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Bio-efficacy of Ammonium Salt of Glyphosate 71% SG for Weed Dynamics in Tea (*Camellia sinensis* L.) and its Effect on Soil Microflora

Adyant Kumar*, Anannya Ghosh, Dibyendu Mondal, Ratikanta Ghosh* and Pintoo Bandopadhyay

Department of Agronomy, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741252, West Bengal, India
**Corresponding author*

A B S T R A C T

An experiment was conducted at Gurjangjhora Tea Estate, Malbazar, Jalpaiguri during kharif seasons of 2013 and 2014 to find out the efficacy of non-selective ammonium salt of glyphosate 71% SG on weed dynamics in tea and its effect on soil microflora. The experiment was laid out in randomized block design and replicated thrice. The treatment comprised of seven herbicidal treatments viz. ammonium salt of glyphosate 710, 1420, 2130 g a.i. ha^{-1}, standard glyphosate 2130 g a.i. ha^{-1} and paraquat dichloride 2130 g a.i. ha^{-1}, HW at 20 and 40 days after application besides weedy check. Both the weed density and biomass at 40 and 60 days after application of all the weed control treatments were significantly lower than weedy check. Ammonium salt of glyphosate (71% SG) 2130 g ha^{-1} proved significantly better for controlling the major pre-dominant tea weed i.e. Cyperus rotundus and Borreria hispida. The higher WCE (90.28%) was recorded under hand-weeding and ammonium salt of glyphosate (71% SG) 2130 g ha^{-1} (89.10%) at 60 DAS followed by its lower doses. The resurgence of weed flora was observed after two months of application. Herbicides did not show any phytotoxicity symptoms on the matured tea plants throughout the observation period. The herbicidal treatments showed initial detrimental effect on soil microbial (total bacteria, fungi and actinomycetes) population, but no harmful effects were recorded after one month of application.

Keywords

Ammonium salt of glyphosate 71% SG, Bio-efficacy, Phytotoxicity, Soil microflora and Tea.

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Introduction

Tea [*Camellia sinensis* (L) Kuntze] belongs to the family Theaceae. It is the oldest evergreen bush which if kept at low level through pruning, more young shoots and ultimately tea leaves are produced which are processed as beverage. It is most commonly used in the preparation of non-alcoholic caffeine containing beverage. Tea has been consumed socially and habitually by people since 3000 BC but apart from the stringent taste, its medicinal properties are often over looked.

However, traditional healers have long believed that drinking tea is a means of prolonging life. Nutritional and therapeutic importance of tea arise from its unique combination of large number of constituents such as proteins, carbohydrates, amino acids, lipids, vitamins, minerals, alkaloids and polyphenols (Krishnamoorthy, 1987). Hudson *et al.*, (2003) was remarked that previously tea was taken only as a stimulant drink, but today tea plays an important role in human health by activating the central nervous system, which may aid the body's ability to burn calories and unwanted fats through thermogenic process. Tea industry in India has an annual turnover of 35 million USD and provides employment to million people (Anonymous, 2015). A manifold increase in production of tea in India is mainly attributed to efficient and integrated agricultural practices including efficient weed management practices.

Weeds compete with tea crops for nutrient, sunshine, moisture and other resources (Ghosh and Das, 2004). Besides reducing the yield, weeds also have adverse effects on tea *viz.* restricted branching, frame development in young tea, reduce plucking efficiency, harbour and serve as an alternate host for some important insect and disease pests of tea. Depending upon the intensity of weed growth, extent of competition and varied location specific associated tea weed species, weed pest reduces the productivity of tea by 45 to 85% (Anonymous, 1980). Just like other plantation crop, yield of tea can drastically be reduced by weed infestation if weed control is not done in critical weed pest infestation period. Weeds remove 5-6 times more nitrogen, 5-12 times phosphorous and 2-5 times potassium than a beverage crop in the early stages of crop growth leading to low tea yield (Opeke, 2005). Ghosh *et al.,* (2007) working on a new molecule Combi SG at Darjeeling tea garden showed that tea weed could be remain under control atleast five months without affecting the tea leaves quality. Therefore, ecosafe weed pest management is an important practice for an efficient management and sustenance of production in tea crop. Manual and mechanical methods do not present a better option because of time, season and expense involved. Adoption of preventive measures is of great importance as it helps to minimize the weed seed bank in soil, thereby mitigating the present and future weed population (Prematilake, 2013). Chemical control scores over other methods due to their efficiency, cost effectiveness and ease of operation. During the past four decades, a few herbicides have been introduced to control tea weeds as pre- and post-emergence in many countries of the world (Barui *et al.,* 2005). So, in order to control the weed population, there is a need to identify new molecules of herbicides to achieve optimum crop yields. Hence, the present investigation was carried out with the objective to evaluate the efficacy of new molecule herbicide ammonium salt of glyphosate 71% SG against weed management of tea.

Materials and Methods

The experiment was conducted at Sector 5 of the Gurjangjhora Tea Estate, Malbazar, Jalpaiguri during *kharif* seasons of 2013 and 2014. The pH of the experimental plot was 6.6 showing acidic, blackish grey in colour. The experiment was in randomized block design and replicated thrice. The treatments comprised ammonium salt of glyphosate 71% SG @ 710, 1420, 2130 g *a.i.* ha^{-1}, standard glyphosate 71% SG @ 2130 g *a.i.* ha^{-1} and paraquat dichloride 24% SL @ 2130 g *a.i.* ha^{-1} besides HW at 20 and 40 days after application (DAA) and weedy check. The tea variety "TV-36" was planted at a spacing of 100 cm × 100 cm and the age of the crop is about 10 years. The application of the herbicides was done on 07.08.2013 and 08.08.2014 in inter- and intra-rows of the experimented matured tea garden with hooded Knapsack sprayer fitted in a flood jet nozzle WFN 0.040 was used with a spray volume of 500 L ha^{-1}.

The weed density and dry matter was recorded at initial, 40 and 60 DAA by using a quadrate of 50 cm × 50 cm randomly placed at three places in each plot. The weed population were subjected to square root transformation ($\sqrt{x + 0.5}$) before statistical analysis. The observation on green leaf yield was recorded at 60 DAA while the phytotoxicity was visually assessed of crop for injury to leaf tips and leaf surface which was rated in the PRS scale of 1-10 by counting the affected plants through certain phytotoxicity parameters *viz*., chlorosis, necrosis, wilting, scorching, hyponasty and epinasty at 1, 7, 30 and 60 DAA.

Results and Discussion

Effects on weeds

The predominant weed species at initial stage were *Axonopus compressus*, *Imperata cylindrica* and *Digitaria ciliaris* among grasses; *Cyperus arometicus*, *Cyperus rotundus*, *Cyperus difformis* and *Fimbristylis dichotoma* among sedges; whereas *Borreria hispida*, *Borreria setidens*, *Polygonum perfoliatum*, *Oldenlandia diffusa*, *Ageratum conyzoides*, *Amaranthus viridis*, *Euphorbia hirta* and *Ludwigia octovalvis* among broadleaf weeds.

The weeds density and dry weight were controlled by all the herbicidal treatments as compared to weedy check at 40 and 60 DAA (Table 1). Ammonium salt of glyphosate (71% SG) 2130 g *a.i.* ha^{-1} significantly reduced the weeds population and dry weight along with same dose of standard glyphosate and hand weeding treatment. However, ammonium salt of glyphosate (71% SG) at its lower two doses (1420 and 710 g *a.i.* ha^{-1}) was found lesser effective to its higher dose (2130 g *a.i.* ha^{-1}) or even the standard paraquat dichloride 1000 g *a.i.* ha^{-1} for controlling the weeds population and dry weight at 40 DAA and at 60 DAA. Similar finding was also observed by Bhowmick (2010) who reported the positive result of glyphosate on controlling wide spectrum of weeds effectively as glyphosate [N-(phosphonomethyl) glycine], an organo-phosphorus family, is a recommended systemic herbicide for weed control in tea. Being a systemic herbicide, it is absorbed by foliage and then translocate throughout the plant *via* phloem. Once an herbicide molecule finds its place in living tissue of plant, a number of biochemical changes begin to take place. While herbicide molecule alters the metabolism of the plant, the later degrades the structure and activity of herbicide by various biochemical processes. Depending upon the altered nature of herbicide metabolites in the plants, the growth and development of crop plant is affected in terms of both quality and quantity. Glyphosate has been proven as a potent and specific 5-enolpyruvyl shikimate-3-phosphate (EPSP) synthase enzyme inhibitor. The superiority of glyphosate (low-dose high-impact) in weed control has also been reported by many authors (Magambo and Kilavuka, 1982; Ghosh *et al.*, 2007) and thus, it is often considered as quick and easy solution as a systemic herbicide for controlling weeds in agriculture.

Therefore, the ammonium salt of glyphosate (71% SG) 2130 g *a.i.* ha^{-1} recorded the highest WCE (91.67 and 89.10 % at 40 and 60 DAA, respectively) which was followed by its lower doses; and was at par with the standard glyphosate 71% SG @ 2130 g *a.i.* ha^{-1} (90.96 and 88.55 % at 40 and 60 DAA, respectively) in tea crop (Table 1). The higher WCE due to higher doses of glyphosate herbicide was also reported by Bhattacharrya *et al.*, (2003).

Effect on leaf yield of tea

The data on green leaf yield presented in Table 1 revealed that all the treatments significantly recorded highest green leaf yield in comparison to weedy check (0.85 t ha^{-1}).

Table.1 Effect of weed control treatments on weed density and weed dry biomass, weed control efficiency and green leaf yield of tea (pooled data of two years)

Treatments	Dose (g *a.i.* ha^{-1})	Total density (no. m^{-2})		Total dry biomass (g m^{-2})		Weed Control Efficiency (%)		Green Leaf Yield (t ha^{-1})	% Increase in Yield
		40 DAA	60 DAA	40 DAA	60 DAA	40 DAA	60 DAA		
AS Glyphosate 71 SG	710	6.65 (43.66)	9.81 (95.67)	28.27	48.63	59.60	52.90	0.99	16.47
AS Glyphosate 71 SG	1420	4.71 (21.65)	6.52 (41.99)	7.52	13.25	89.26	87.18	1.07	25.88
AS Glyphosate 71 SG	2130	4.06 (16.01)	5.90 (34.34)	5.83	11.26	91.67	89.10	1.14	34.12
Glyphosate 71 SG	2130	4.38 (18.68)	6.18 (37.68)	6.33	11.82	90.96	88.55	1.13	32.94
Paraquat dichloride 24 SL	1000	6.66 (45.67)	8.61 (73.66)	19.81	37.03	71.72	64.18	0.96	12.94
HW at 20 and 40 DAA	-	2.74 (7.01)	4.92 (23.67)	4.87	10.05	93.05	90.28	1.17	37.65
Weedy Check	-	13.50 (181.65)	13.48 (181.33)	70.09	103.43	0.00	0.00	0.85	-
SEm ±		**0.15**	**0.17**	**0.67**	**1.03**	**-**	**-**	**0.02**	**-**
CD at 5%		**0.46**	**0.54**	**2.08**	**3.17**	**-**	**-**	**0.07**	**-**

* Original figures in parentheses were subjected to square-root transformation $\sqrt{x + 0.5}$ before statistical analysis.
SG, Soluble granules; SL, Soluble liquids; HW, hand-weeding; DAA, days after application

Table.2 Phytotoxicity effect of herbicides on tea plants (mean data of two years)

Treatments	Dose (g a.i. ha^{-1})	Mean observations recorded after 1, 7, 30 and 60 days of treatment					
		Leaf injury on tips/surface	**Wilting**	**Necrosis**	**Vein clearing**	**Epinasty**	**Hyponasty**
AS Glyphosate 71 SG	710	0	0	0	0	0	0
AS Glyphosate 71 SG	1420	0	0	0	0	0	0
AS Glyphosate 71 SG	2130	0	0	0	0	0	0
Glyphosate 71 SG	2130	0	0	0	0	0	0
Paraquat dichloride 24 SL	1000	0	0	0	0	0	0

SG, Soluble granules; SL, Soluble liquids; HW, hand-weeding; DAA, days after application

Fig.1 Effect of treatments on total bacteria (CFU × 10^6 g^{-1} of soil) (mean data of two years)

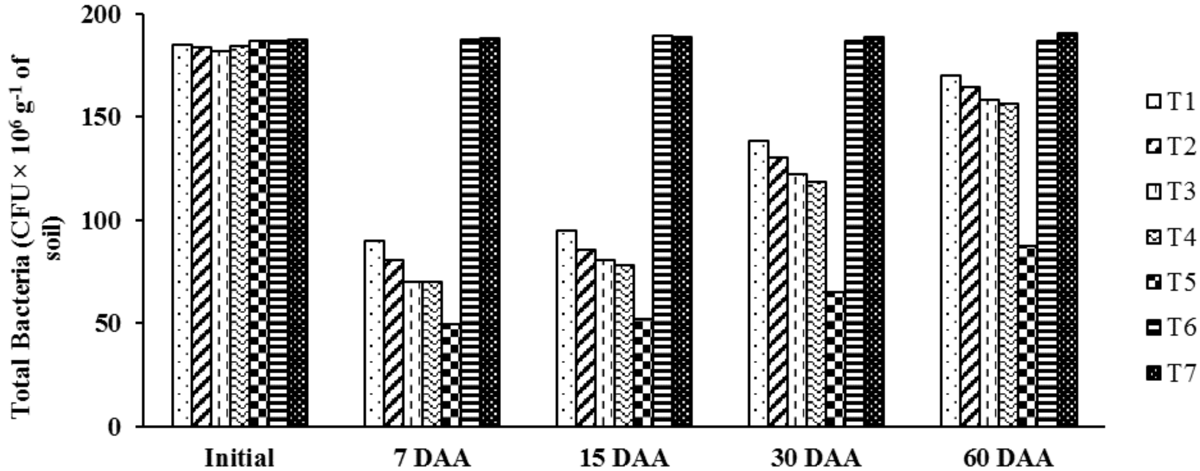


Fig.2 Effect of treatments on total fungi (CFU × 10^4 g^{-1} of soil) (mean data of two years)

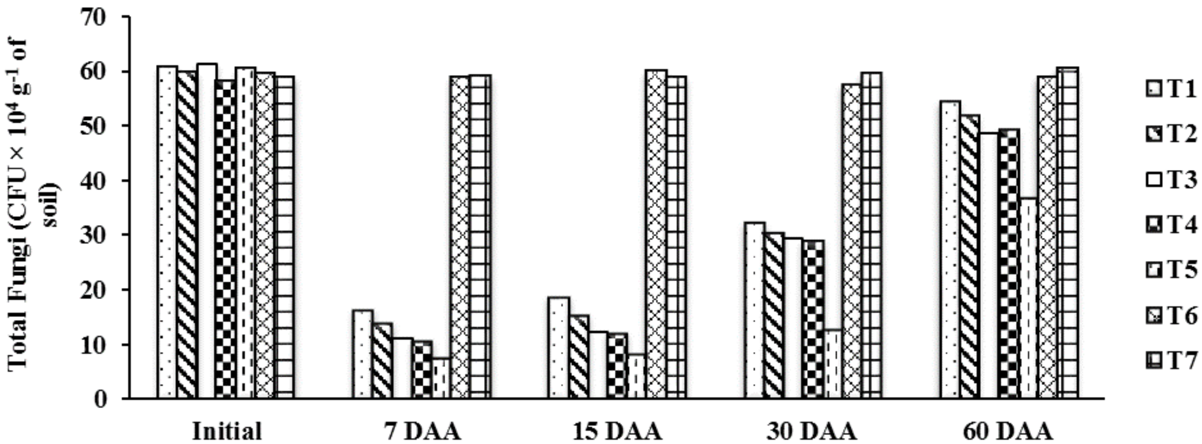


Fig.3 Effect of treatments on total actinomycetes (CFU × 10^5 g^{-1} of soil) (mean data of two years)

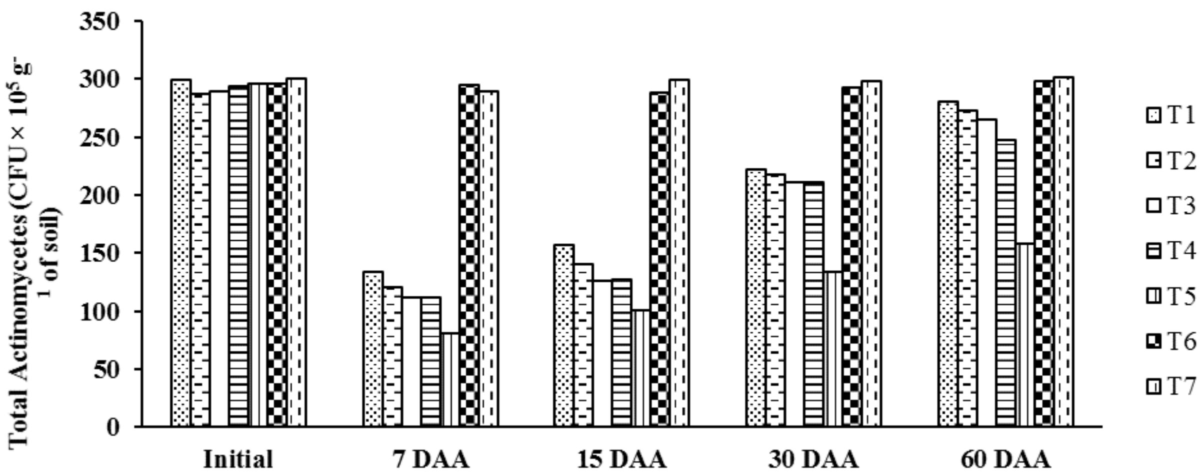


Fig.4 Correlation study of different monocot weed species density (X-axis) and dry biomass (Y-axis) at 40 and 60 days after application of the treatments

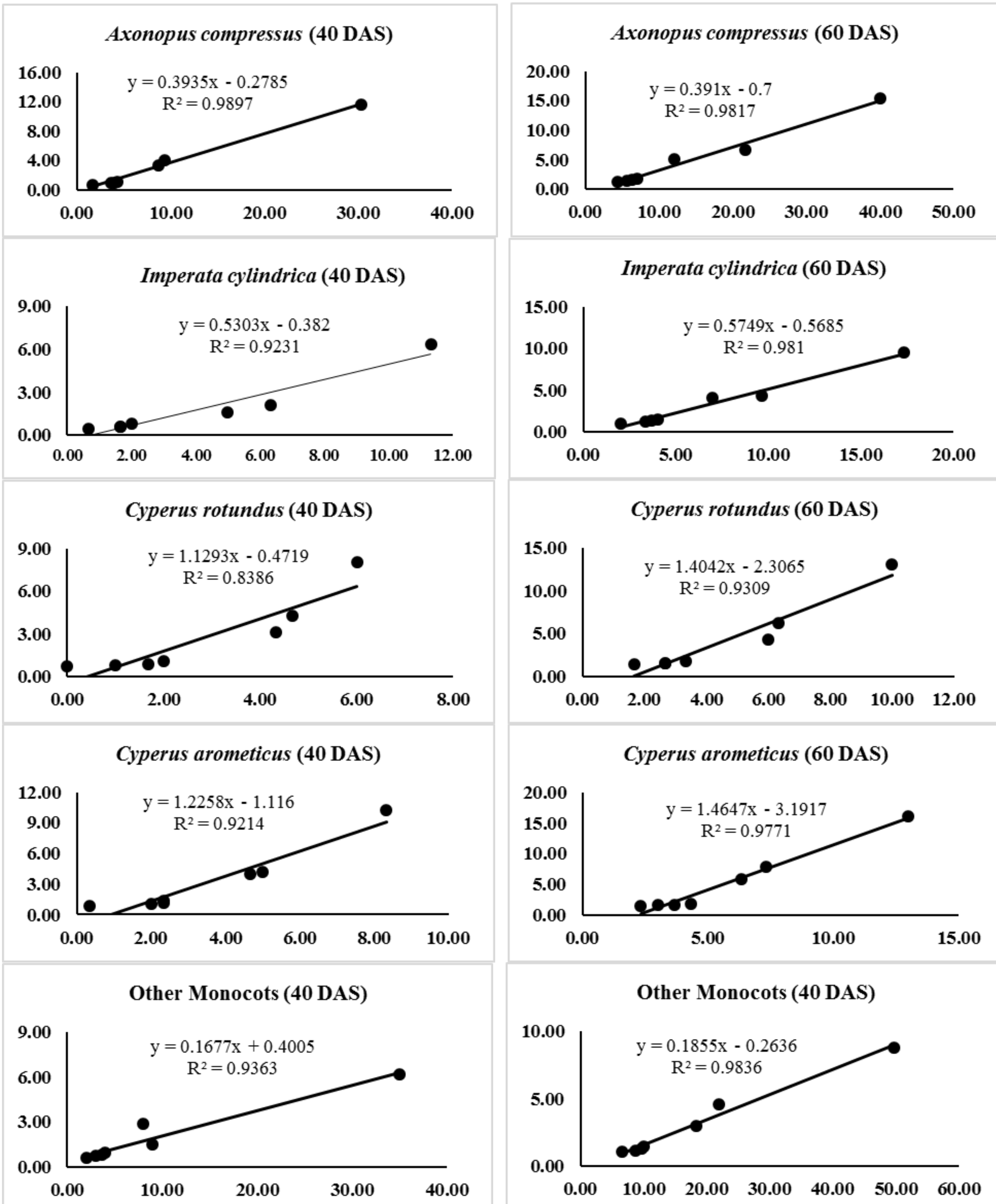


Fig.5 Correlation study of different dicot weed species density (X-axis) and dry biomass (Y-axis) at 40 and 60 days after application of the treatments (mean data of two years)

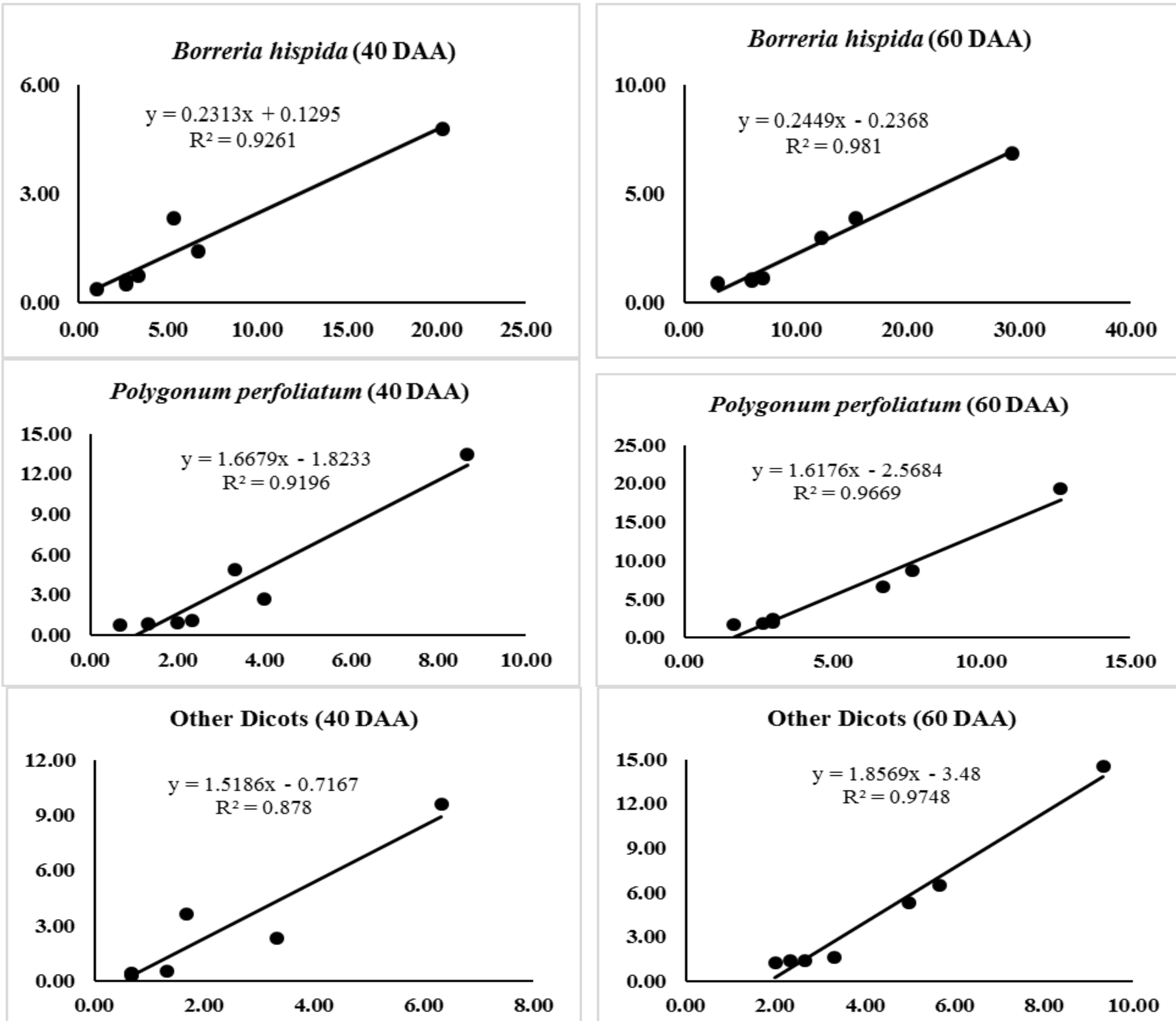


Fig.6 Correlation study of different weed species density (X-axis) and dry biomass (Y-axis) at 40 and 60 days after application of the treatments (mean data of two years)

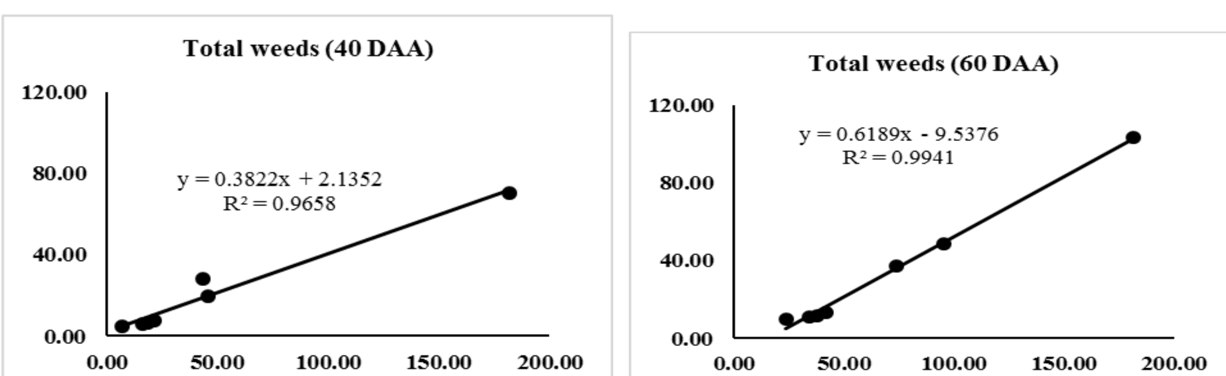
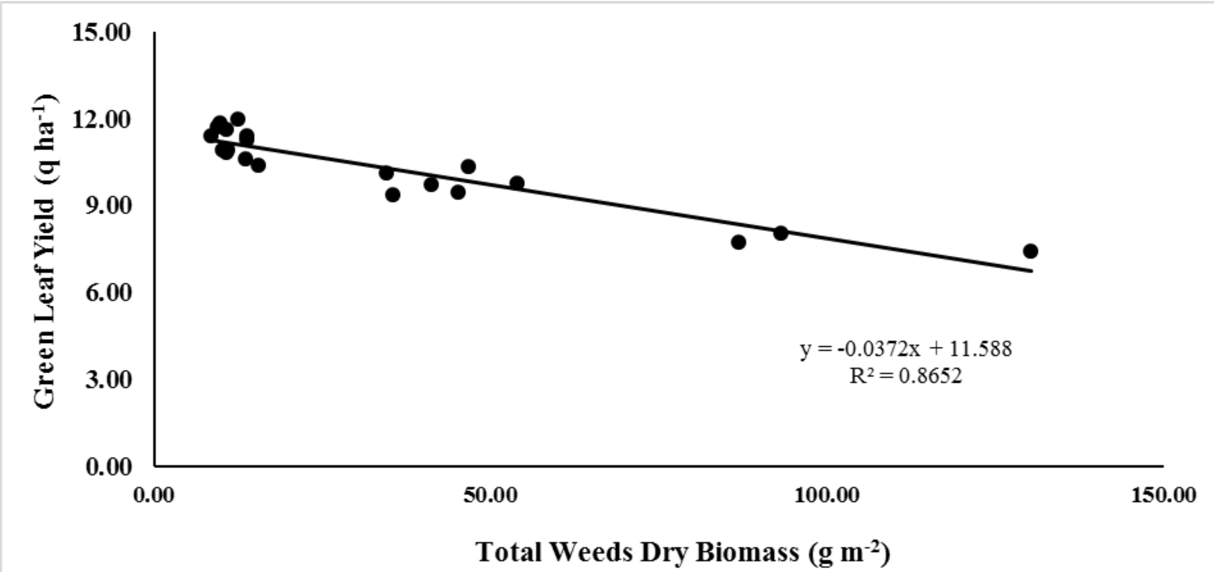


Fig.7 Relationship between green leaf yield and total weeds dry biomass at 60 DAA of herbicides (mean data of two years)



The maximum green leaf yield of tea (1.17 t ha^{-1}) was obtained under HW twice at 20 and 40 DAA and was at par with ammonium salt of glyphosate (71% SG) 2130 g ha^{-1} (1.14 t ha^{-1}) and standard glyphosate 2130 g *a.i.* ha^{-1} (1.13 t ha^{-1}) and followed by lower dose of ammonium salt of glyphosate. Ammonium salt of glyphosate (71% SG) had been a successful alternative to control weeds in broad leaf crops (Ghosh *et al.*, 2005).

Phytotoxicity on tea plants

Application of the various levels of herbicide did not show any kind of phytotoxicity symptoms *viz*. leaf epinasty and hyponasty, vein clearing, wilting, injury to leaf tips and leaf surface on the matured tea plants (Table 2). Mirghasemi *et al.*, (2012) reported that glyphosate + ammonium sulphate (2 L ha^{-1} + 6 kg ha^{-1}) when applied around the collar of the bush was safe and the treatments had no adverse effect on tea crop and quality.

Effect on soil microflora

All the herbicidal treatments showed an initial depression in the colony count concomitant effect on growth of soil microflora (total bacteria, fungi and actinomycetes). This effect was restricted till 30 DAA of the herbicide application. From 30 DAA onwards, the microflora population increased rapidly in all the treatments as well. No harmful effects were recorded in any of the herbicidal treatments when tested, excepting in the case of paraquat dichloride (Figure 1, 2 and 3). This finding is similar with the findings recorded by Poddar *et al.*, (2014).

Correlation and regression

The results of correlation coefficients and regression calculated revealed that weed species density was positively correlated with dry biomass in all weed species. The highest correlation coefficient of monocot weeds was calculated under *Axonopus compressus* (r^2 = 0.9897) followed by *Imperata cylindrica* (r^2 = 0.9231), *Cyperus arometicus* (r^2 = 0.9214), *Cyperus rotundus* (r^2 = 0.8386) and other monocots (r^2 = 0.9363) at 40 DAA of herbicides (Figure 4). While, at 60 DAA of herbicides, the correlation coefficient between weed species density and dry biomass was increased in all weeds except *Axonopus compressus* and value was 0.9817 (Figure 4). This results that the weed density and weed dry biomass improved with interval period of herbicides application.

In case of dicots weed species, the correlation coefficient was estimated 0.9261, 0.9196 and 0.878 at 40 DAA of herbicides and 0.981, 0.9669 and 0.9748 at 60 DAA of herbicides (Figure 5) under *Borreria hispida*, *Polygonum perfoliatum* and other dicot weeds, respectively. The effect of herbicides was more longer to dicots weeds as compared to monocots weeds. The correlation coefficient of all weed species density and weed dry biomass was calculated 0.981 and 0.9669 at 40 and 60 DAA of herbicides, respectively (Figure 6).

While the green leaf yield and total weeds dry biomass had showed negative relationship (r^2=0.8652) at 60 DAA of herbicides. The negative correlation denoted that the green leaf tea yield was significantly reduced with the increment in weed dry biomass in the tea field. Aktar *et al.,* (2013) also reported the same result the lentil field where lentil yield had shown negative correlation to weed dry matter at 25 and 40 day after sowing.

From this experiment, it is observed that for effective management of weeds in tea applied ammonium salt of glyphosate (71% SG) 2130 g *a.i.* ha^{-1} within critical weed infestation period, the tea green leaf productivity was also increased by 34.12% without showing any phytotoxicity on tea plants. There was no long term adverse effect of the applied herbicides on the microbial population in the rhizosphere region of the experimental tea soil. Therefore, ecosafe management of weed pest in its' critical infestation period is an option for sustainable increase of tea green leaf yield.

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