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Weed Dynamics and Yield of Potato As Influenced By Weed Management Practices

Chaitan Soren[1*], Korla Aditya Chowdary[1], Gokenapally Sathish[2] and Bikas Chandra Patra[1]

[1]Department of Agronomy, [2]Department of Agricultural Statistics,

Bidhan Chandra KrishiViswavidyalaya, Mohanpur, Nadia, West Bengal, India – 741252

*Corresponding Author E-mail: chaitan_agronomy@rediffmail.com

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ABSTRACT

A field experiment was conducted during the rabi season of 2015-16 and 2016-17 at Regional Research Sub-station, Raghunathpur, Bidhan Chandra Krishi Viswavidyalaya, Purulia, West Bengal to evaluate the bio-efficacy of post emergence herbicide application as well as influence on yield of potato. The treatments were arranged in a Randomized Block Design (RBD) with four replications. Results of this study indicated that hand weeding recorded superiority over remaining treatments; however, it required a lot of man force and time which was uneconomic to the farmer's point of view. Among the herbicides, Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1} recorded the lowest weed density and dry weight. Hand weeding recorded significantly higher tuber yield (24.13 t ha^{-1}) followed by Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1} (21.67 t ha^{-1}) which was at par with Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1} (17.45 t ha^{-1}). Lowest tuber yield (14.54 t ha^{-1}) was recorded in unweeded control plot. It revealed that total bacteria population in Paraquat Dichloride 24% SL applied plots did not show any significant influence on the population of total bacteria in Rhizosphere soil as compared to the initial population. The data on the population of fungi in Rhizosphere region at harvest, showed slight increment than the initial one and the similar trend was also found in the case of Actinomycetes population. Paraquat Dichloride 24% SL @ 2.0 litre ha^{-1} was proved to be superior in terms of weed control, increased crop yield and microbial population in the rhizosphere and it can be recommended as a post-emergence herbicide in potato for effective and eco-friendly weed control to obtain higher tuber yield.

Key words: *Herbicide, Potato, Weed control efficiency, Microbial population, Yield*

INTRODUCTION

Potato is the world's most important root and tuber crop worldwide. It is grown in more than 125 countries and consumed almost daily by more than a billion people. The potato production in the country has increased from 43.4 million tonnes to 46.5 million tonnes in the current year (2016-17) which is 7.2% higher than the previous year (2015-16). It is an economically important staple food in both developed and developing countries because of its high yield potential and rich nutritive value.

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India is the second largest potato producing country in the world after China. With annual production of 43.8 million tonnes from an area of 2.12 million hectares (Source: Department of Agriculture, Co-operation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India, 2016-17). In West Bengal, it is also occupying 386.61 hectares of the area with a production of 11,591.30 tonnes and 29,982 kg ha^{-1} productivity in 2016-17 (Horticulture Division, Ministry of Agriculture, Govt. of West Bengal, 2017). Potato is one of the most important vegetable crops and at present it has emerged as a fourth most important food crop in the world after rice, wheat and maize[16]. It is also known as the poor man's food. It plays a major role in Indian economy. It has cosmopolitan application in wide range of fields. There are so many factors that affect the potato tuber yield. One of the major problems in the area is posed by the weeds; decrease in tuber yield to the extent of 30-50% has been reported due to weed interference in potato under different agro-ecological situation[9]. Uncontrolled weed growth reduces the tuber yield to the tune of 18-82% depending on types of weed flora, their intensity and duration of crop-weed competition[17]. A broad spectrum of grasses and broad leaved weeds infests potato fields. These weeds can cause substantial yield reduction if not satisfactorily controlled. Weed management techniques like manual and herbicidal methods are found to be effective in controlling different groups of weeds in cropped fields[34]. Hand weeding in potato is very costly and injured roots. Chemical weed control greatly reduces yield losses and its regarded as a useful supplement to mechanical weed control[33]. Manual weeding is often difficult due to an adequate supply of labour in proper time, higher cost and non-workable condition of the labour[32]. Today, high-yielding agriculture heavily depends on herbicides, as they constitute a vital and integral component of weed management practices[5]. Herbicides are truly essential to a good tuber yield of potato crop by suppressing different types of weeds. Soil microbial population in soil was suppressed due to application of metribuzin 0.35 kg ha^{-1} and fluchloralin 1.0 kg $ha^{-}1$, but simultaneous application of FYM @ 10 t $ha^{-}1$ supported the proliferation of microbial population[26]. Considerable yield reduction due to weed infestation in potato has been reported by[37]. All the combination of atrazine 0.75 and 0.5 kg ha^{-1} with isoproturon 1.0 and 0.75 and pendimethalin 0.9 and 0.6 kg ha^{-1}except atrazine 0.50 kg ha^{-1} + isoproturon 0.75 kg ha^{-1} and atrazine 0.50 kg + pendimethalin 0.6 kg ha^{-1} atrazine at 1.0 kg ha^{-1}, isoproturon at 1.25 kg ha^{-1} and pendimethalin at 1.25 kg ha^{-1}, hand weeding twice and farmers practices being statistically similar produced significantly higher tuber yield than weedy check[29]. However, unchecked weed growth throughout the growing period was also caused 52% reduction in tuber yield of potato[31]. There are very few herbicide options available forweed control in potato. Maximum reduction in crop yield due to presence of weed by 34.4% and 37.2% during first year and second year respectively was found under weedy check plot followed farmer's practices compared to weedfree treatment[38]. Though herbicides decreased the micro-flora initially but there was no detrimental effect in the long run[8]. The weeds can cause productivity losses upto 80%, depending upon agro-ecological zones and crop management practices[20], Mandany *et al*.[22], were also reported that with increasing duration of weed interference, the number of potato stems decline that finally potato yield significantly decreased. Hassan is the major potato growing district in the state with an area of 25,000 ha producing 314750 tonnes of potato tubers with a productivity of 12.59 t $ha^{-}1$which contributes nearly 60% of total production of potato crop in the state[14]. Keeping all these in view, the present study was carried out to determine how well selected post- emergence herbicides worked when applied at normal use rates for weed control instead of others herbicides towards environmental sustainability and increased potato tuber yield.

MATERIAL AND METHODS

Experimental site:

The experiment was conducted at Regional Research Sub-station, Raghunathpur, Bidhan Chandra Krishi Viswavidyalaya, Purulia, West Bengal in two consecutive years of 2015-16 and 2016-17. The study area belongs to humid and tropical climate characterised by a wet monsoon season (June to September) and a dry post-monsoon season. The experimental site was situated at 23.55°N latitude and 86.67°E longitude with the altitude of 155 meters above the mean sea level (MSL). The soil characteristics were given in Table1.

Table 1: Basic physical, chemical and microbiological properties of the soil in the study area

Sand (%)	55.5	
Silt (%)	21.7	Piper, 1966
Clay (%)	16.85	
pH	5.47	Jackson,1973
EC (dsm^{-1})	0.14	Jackson,1973
Organic carbon (%)	0.57	Jackson, 1973
Total N (%)	0.045	Jackson, 1973
Available P_2O_5	24.71	Jackson, 1973
Available K_2O	210.13	Jackson, 1973
Total bacteria (CFU x 10^6 $g^{-1}$of soil)	72.12	Thornton, 1922
Fungi (CFU x 10^4 g^{-1} of soil)	9.28	Martin, 1950
Actinomycetes (CFU x 10^5 $g^{-1}$of soil)	96.24	Jensen, 1930

Experimental design and treatments:

The experiment was laid out in Randomized Block Design. There were 6 treatment combinations with four replications. The treatments were :-T_1-Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}, T_2- Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1},T_3-Oxyfluorfen23.5% EC @ 0.425lit ha^{-1},T_4-Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1},T_5- hand weeding at 20 and 40 DAT and T_6- Weedy check. The individual plot size was 5m × 4m.

Crop management:

The potato variety Kufri Chandramukhi was planted on 10-11-2015 and 12-11- 2016 and harvested on 14-02-2016 and 18-02-2017 respectively taking a total duration of 96 and 98 days. The seed rate of 20 q ha^{-1} and spacing 60cm × 20cm. The recommended fertilizer dose of 250:150:150 kg N, P_2O_5 and K_2O ha^{-1} were used for the crop. 50% N along with afull dose of P_2O_5 and K_2O were applied as basal at the time of final land preparation and the rest amount of nitrogen was applied at 30 days after transplanting (DAT) or at the time of first irrigation. The herbicide Paraquat Dichloride 24% SL was sprayed as post- emergence treatments (*i.e.* 20 DAT) or 5-10% emergence of potatoes and Oxyfluorfen 23.5% EC was sprayed as pre-emergence treatments (*i.e.* 2 DAT) using a water volume of 500 litres ha^{-1} with knapsack sprayer fitted with flat fan deflector nozzle.

Plant and weed sampling:

The population of different types of weeds (Grasses, Broadleaf & sedge) and were recorded at 30, 45 and 60 DAA (Days after herbicide Application). A quadrate with a dimension of 1 m × 1 m was placed randomly at three places in each plot and the weeds from

that area were counted and expressed as number per square meter. Weeds belonging to three categories obtained in the population at 30, 45 & 60 DAA (Days after herbicide application) were labelled properly. The labelled samples were then sun-dried for 24 hours and then oven dried at 70^{o}C for 72 hours. The dry weight of weeds was then taken and recorded separately. For measuring the potato tuber yield, the entire produce from the net plot area (from the demarcated portion, leaving the border area) was harvested and weighed after proper drying under the sun. Data on tuber yield was recorded at the time of harvest of the Potato. The tuber yield of potato in kg plot^{-1} was recorded harvesting of the potato and expressed as Tons ha^{-1}. Weed control efficiency is expressed as the percentage of control of weeds over unweeded control. It denotes the efficiency of the applied herbicide for comparison purpose. WCE of different treatments was computed on the basis of weed dry weight by using the following formula,

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where,

DWC = Dry weight of weeds in untreated control plot

DWT = Dry weight of weeds in treated plot

Soil sampling:

Soil samples from the experimental plots were collected from the space between the rows at a depth 0-30 cm after harvesting of the Potato crop.The soil sample from the different places per replicates for the same weed control treatment was pulled together and then requisite composite samples of each treatment were taken for microbial population by following standard methods.

Statistical analysis:

Data were analysed using analysis of variance (ANOVA) following randomised block design[12]. Differences were considered significant at 5% level of probability.

RESULTS

The important weed flora observed in the experimental plot was *Echinochloa colona, Digitaria sanguinalis, Eleusine indica, Cyperus rotundus, Chenopodium album, Anagallis arvensis, Trianthema monogyna, Fumaria parviflora, Digera arvensis, Alternanthera philoxeroides.*

Weed density and dry weight:

Weeds type and severity of weed infestation in field crops are considered the precursor of yield loss in a crop. Therefore, timely control of weeds is very necessary for realizing an optimum yield of any crop. The pooled data of two years pertaining to weed density and dry weight were given in table 2 to table 7. All the weed management treatments significantly reduced weed density and weed dry weight as compared to the weedy-check when observed at 30, 45 and 60 DAA. Among the herbicides Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1} recorded lowest weed density and dry weight followed by Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}.Hand weeding twice at 20 and 40 DAT significantly recorded the lowest weed density and dry weight at 30, 45 and 60 DAA compared to other management practices.

Weed control efficiency

Data regarding Weed Control Efficiency (Table 8 to 10), revealed that highest weed control efficiency was recorded in hand weeding twice at 20 and 40 DAT at 30, 45 and 60 DAA. Among the herbicides Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1} recorded highest weed control efficiency followed by Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}.

Crop Yield

The pooled data of potato tuber yield was given in Table 11 reveals that hand weeding gives significantly higher tuber yield (24.13 t ha^{-1}) followed by Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1} (21.67t ha^{-1}) which is at par with

Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1} (17.45t ha^{-1}). Lowest tuberyield (14.54 t ha^{-1}) was observed in control plot.

Microbial population

Data given in Table 12 reveals that total bacteria population in Paraquat Dichloride 24% SL applied plots did not show any significant influence on the population of total bacteria in Rhizosphere soil at the initial stage. But at harvest the population had been increased slightly as compared to the initial observation. The data on the population of fungi in Rhizosphere region at harvest, showed slightly higher than the initial one. Like the bacteria and fungi, similar trend was also found in the case of Actinomycetes population. However, in all the three cases (total bacteria, fungi and actinomycetes) the herbicide treatments did not vary significantly among themselves. Since the effect of herbicide treatments on the beneficial soil microbes may be considered as safer to the soil beneficial microbes.

DISCUSSION

Weed density and dry weight

The better performance of these herbicides might be due to longer persistence effect. Whereas under hand weeding, it could be attributed to the reduced crop-weed competition in the initial stage and removal of the late emerged weeds by hand weeding at 40 days[13,31,34]. In addition to this, dense crop canopy might have suppressed weed growth and ultimately less biomass. The weedy check recorded significantly the highest number and dry weight of weeds owing to uncontrolled condition favoured luxurious weed growth leading to increased density and dry matter of weeds[7,20,24.]. The reduced weed biomass is might be due to using of selective postemergence herbicides for controlling different weed species in maize[2,6,20].

Weed control efficiency

This result further indicates that herbicides are more effective in reducing density and dry weights of weeds next to hand weeding as compared to weedy check[35]. Better weed control efficiency of herbicides along with weedfree condition might be due to effective weed control obtained under hand weeding, application of herbicides mixture at initial and early growth stage, which resulted in the lowest weed counts and finally reduced the total dry weight of weeds at harvest[11].

Crop Yield

The improved growth and yield under these treatments might be due to the periodical removal of weeds by hand weeding or herbicide application as evidenced by less weed density, weed dry weight and weed control efficiency compared other weed management practices. It clearly indicated that there was less competition for nutrient, moisture and light in this treatment as compared other treatments[7,10,24,31]. A significant difference in grain and straw yields of maize was observed might be due to minimum weed seed bank and eradication of weeds providing a healthy environment for crop plant growth[30]. Totally, the result showed that application of herbicide led to a reduction of damages caused by weeds, also, it was determined that using of 2,4 D Ethyl Ester 38% EC had the highest effect on weed control in comparison to control resulted in increased straw and grain yield[6].

Microbial population

The toxic effects of herbicides are normally most severe immediately after application. Later the population was increased might be due to the reason thatmicroorganismsinitiate degradation process, and then the degraded herbicides release carbon-rich substrates which in turn maximize the microbial population in the root zone[1]. A hormone herbicide 2,4-D decomposes into the soil very fast. In general, herbicides affect soil microbial population indirectly. Herbicides act as a source of nutrition for microbes, in which case they significantly affect microbial growth and multiplication[25]. Hand weeding rendered a significant increase in the population of microorganisms in soil is might be due to the influence of available nutrients stimulatory to the soil microflora[19].

Table 2: Population of weed flora (per m^2) at 30 days after application of herbicides

Treatments	*Chenopodium album*	*Anagallis arvensis*	*Trianthema monogyna*	*Cyperus rotundus*	*Fumaria parviflora*	Other Weeds
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	3.82 (2.07)	2.81 (1.81)	2.14 (1.62)	7.02 (2.74)	4.24 (2.17)	4.69 (2.27)
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	1.59 (1.45)	1.24 (1.32)	0.91 (1.18)	2.58 (1.75)	1.82 (1.52)	2.03 (1.59)
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	2.35 (1.69)	2.25 (1.66)	1.59 (1.45)	4.24 (2.17)	2.59 (1.76)	3.02 (1.88)
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	2.25 (1.66)	2.02 (1.59)	1.58 (1.44)	3.91 (2.10)	2.46 (1.72)	2.81 (1.82)
Weed free check	1.35 (1.36)	1.13 (1.28)	0.69 (1.09)	2.35 (1.69)	1.68 (1.48)	1.91 (1.55)
Control	15.24 (3.97)	11.68 (3.49)	9.02 (3.09)	28.13 (5.35)	16.82 (4.16)	18.62 (4.37)
CD at 5 %	0.78	NS	NS	0.90	0.70	0.56

Table 3: Population of weed flora (per m^2) at 45 days after application of herbicides

Treatments	*Chenopodium album*	*Anagallis arvensis*	*Trianthema monogyna*	*Cyperus rotundus*	*Fumaria parviflora*	Other Weeds
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	4.12 (2.15)	3.36 (1.96)	2.68 (1.78)	7.59 (2.84)	4.80 (2.30)	5.35 (2.42)
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	1.91 (1.55)	1.58 (1.44)	1.13 (1.28)	3.24 (1.93)	2.13 (1.62)	2.58 (1.75)
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	2.90 (1.84)	2.58 (1.75)	2.03 (1.59)	4.69 (2.28)	3.02 (1.88)	3.47 (1.99)
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	2.80 (1.82)	2.35 (1.69)	2.03 (1.59)	4.59 (2.26)	3.01 (1.87)	3.36 (1.96)
Weed free check	1.69 (1.48)	1.47 (1.40)	1.02 (1.23)	2.81 (1.82)	2.03 (1.59)	2.36 (1.69)
Control	16.91 (4.17)	13.47 (3.74)	10.69 (3.35)	29.92 (5.52)	18.69 (4.38)	21.47 (4.69)
CD at 5 %	0.38	NS	NS	0.93	0.74	0.60

Table 4: Population of weed flora (per m^2) at 60 days after application of herbicides

Treatments	*Chenopodium album*	*Anagallis arvensis*	*Trianthema monogyna*	*Cyperus rotundus*	*Fumaria parviflora*	Other Weeds
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	6.13 (2.57)	4.91 (2.33)	3.82 (2.08)	10.58 (3.33)	6.59 (2.66)	8.02 (2.92)
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	2.25 (1.66)	1.91 (1.55)	1.36 (1.36)	4.13 (2.15)	2.58 (1.75)	3.02 (1.88)
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	3.46 (1.99)	3.03 (1.88)	2.25 (1.66)	5.69 (2.49)	3.68 (2.04)	4.24 (2.18)
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	3.25 (1.94)	2.92 (1.85)	2.24 (1.66)	5.58 (2.47)	3.59 (2.02)	4.02 (2.13)
Weed free check	2.05 (1.60)	1.71 (1.49)	1.25 (1.32)	3.82 (2.08)	2.35 (1.69)	2.58 (1.75)
Control	18.47 (4.36)	15.05 (3.94)	11.48 (3.46)	32.58 (5.75)	20.27 (4.56)	24.70 (5.02)
CD at 5 %	0.90	NS	NS	1.01	0.80	0.67

Table 5: Dry mass of weed flora (g per m^2) at 30 days after application of herbicides

Treatments	*Chenopodium album*	*Anagallis arvensis*	*Trianthema monogyna*	*Cyperus rotundus*	*Fumaria parviflora*	Other Weeds
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	3.62 (2.03)	2.43 (1.71)	2.27 (1.66)	4.25 (2.18)	4.89 (2.32)	5.71 (2.49)
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	1.66 (1.47)	1.09 (1.26)	0.79 (1.14)	2.07 (1.60)	2.25 (1.66)	2.60 (1.76)
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	2.48 (1.73)	1.76 (1.50)	1.57 (1.44)	2.96 (1.86)	3.22 (1.93)	4.04 (2.13)
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	2.42 (1.71)	1.69 (1.48)	1.47 (1.40)	2.83 (1.82)	3.10 (1.90)	3.83 (2.08)
Weed free check	1.55 (1.43)	1.05 (1.24)	0.77 (1.13)	1.84 (1.53)	1.99 (1.58)	2.34 (1.69)
Control	13.42 (3.73)	9.27 (3.13)	8.49 (3.00)	16.35 (4.10)	18.19 (4.32)	22.12 (4.76)
CD at 5 %	0.77	NS	NS	0.71	0.74	0.62

Table 6: Dry mass of weed flora (g per m^2) at 30 days after application of herbicides

Treatments	*Chenopodium album*	*Anagallis arvensis*	*Trianthema monogyna*	*Cyperus rotundus*	*Fumaria parviflora*	Other Weeds
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	4.65 (2.27)	3.28 (1.94)	3.66 (2.04)	6.02 (2.55)	6.63 (2.67)	7.62 (2.85)
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	2.25 (1.66)	1.56 (1.44)	1.68 (1.48)	2.86 (1.83)	3.12 (1.90)	3.55 (2.01)
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	3.20 (1.92)	2.27 (1.66)	2.53 (1.74)	4.08 (2.14)	4.34 (2.20)	5.43 (2.44)
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	3.05 (1.88)	2.26 (1.66)	2.42 (1.71)	3.86 (2.09)	4.17 (2.16)	5.29 (2.41)
Weed free check	2.12 (1.62)	1.49 (1.41)	1.61 (1.45)	2.68 (1.78)	2.97 (1.86)	3.41 (1.98)
Control	15.58 (4.01)	11.19 (3.42)	12.62 (3.62)	20.65 (4.60)	22.07 (4.75)	27.28 (5.27)
CD at 5 %	0.85	NS	NS	0.81	0.84	0.70

Table7: Dry mass of weed flora (g per m^2) at 60 days after application of herbicides

Treatments	*Chenopodium album*	*Anagallis arvensis*	*Trianthema monogyna*	*Cyperus rotundus*	*Fumaria parviflora*	Other Weeds
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	6.89 (2.72)	4.24 (2.18)	4.58 (2.25)	7.75 (2.87)	8.45 (2.99)	10.63 (3.34)
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	3.77 (2.07)	2.21 (1.65)	2.55 (1.75)	3.88 (2.09)	4.71 (2.28)	5.22 (2.39)
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	5.05 (2.36)	3.14 (1.91)	3.45 (1.99)	5.42 (2.43)	5.96 (2.54)	7.08 (2.75)
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	4.85 (2.31)	3.03 (1.88)	3.38 (1.97)	5.15 (2.38)	5.88 (2.53)	6.89 (2.72)
Weed free check	3.36 (1.96)	2.01 (1.58)	2.09 (1.61)	3.65 (2.04)	4.25 (2.18)	4.68 (2.28)
Control	21.79 (4.72)	13.69 (3.77)	14.80 (3.91)	24.45 (4.99)	27.11 (5.25)	33.33 (5.82)
CD at 5 %	1.03	NS	NS	0.90	0.95	0.79

*Data in the parenthesis are transformed value

**Square root-transformed value of (X+0.5) was used for statistical analysis

Table 8: Weed control efficiency (%) of weed flora at 30 days after application of herbicides

Treatments	*Chenopodium album*	*Anagallis arvensis*	*Trianthemam onogyna*	*Cyperusro tundus*	*Fumariap arviflora*	Other Weeds
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	73.03	73.65	73.35	74.08	73.07	74.10
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	87.62	88.36	90.70	87.26	87.69	88.10
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	81.52	81.06	81.01	81.82	82.28	81.68
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	82.08	81.82	82.76	82.64	82.91	82.64
Weed free check	88.63	88.91	91.34	88.73	88.91	89.20
Control	-	-	-	-	-	-

Table 9: Weed control efficiency (%) of weed flora at 45 days after application of herbicides

Treatments	*Chenopodium album*	*Anagallisar vensis*	*Trianthemamo nogyna*	*Cyperusrot undus*	*Fumariapar viflora*	Other Weeds
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	70.01	70.49	70.97	70.92	69.85	71.82
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	85.58	86.31	86.50	86.12	85.71	86.82
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	79.32	79.36	79.82	80.32	80.26	80.01
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	80.22	80.01	80.83	81.18	81.13	80.39
Weed free check	86.20	86.61	87.19	86.82	86.31	87.24
Control	-	-	-	-	-	-

Table 10: Weed control efficiency (%) of weed flora at 60 days after application of herbicides

Treatments	*Chenopodium album*	*Anagallisa rvensis*	*Trianthemamo nogyna*	*Cyperusrot undus*	*Fumariaparv iflora*	Other Weeds
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	68.23	69.02	68.72	68.02	68.72	67.92
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	82.51	83.82	82.75	84.05	82.38	84.18
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	76.62	77.02	76.42	77.62	77.82	78.52
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	77.36	77.82	77.19	78.75	78.28	79.19
Weed free check	84.52	85.34	85.82	85.04	84.31	85.91
Control	-	-	-	-	-	-

Table 11: Yield (t ha^{-1}) of Potato

Treatments	Yield t ha^{-1}
	Tuber
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	17.45
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	21.67
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	18.59
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	19.09
Weed free check - 20 and 40 DAT	24.13
Control	14.54
CD at 5 %	5.88

Table 12: Influence of herbicides on soil micro-flora at harvest

Treatments	Total bacteria (CFU x 10^6 g^{-1} of soil	Fungi (CFU x 10^4 g^{-1} of soil)	Actinomycetes (CFU x 10^5 g^{-1} of soil)
Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}	72.86	10.56	100.85
Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1}	73.86	10.97	102.81
Oxyfluorfen 23.5% EC @ 0.425 lit ha^{-1}	72.52	10.04	100.24
Oxyfluorfen 23.5% EC @ 0.850 lit ha^{-1}	72.84	10.23	100.58
Weed-free check - 20 and 40 DAT	70.63	7.10	86.91
Control	70.02	6.78	86.08
C.D. (P=0.05)	NS	NS	NS

CONCLUSION

According to the results of this study, hand weeding shown superiority in controlling weed density, weed dry matter and higher control efficiency and potato tuber yield when compared to the remaining treatments. But, it requires a lot of man force which was not economic to the farmer point of view. Among the herbicidal treatments Paraquat Dichloride 24% SL @ 2.0 lit ha^{-1} shown better performance followed by Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}in terms of controlling weeds and increasing crop yield and microbial population in the rhizosphere. As there is no much difference between Paraquat Dichloride 24% SL @ 2.0 lit $ha^{-1}$and Paraquat Dichloride 24% SL @ 1.5 lit ha^{-1}response to yield, microbial population and controlling weeds.Paraquat Dichloride 24% SL @ 2.0 lit $ha^{-1}$was recommended as a post-emergent herbicide in *rabi* potato for effective controlling of weeds and getting higher potato tuber yield.

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