicide, Potato, Yield, Microflora

Potato is one of the important staple food crops in the world. Potato has always been the 'poor man's friend'. For vegetable purposes it has become one of the most popular crops in the country. Potatoes are an economical food; they provide a source of low cost energy to the human diet. There are several constraints in potato production, of which weeds often pose a serious problem. Even though potato plants have robust growing and quick spreading nature but it turns as a weak competitor with weeds. Weeds not only compete with crop plants for nutrients, soil moisture, space and sunlight but also serve as an alternative hosts for several insect pest and diseases. Wider spacing, frequent irrigations and liberal use of manures and fertilizers provide favorable conditions for an early start of weeds well before the emergence of potato plant. Singh and Bhan (1999) reported that the presence of weeds throughout the growing season caused 62% reduction in tuber yield. The weed control in potato crop is normally by manual labour. But due to labour problem, alternative herbicidal measures should be evaluated. The addition of herbicides can cause qualitative and quantitative alterations in the soil microbial populations and their enzyme activities (Min *et al,* 2002; Saeki and Toyota, 2004). Herbicide application may also kill species of bacteria, fungi and protozoa upsetting the balance of pathogens and beneficial organisms and allowing the opportunist, disease causing organisms to become a problem (Kalia and Gupta, 2004). In addition, change in the soil microflora has been listed as one of the possible causes of productivity decline (Reichardt *et al,* 1998). Keeping all these points in view the investigation was planned to generate information on weed flora and microflora population in the *rhizosphere* and yield of potato as influenced by weed management practices.

Materials and Methods

The experiment was conducted with seven treatments replicated thrice with randomized block design. Each plot size was of 5 m x 4 m. The crop was grown during consecutive two *kharif* seasons of 2008-9 and 2009-10 at the 'C' Block farm (latitude: 22°57' E, longitude: 88°20'N and altitude: 9.75 m) of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The experimental soil was well drained, alluvial in nature and sandy loam in texture (Sand 63%, silt 21%, clay 16%), having pH 6.88, organic carbon 0.57%, available nitrogen 238.21 kg ha$_{-1}$, available phosphorus 19.87 kg ha$_{-1}$ and available potassium 173.59 kg ha$_{-1}$ respectively. The variety used in this experiment was Kufri - Jyoti. The treatments are as follows: pre-emergence application of oxyfluorfen @ 100, 200, 300 g ha$_{-1}$, atrazine @ 1000 g ha$_{-1}$ and pendimethalin @ 1500 g ha$_{-1}$, farmer practice (hand weeding twice at 15 and 30 DAP) and unweeded control. All the herbicides were applied at 5 DAP. All the treatments are followed by one earthing up at 45 DAP. Potato was sown at the middle of the November of the two consecutive years with the fertilizer dose @ 150:100:100 kg ha^{-1} of N, P_20_5 and K_20. Half of the recommended dose (50 %) of nitrogen @ 150 kg ha$_{-1}$ through urea along with full phosphorus through single super phosphate and full potash through muriate of potash, both @ 100 kg ha$_{-1}$ were applied as basal during final land preparation. The remaining half N was top dressed at the time of final weeding (tuber bulking starting period) at 30 DAP. One day before sowing, the seeds were treated with *Trichoderma viride* @ 4 g kg$_{-1}$ of potato seeds. The treated seeds were kept under shade for overnight before sowing in the main field and sown at 45 cm x 15 cm spacing in ridge. Spraying was done with knapsack sprayer with floodjet deflector WFN 040 nozzle with 500 Litre

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of water ha^{-1}. Weed biomass, density were recorded at 15 and 30 DAA, and phytotoxicity observation as per CIB guidelines (observations on yellowing, stunting, necrosis, leaf injure on tips & leaf surface, wilting, epinasty and hyponasty) was recorded accordingly. At the time of harvest, the tuber yield was measured. The enumeration of the microbial population was done on agar plants containing appropriate media following serial dilution technique and pour plate method (Pramer and Schmidt, 1965); plates were incubated at 30 ^{0}C. The counts were taken at 3rd, 5th and 7th day of incubation in case of total bacteria, fungi and actinobacteria, respectively. The data were subjected to statistical analysis by analysis of variance method (Gomez and Gomez, 1984). As the error mean squares of the individual experiments were homogenous, combined analysis over the years were done through unweighted analysis. Here, the interaction between years and treatments were not significant. Means were compared at the 5% level of significance using Duncan's multiple range test.

Results and Discussion

Weed growth

Weed flora in potato consisted of *Dactyloctenium aegypticum, Digitaria sanguinalis, Echinochloa colona, Eleusine indica* (grass), *Cyperus rotundus* (sedge), *Anagallis arvensis, Chenopodium album, Fumaria parviflora, Gnaphalium luteoalbum, Melilotus alba, Physalis minima, Portulaca oleracea, Solanum nigrum, Digera arvensis and Trianthema monogyna* (broadleaved).These weeds were highly aggressive at the initial stage of crop and emerged throughout crop season resulting in higher crop-weed competition.

At 15 DAA, farmer practice recorded least weed density which was statistically at par with all the doses of oxyfluorfen. At 30 DAA, highest dose of oxyfluorfen recorded the least density which was statistically at par with lower doses of oxyfluorfen. Unweeded control recorded highest density at both dates of observation. Among the weed management practices, oxyfluorfen @ 300 g ha^{-1} recorded the highest weed control efficiency (WCE%) both at 15 and 30 DAA (78.66 and 74.44%). This treatment was closely followed by oxyfluorfen @ 200 g ha^{-1}. Higher value of weed control efficiency of oxyfluorfen @ 200 and 300 g ha^{-1} made them effective in controlling weeds without showing phytotoxicity on potato plant. Prasad and Singh, 1995 reported the efficacy of oxyfluorfen in potato. Among the herbicidal treatments, atrazine @ 1000 g ha^{-1} and pendimethalin @ 0.60 kg ha^{-1} caused stunted growth of potato plant for short period after emergence and crop recovered completely at later part of its growth stages (Mukherjee *et al*., 2012).

Tuber yield

Tuber yield of potato was influenced significantly by different weed management practices (Table 1). Tuber yield was less when the weeds were allowed to compete with crop throughout the crop period in the control plot but the yield increased incidentally

Table 1. Effect of treatments on density and biomass of dominant weeds, WCE and tuber yield (pooled)

Treatment	Weed density m^{-2}		Weed biomass g m^{-2}		WCE%		Tuber yield
	15DAA	30DAA	15DAA	30DAA	15DAA	30DAA	(t ha^{-1})
T_1	9.73 (94.11)	11.04 (121.44)	49.35	68.60	0.00	0.00	21.605
T_2	7.28 (52.44)	8.64 (74.11)	12.71	20.17	74.25	70.60	28.173
T_3	7.00 (48.56)	7.84 (60.89)	11.88	22.70	75.93	66.91	34.706
T_4	6.85 (46.44)	7.50 (55.78)	10.53	17.33	78.66	74.74	35.032
T_5	7.74 (59.44)	7.96 (62.89)	20.72	18.67	58.01	72.78	31.675
T_6	7.93 (62.44)	8.27 (67.89)	15.67	20.21	68.25	70.54	30.204
T_7	6.50 (41.78)	7.86 (61.33)	13.81	19.11	72.02	72.14	31.101
CD (P=0.05)	1.02	1.12	6.327	7.17	-	-	3.028

T_1- Unweeded control, T_2- Oxyfluorfen @ 100 g a.i. ha^{-1}, T_3- Oxyfluorfen @ 200 g a.i. ha^{-1}, T_4- Oxyfluorfen @ 300 g a.i. ha^{-1}, T_5- Atrazine @ 1000 g a.i. ha^{-1}, T_6- Pendimethalin @ 1500 g a.i. ha^{-1}, T_7- Farmer practice (Hand weeding twice at 15 and 30 DAP)
**Figures in the parenthesis are original values which are subjected to square root transformation $\sqrt{(x+1)}$.*

when the weeds were controlled either by herbicides or hand weeding twice due to elimination of weeds during critical crop-weed competition (Yadav and Kumar, 2011). Highest tuber yield was recorded to the treatment of oxyfluorfen @ 300 g a.i. ha^{-1} (35.032 t ha^{-1}) which is statistically at par with oxyfluorfen @ 200 g a.i. ha^{-1} (34.706 t ha^{-1}) which gave significantly higher than other treatments used in the experiment. Among all the treatments unweeded control gave the lowest tuber yield (21.605 t ha^{-1}) over all other treatments. From the above discussion it is quite evident that oxyfluorfen produced the maximum tuber yield of potato mainly due to the fact that this treatment allowed minimum crop-weed competition at the critical period of crop growth resulting favourable condition of greater synthesis of carbohydrates and their translocation. Regarding percentage increase in yield over unweeded control, the highest yield increase (62.15%) was obtained from the treatment oxyfluorfen @ 300 g ha^{-1} followed by the treatments oxyfluorfen @ 200 g ha^{-1} (60.64%), atrazine @ 1000 g a.i. ha^{-1} (46.61%), farmer's practice (43.95%) and pendimethalin @ 1500 g a.i. ha^{-1} (39.80%). The lowest yield increment (30.40%) was obtained from the treatment oxyfluorfen@ 100 g ha^{-1}) over the unweeded control.

Microflora population

Initially, total bacteria recorded no significant variations under different treatments. The population of total bacteria decreased up to 10 DAA as compared to the observation before spraying and then increased for herbicidal treatments (Table 2). Farmer practice and control recorded steady but very slow increase of the population. At 60 DAA, treatments recorded 32.89 to 206.21% (Fig. 1) higher population of total bacteria than initial count. At 60 DAA, T_4 recorded highest population of total bacteria which was statistically at par with T_3. Farmer practice recorded least population at 60 DAA. The decrease in the population up to different dates was due to competitive influence and the toxic effect as well as different persistence periods of different chemical herbicides in different soil ecosystems. On the other hand, the increase was affected by the commensalic or

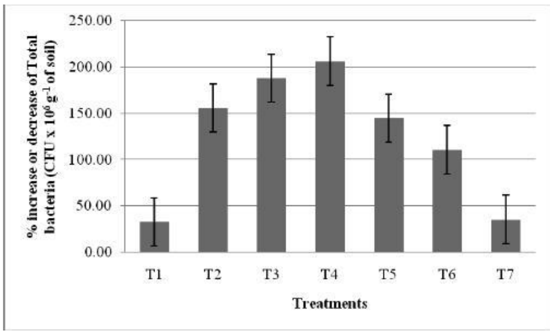
Table 2. Effect of herbicides on total bacteria, fungi and actinobacteria in potato rhizosphere (pooled)

Treatment	Total bacteria (CFU x 10^6 g^{-1} of soil)					Fungi (CFU x 10^4 g^{-1} of soil)					Actinobacteria (CFU x 10^5 g^{-1} of soil)				
	Initial	3 DAA	10 DAA	30 DAA	60 DAA	Initial	3 DAA	10 DAA	30 DAA	60 DAA	Initial	3 DAA	10 DAA	30 DAA	60 DAA
T_1	1.58_a (38.25)	1.61_a (40.83)	1.64_a (43.17)	1.66_a (45.83)	1.71_d (50.83)	1.65_a (44.75)	1.68_a (47.58)	1.70_a (49.58)	1.79_a (61.33)	1.91_b (80.75)	1.56_a (36.58)	1.57_a (37.33)	1.58_a (38.33)	1.59_b (39.08)	1.66_d (45.50)
T_2	1.60_a (40.17)	1.30_b (19.75)	1.19_b (15.42)	1.59_a (39.17)	2.01_b (102.83)	1.67_a (46.42)	1.36_c (23.17)	1.49_b (31.00)	1.65_b (44.42)	1.98_a (94.75)	1.58_a (38.25)	1.43_c (27.00)	1.36_c (22.75)	1.56_b (36.17)	1.76_b (57.50)
T_3	1.59_a (38.83)	1.25_b (17.67)	1.16_b (14.33)	1.57_a (37.17)	2.05_a (111.83)	1.69_a (49.08)	1.52_b (33.25)	1.57_b (37.00)	1.61_b (40.58)	1.98_a (96.42)	1.55_a (35.83)	1.35_d (22.33)	1.28_d (19.08)	1.48_c (30.42)	1.79_a (62.17)
T_4	1.57_a (37.50)	1.20_b (16.00)	1.11_b (13.00)	1.53_a (34.17)	2.06_a (114.83)	1.64_a (44.08)	1.49_b (30.58)	1.55_b (35.50)	1.65_b (44.67)	2.00_a (99.42)	1.59_a (38.83)	1.30_d (20.08)	1.27_d (18.75)	1.44_d (27.33)	1.80_a (63.17)
T_5	1.57_a (37.50)	1.08_c (12.00)	0.90_c (8.00)	1.59_a (39.17)	1.96_c (91.83)	1.66_a (46.17)	1.49_b (30.67)	1.55_b (35.33)	1.59_c (38.83)	1.97_a (92.42)	1.57_a (37.25)	1.51_b (32.33)	1.46_b (29.17)	1.51_c (32.58)	1.74_c (54.58)
T_6	1.59_a (39.17)	1.02_c (10.50)	1.14_b (13.92)	1.57_a (37.17)	1.92_c (82.58)	1.69_a (48.42)	1.51_b (32.50)	1.51_b (32.33)	1.65_b (45.08)	1.98_a (95.08)	1.58_a (37.92)	1.49_b (30.83)	1.46_b (28.83)	1.46_d (29.00)	1.76_b (58.17)
T_7	1.58_a (38.25)	1.59_a (39.08)	1.62_a (41.92)	1.68_a (48.25)	1.71_d (51.83)	1.66_a (45.42)	1.67_a (47.08)	1.69_a (49.33)	1.78_a (60.17)	1.90_b (79.08)	1.57_a (36.92)	1.58_a (38.33)	1.60_a (39.50)	1.63_a (42.17)	1.71_c (51.33)
SEm (±)	0.11	0.09	0.07	0.05	0.18	0.14	0.07	0.09	0.12	0.14	0.12	0.05	0.05	0.08	0.13

*T_1- Unweeded control, T_2- Oxyfluorfen @ 100 g a.i. ha^{-1}, T_3- Oxyfluorfen @ 200 g a.i. ha^{-1}, T_4- Oxyfluorfen @ 300 g a.i. ha^{-1}, T_5- Atrazine @ 1000 g a.i. ha^{-1}, T_6- Pendimethalin @ 1500 g a.i. ha^{-1}, T_7- Farmer practice (Hand weeding twice at 15 and 30 DAP)*Figures in the parenthesis are original values which are subjected to log transformation $log_{10}(x)$.*In vertical columns means followed by similar letters as subscripts are non significant (P = 0.05) by DMRT.*

proto-cooperative influence of various micro-organisms on total bacteria in the *rhizosphere* of potato. For all the cases of herbicidal treatments, total bacteria recovered from initial loss and exceeded than initial counts (Ghosh *et al.,* 2012).

Fungi contributed the maximum portion of microbial biomass among the microorganisms. There were no significant variations among the treatments regarding fungi populations initially. The populations of fungi decreased on 3 DAA as compared to the observation before spraying of herbicidal treatments. The fungal population decreased after application and then it

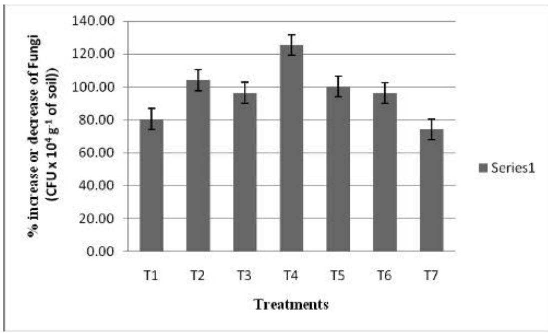


T_1- Unweeded control, T_2- Oxyfluorfen @ 100 g a.i. ha^{-1}, T_3- Oxyfluorfen @ 200 g a.i. ha^{-1}, T_4- Oxyfluorfen @ 300 g a.i. ha^{-1}, T_5- Atrazine @ 1000 g a.i. ha^{-1}, T_6- Pendimethalin @ 1500 g a.i. ha^{-1}, T_7- Farmer's practice (Hand weeding twice at 15 and 30 DAP)*Error bar denotes the standard error

Fig. 1. Influence of herbicides on total rhizosphere bacteria in potato 60 DAA

recovered its population at 60 DAA (Table 2). This might be due to the toxic effect or ammensalic or competitive influence of various micro-organisms on the population of fungi in the *rhizosphere* soil of potato. From 10 DAA the population is again significantly increased in all the treatments because chemicals are degraded at that time and no toxic effect in the soil remained after the persistence period of the concerned herbicides. But in case of farmer practice and unweeded control, it showed slow and steady increase of fungi population. The treatments recorded 74.11 to 125.54 % higher population of fungi than control at 60 DAA (Fig. 2). The treatment, T_2, T_3, T_4, T_5 and T_6 were statistically at par among themselves at 60 DAA.

The fate of actinobacteria was more or less similar as bacteria. The populations of actinobacteria in the *rhizosphere* soil of potato decreased on 10 DAA as compared to the observation before spraying and then increased on 30 DAA (Table 2) for the herbicidal treatments. The treatments recorded 24.38 to 73.51 % higher population of actinobacteria than control at

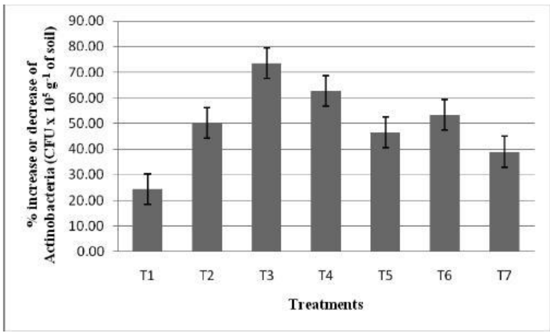


T_1- Unweeded control, T_2- Oxyfluorfen @ 100 g a.i. ha^{-1}, T_3- Oxyfluorfen @ 200 g a.i. ha^{-1}, T_4- Oxyfluorfen @ 300 g a.i. ha^{-1}, T5- Atrazine @ 1000 g a.i. ha^{-1}, T_6- Pendimethalin @ 1500 g a.i. ha^{-1}, T_7- Farmer's practice (Hand weeding twice at 15 and 30 DAP)*Error bar denotes the standard error

Fig. 2. Influence of herbicides on rhizosphere fungi of potato at 60 DAA

60 DAA (Fig. 3). This might be due to the competitive influence of various micro-organisms on the population of actinobacteria in the *rhizosphere* soil of potato as well as toxic effect of the chemicals applied. Sapundjieva *et al.* (2008) reported similar findings.

Therefore the testing herbicide did not show any adverse effect on the soil of the experimental field of potato and was safe in comparison to untreated



*T_1- Unweeded control, T_2- Oxyfluorfen @ 100 g a.i. ha^{-1}, T_3- Oxyfluorfen @ 200 g a.i. ha$_{-1}$, T_4- Oxyfluorfen @ 300 g a.i. ha$_{-1}$, T_5- Atrazine @ 1000 g a.i. ha$_{-1}$, T_6- Pendimethalin @ 1500 g a.i. ha$_{-1}$, T_7- Farmer's practice (Hand weeding twice at 15 and 30 DAP)*Error bar denotes the standard error*

Fig 3. Influence of herbicides on rhizosphere actino bacteria of potato at 60 DAA

control. All the treatments recorded no detrimental effect on soil microflora (total bacteria, actinobacteria and fungi) in the long run though the application of herbicides decreased the microflora population initially. With the degradation of applied herbicides within a considerable time, the population even exceeded at 60 DAA than the initial count. Similar findings were recorded by Sokolova and Gulidova, 2010.

From the above study, it could be concluded that herbicidal treatments did not show any long run adverse effect on the soil of the experimental field of potato and was safe in comparison to untreated control. Considering the tuber yield as well as soil microflora population (total bacteria, actinobacteria and fungi) pre-emergence application of oxyfluorfen @ 200 g ha$_{-1}$ followed by one earthing up at 45DAP can be alternative against farmer practice.

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