Effect of Physico-chemical Properties and Weed Management Practices on Weed Dynamics of Dalpatsagar Reservoir, Jagdalpur

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Abstract

Dalpatsagar reservoir was severely infested with many aquatic macrophytes throughout the year since last decade and modified the structure of habitat and influenced the aquatic organism. An experiment was conducted in Dalpatsagar reservoir Jagdalpur, Chhattisgarh during February 2019 to February 2020 throughout the year under Randomized Complete Block Design (RCBD) with three replications comprising seven treatments viz. Glyphosate (41 SL), Paraquat (24 SL) and 2,4-D (amine salt 58% SL) at 2.00 and 1.00 litre/ha with each herbicides including Absolute control. The herbicides were mixed with sticker (Latron AG-98) and sprayed in three replications by power spray machine (1HP HTP MAK ASPEE) mounted on the boat. The pH was 6.77 to 6.10 at observation of 3 to 120 days but it gradually increased 7.92 at 300 days of observation. The pH was lowest 6.40 with Glyphosate @ 2.00 litre/ha, EC was increased 0.59 dSm⁻¹ till 300 days and it was significantly higher (0.41 dSm⁻¹) value was observed. The value of TDS was also gradually increased 237 mg/l at 300 days, but after spray of herbicide, the value was reduced 199 mg/l with application of Glyphosate @ 2.00 litre/ha. CO₃ and HCO₃ of Dalpatsagar were increased 57.38 mg/l and 319 mg/l in response to Glyphosate applied @ 2.00 litre/ha at 300 DAS. The reduction of weed dry weight (g/ m²) was maximum with Glyphosate @ 2.00 litre/ha followed by 2,4-D @ 2.00 litre/ha at 20 DAS. Weed control efficiency was significantly higher in Pistia stratiotes (81.27%) and Nelumbo nucifera (81.26%) with glyphosate @ 2.00 litre/ha at 5 and 20 DAS. Mean Weed control efficiency was higher (63.80%) with glyphosate @ 2.00 litre/ha with higher cost of control Rs. 6684 per ha followed by 2,4-D @ 2.00 litre/ha. This can be proved that Glyphosate @ 2.00 litre/ha was much effective herbicides to control aquatic weed population followed by 2,4-D @ 2.00 litre/ha with Rs. 5747 per ha than other herbicides.

Keywords
Aquatics, Water ecosystem, Herbicides, Economics of pond

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Introduction

Scientifically Aquatic weed is known as aquatic macrophytes those plants are unwanted and important secondary producer for any wetland ecosystem. The wetland are the essential part of biological diversity and ecosystem functioning and its utility performance varied by the hydrological and ecosystem functioning (Banner and MacKenzie, 2000). In natural condition, many of aquatic wildlife such as different fish spices, animal, birds, amphibians, and plant spices (macrophytes and plankton diversity)
are found in their Natural Habitat. So wetland is a most productive ecosystem they fulfill critical regulatory function of hydrological process within the watershed (Hernandez and Mitsch, 2007; Palit and Mukherjee, 2010). The aquatic weed species is grouped into categories of algae, emergent, submersed and floating species based on their habitat and morphological characteristics (Varshney et al., 2008). Aquatic weed species Alternanthera philoxeroides, Chara spp., Ipomoea spp. Eichhornia crassipes, Hydrilla verticillata, Nelumbo nucifera, Nitella spp. Nymphaea stellata, Salvinia molesta, Typha angustata, Vallisnaria spp. are primary concern in Indian aquatic condition (Gopal and Sharma, 1981). Among these, Eichhornia crassipes, alligator weed and lotus species of aquatic weeds are of primary concern in India and all over world. In general, it is estimated that 20-25% of the total utilisable water in India is currently infested with Eichhornia crassipes (water hyacinth), while in the state of Assam, Kerala, West Bengal, Orissa and Bihar, more than 40% water bodies are infested with water hyacinth (Sushilkumar, 2011). Health of any wetland and their ecological functioning are directly related to the survival of any aquatic organisms (Ramesh et al., 2007) and regular monitoring of ecosystem is much needed (Ramachandran et al., 2006). Monitoring of water quality is aimed for the management and conservation of the aquatic habitat by suitable maintaining the physiochemical quality of pond water within the acceptable level (Garg et al., 2010). The Physico-chemical properties such as electric conductivity (EC), pH, Carbonate and Bicarbonate content etc. play a significant role in the composition, distribution, and abundance of aquatic organisms (Mustapha and Omotosho, 2005).

The Dalpatsagar reservoir was constructed by king of Bastar Shree Dalpatdev in 1772 for the purpose of domestic as well as agricultural use for assured water resource by harvesting rain water and store in low lying areas. The lake was constructed with the help of villagers belonging to the kingdom, expanding the area of 3 small ponds into 340.44 acre that sprawled half of the city under the catchment. The important aquatic macrophytes include Ipomoea aquatic, Oryza nivara, Oxalis carniculata, Ipomoea carnea, Typha augustata, Echinodorus grisebachii, Nymphaea alba, Nelumbo nucifera, Nymphaea rubra and Nymphaea indica also found (Pradhan and Patil, 2017). In the integrated weed management practices uses of chemical herbicide is an important tool. In some case use of herbicide is necessary to suppress the aggressive nuisance of vegetation. However, the herbicide is applied as a last option in weed suppression system. In India for controlling various type of submerged and floating weed spices commonly several chemical herbicide like 2,4-D, glyphosate, metsulfuron methyl, paraquat etc. are used in a water bodies (Varshney et al., 2008). Based on environment and system application rate varies and herbicidal efficiency dependent on the specific herbicide and their formulation ((Masser et al., 2013, Whetstone, 2004). In the view of densely infested weed mat on the water surface, manual removal was experienced difficult and costly. The Biological method of control was available only for water hyacinth, but it was considerably more time taking method while other weeds would not be controlled. Therefore, it was necessary to manage the dance weed mat by application of herbicides followed by manual and mechanical removal to reduce the cost of operation by manual method alone. Hence, keeping in the view of above importance, a research programme was conducted to find out the effective weed management practices for infested aquatic weeds population in Dalpatsagar reservoir Jagdalpur.
Materials and Methods

The research was conducted in aquatic ecosystem during the month of March 2019 to February 2020 at Dalpatsagar reservoir Jagdalpur in Chhattishgarh, India. Dalpat sagar reservoir situated in between 19º5´41"N and 82º0´43"E with elevation of 563 m MSL, the water body was severely infested with many type of aquatic weeds. The average annual rainfall of the area is 1400 mm. the major amount of precipitation occurs between June to September (about 3 to 4 months) which is main source of water in aquatic water body. The average annual temperature is during experiment is between 25°C to 30°C and the hottest and coolest month was May and January respectively were recorded from meteorological observatory S.G. CARS Jagdalpur. The experiment consists of seven treatments with three replications that were laid out in Randomized Complete Block Design (RCBD) by piling bamboo poles at measured distance and one bot (one inch) net was used to confine the aquatic weeds in particular treatments.

The treatments comprised of T₁: Glyphosate 41 SL @ 2.0 litre/ha, T₂: Glyphosate 41 SL @ 1.0 litre/ha, T₃: Paraquat 24 SL @ 2.0 kg/ha, T₄: Paraquat 24 SL @ 1.0 kg/ha, T₅: 2, 4-D (amine salt 58%) @ 2.0 litre/ha, T₆: 2, 4-D (amine salt 58%) @ 1.0 litre/ha and T₇: Absolute control (herbicide use restricted). Application of herbicides was done over weed mat dissolving into 500 litre water and added sticker 20 ml (Latron AG-98). The chemical spray was done with power spray machine (1HP HTP MAK ASPEE) mounted on the boat. The experimental area was equally divided into 21 plots of 5 m² by piling bamboo poles at corners of each plot and separated by net. The gap between replication was 3 meter. Herbicide spraying was done on 31 December 2019.

Water samples of Dalapat sagar reservoir were collected throughout the year at 15 days interval from each plot under different treatments. The samples were analysed for physiochemical properties such as pH, EC and TDS (Jackson, 1967) and carbonate & bicarbonate (Chopra and Kanwar, 1999) using standard procedure. Different types of aquatic weeds were collected and identified during experiment. Treatment wise weed dry weight (g/m²) was recorded after oven drying at 60±5oC for 72 hours and weed control efficiency was calculated following the standard method. Economics of each treatment was calculated taking into consideration the cost of hiring the boat, machine and labours. Data on density and dry weight of weeds were transformed using square root transformation ($\sqrt{x + 0.5}$) before statistical analysis as suggested by Panse and Sukhatme (1967). Observed data studies were subjected to statistical analysis as per the guidelines of Gomez and Gomez (1984). The variance ratio (F-value) was used to test the significance of the treatment effect. Appropriate standard errors and critical difference at 5% probability level was used to test the statistical significance of the results.

Results and Discussion

Physio-chemical properties of Dalpatsaghr water body

pH

The pH of Dalpatsagar reservoir was varied with 6.77 to 6.10 at observation of 3 to 120 days and after that the pH was continuous increases upto 6.23 to 7.92 up to 300 days and ending with increased (Table 1). In weed management treatments, the highest pH was noted at Absolute control in which herbicide use restricted. The lower value of pH 6.64 was noticed with application of Glyphosate @ 2.00 litre/ha as on weed mat due to fast
decomposition of weeds, that contributed in biological degradation over the period of time resulting lower pH with higher dose of Glyphosate.

Although higher pH was noticed with lower dose of Glyphosate @ 1.00 litre/ha due to summer season during 120 to 150 days showed higher pH in all the herbicidal treatments whereas lower pH during winter season because of production of CO$_2$ from biological oxidation process reduced pH value in the particular treatment (Sharma et al., 1984; Shrinivas and Aruna, 2018).

**Electric conductivity (EC)**

The EC of Dalpatsagar reservoir was lowest (0.26 dSm$^{-1}$) at initial 30 Days observation with Absolute control treatment while the highest electric conductivity was recorded 0.59 dSm$^{-1}$ at 240 days under 2,4-D @ 2.00 litre per hectare (Table 2). The value of EC was significantly increased upto 180 days due to dilution of sewage water showing low till 360 days. In weed management treatment EC is higher (0.41 dSm$^{-1}$) with lower dose of 2,4-D 1.00 litre per hectare and lowest (0.30 dSm$^{-1}$) was recorded for higher dose of Glyphosate @ 2.0 litre/ha.

The maximum electric conductivity (EC) was recorded during summer season and in monsoon season conductivity is gradually decrease is due to increased volume of water as a result of frequent rain that caused a decline in salt concentration (Chandrakiran, 2011).

**Total Dissolved Solid (TDS)**

The value of TDS of Dalpatsagar reservoir was significantly differed as advanced in time with season change (Table 3). At the beginning, value of TDS is decreased from 223 mg/l to 183 mg/l during 30 to 120 days and later the value of TDS was increased significantly (237 mg/l) up to 300 days. The significant reduction of TDS was noticed under Glyphosate @ 2.00 litre/ha followed by 2,4-D @ 2.00 litre per hectare which were 199 mg/l and 198 mg/l, respectively while lower dose of Paraquat @ 2.00 kg/ha and Glyphoste @ 1.00 litre/ha were more effective in reducing TDS over other lower dose of herbicides. Similar study on TDS was quoted by Verma et al., (2012) and Bhatt et al., (1999).

**Carbonate (CO$_3$) and bicarbonate (HCO$_3$) content**

In pond ecosystem higher value of pH is due to reduced photosynthetic activity and assimilation of CO$_2$ and Bicarbonate during in summer season, which was obvious from the data shown in Table 4 and 5. The availability of Carbonate (CO$_3$) was highest 57.38 mg/l with 2,4-D @ 1.00 litre/ha at 300 days and the lowest CO$_3$ 43.80 mg/l under 2,4-D @ 2.00 litre/ha at 120 days. The significantly higher CO$_3$ value (54.66 mg/l) found with 2,4-D @ 1.00 litre/ha followed by Glyphosate @ 1.0 litre/ha.

The reduction of CO$_3$ was grater with higher dose of Glyphosate @ 2.00 litre/ha and 2,4-D @ 2.00 litre/ha. The Bicarbonate content was found higher (319 mg/l) with Glyphosate @ 1.00 litre/ha at 300 days and lowest (246 mg/l) was under 2,4-D @ 2.00 litre/ha at 120 days among all treatments. At lower dose, bicarbonate content was significantly higher (307 mg/l) with 2,4-D @ 1.00 litre/ha. The highest carbonate concentration in September and bicarbonate concentration in April. The higher carbonate and bicarbonate is due to the accumulated organic matter which is produced from decay and decomposition of vegetation and domestic sewage (Shrinivas and Aruna, 2018).
Table 1 Monthly Variation in pH of water at Dalpatasgar reservoir

| Treatment   | 30 DAYS | 60 DAYS | 90 DAYS | 120 DAYS | 150 DAYS | 180 DAYS | 210 DAYS | 240 DAYS | 270 DAYS | 300 DAYS | 330* DAYS | 360 DAYS |
|-------------|---------|---------|---------|----------|----------|----------|----------|----------|----------|----------|-----------|----------|
| T1          | 6.77    | 6.64    | 6.27    | 6.10     | 6.40     | 6.23     | 6.54     | 6.80     | 6.89     | 6.97     | 6.64      | 6.72     |
| T2          | 7.5     | 7.47    | 7.02    | 6.92     | 7.17     | 7.07     | 7.32     | 7.64     | 7.74     | 7.83     | 7.46      | 7.55     |
| T3          | 7.14    | 7.18    | 6.78    | 6.60     | 6.92     | 6.74     | 7.07     | 7.27     | 7.36     | 7.45     | 7.10      | 7.19     |
| T4          | 7.42    | 7.61    | 6.92    | 6.70     | 7.07     | 6.84     | 7.22     | 7.58     | 7.67     | 7.77     | 7.40      | 7.49     |
| T5          | 6.84    | 6.78    | 6.31    | 6.04     | 6.44     | 6.17     | 6.58     | 6.75     | 6.84     | 6.92     | 6.60      | 6.68     |
| T6          | 7.30    | 7.4     | 6.61    | 6.90     | 6.75     | 7.05     | 6.89     | 7.72     | 7.82     | 7.91     | 7.54      | 7.63     |
| T7          | 7.29    | 7.44    | 6.39    | 6.23     | 6.52     | 6.36     | 6.66     | 6.95     | 7.03     | 7.12     | 6.78      | 6.87     |
| SEM±        | 0.03    | 0.04    | 0.01    | 0.02     | 0.01     | 0.01     | 0.02     | 0.02     | 0.01     | 0.01     | 0.01      | 0.01     |
| CD (P=0.05) | 0.08    | 0.14    | 0.04    | 0.07     | 0.05     | 0.05     | 0.04     | 0.06     | 0.06     | 0.05     | 0.04      | 0.05     |

* Observation recorded after herbicide application
T1: Glyphosate @ 2.0 litre/ha, T2: Glyphosate @ 1.0 litre/ha, T3: Paraquat @ 2.0 kg/ha, T4: Paraquat @ 1.0 kg/ha, T5: 2,4-D @ 2 litre/ha, T6: 2,4-D @ 1 litre/ha, T7: Absolute control

Table 2 Monthly variation in EC (dSm⁻¹) of water at Dalpatasgar reservoir

| Treatment   | 30 DAYS | 60 DAYS | 90 DAYS | 120 DAYS | 150 DAYS | 180 DAYS | 210 DAYS | 240 DAYS | 270 DAYS | 300 DAYS | 330* DAYS | 360 DAYS |
|-------------|---------|---------|---------|----------|----------|----------|----------|----------|----------|----------|-----------|----------|
| T1          | 0.27    | 0.30    | 0.31    | 0.40     | 0.31     | 0.48     | 0.45     | 0.45     | 0.44     | 0.40     | 0.30      | 0.39     |
| T2          | 0.27    | 0.28    | 0.30    | 0.40     | 0.30     | 0.52     | 0.50     | 0.47     | 0.45     | 0.43     | 0.33      | 0.37     |
| T3          | 0.34    | 0.33    | 0.36    | 0.34     | 0.33     | 0.51     | 0.49     | 0.44     | 0.42     | 0.43     | 0.35      | 0.34     |
| T4          | 0.32    | 0.31    | 0.34    | 0.35     | 0.33     | 0.51     | 0.49     | 0.44     | 0.42     | 0.43     | 0.35      | 0.34     |
| T5          | 0.28    | 0.30    | 0.32    | 0.40     | 0.30     | 0.49     | 0.49     | 0.44     | 0.44     | 0.42     | 0.39      | 0.37     |
| T6          | 0.31    | 0.32    | 0.34    | 0.48     | 0.37     | 0.54     | 0.58     | 0.59     | 0.58     | 0.55     | 0.41      | 0.36     |
| T7          | 0.26    | 0.27    | 0.28    | 0.38     | 0.28     | 0.51     | 0.47     | 0.44     | 0.45     | 0.43     | 0.38      | 0.35     |
| SEM±        | 0.01    | 0.01    | 0.01    | 0.01     | 0.01     | 0.01     | 0.01     | 0.02     | 0.01     | 0.01     | 0.02      | 0.02     |
| CD (P=0.05) | 0.03    | 0.02    | 0.02    | 0.03     | 0.03     | 0.03     | 0.02     | 0.03     | 0.02     | 0.03     | NS        | NS       |

* Observation recorded after herbicide application
T1: Glyphosate @ 2.0 litre/ha, T2: Glyphosate @ 1.0 litre/ha, T3: Paraquat @ 2.0 kg/ha, T4: Paraquat @ 1.0 kg/ha, T5: 2,4-D @ 2 litre/ha, T6: 2,4-D @ 1 litre/ha, T7: Absolute control
### Table 3 Monthly variation of Total Dissolved Solid (TDS) of water at Dalpatasgar reservoir

| Treatment | 30 DAYS | 60 DAYS | 90 DAYS | 120 DAYS | 150 DAYS | 180 DAYS | 210 DAYS | 240 DAYS | 270 DAYS | 300 DAYS | 330* DAYS | 360 DAYS |
|-----------|---------|---------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| T1        | 203     | 199     | 188     | 183      | 192      | 196      | 187      | 204      | 207      | 209      | 199      | 202      |
| T2        | 214     | 215     | 203     | 198      | 208      | 212      | 202      | 218      | 221      | 224      | 213      | 216      |
| T3        | 225     | 224     | 211     | 208      | 215      | 220      | 212      | 229      | 232      | 235      | 224      | 227      |
| T4        | 223     | 228     | 208     | 201      | 212      | 217      | 205      | 227      | 230      | 233      | 222      | 225      |
| T5        | 205     | 203     | 189     | 181      | 193      | 197      | 185      | 203      | 205      | 208      | 198      | 200      |
| T6        | 219     | 222     | 198     | 207      | 203      | 207      | 211      | 232      | 234      | 237      | 226      | 229      |
| T7        | 219     | 223     | 192     | 185      | 196      | 200      | 191      | 208      | 211      | 214      | 204      | 206      |
| SEM±      | 2.15    | 1.83    | 1.51    | 0.67     | 1.01     | 1.02     | 1.34     | 1.38     | 1.41     | 1.80     | 1.92     | 1.41     |
| CD(P=0.05)| 5.51    | 5.67    | 4.82    | 2.34     | 3.15     | 3.08     | 4.83     | 4.02     | 4.82     | 5.85     | 5.95     | 4.13     |

* Observation recorded after herbicide application

T1: Glyphosate @ 2.0 litre/ha, T2: Glyphosate @ 1.0 litre/ha, T3: Paraquat @ 2.0 kg/ha, T4: Paraquat @ 1.0 kg/ha, T5: 2,4-D @ 2 litre/ha, T6: 2,4-D @ 1 litre/ha, T7: Absolute control

### Table 4 Monthly variation in Carbonate (CO$_3$) content of water at Dalpatasgar reservoir

| Treatment | 30 DAYS | 60 DAYS | 90 DAYS | 120 DAYS | 150 DAYS | 180 DAYS | 210 DAYS | 240 DAYS | 270 DAYS | 300 DAYS | 330* DAYS | 360 DAYS |
|-----------|---------|---------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| T1        | 49.05   | 48.14   | 45.44   | 44.26    | 46.40    | 45.19    | 47.39    | 49.31    | 49.92    | 50.55    | 48.15    | 48.75    |
| T2        | 54.38   | 54.16   | 50.91   | 50.17    | 51.99    | 51.23    | 53.10    | 55.39    | 56.08    | 56.78    | 54.09    | 54.77    |
| T3        | 51.80   | 52.07   | 49.13   | 47.87    | 50.17    | 48.88    | 51.24    | 52.70    | 53.35    | 54.02    | 51.46    | 52.10    |
| T4        | 53.80   | 55.17   | 50.18   | 48.59    | 51.25    | 49.62    | 52.33    | 54.96    | 55.64    | 56.34    | 53.67    | 54.34    |
| T5        | 49.57   | 49.17   | 45.76   | 43.80    | 46.73    | 44.73    | 47.72    | 48.97    | 49.58    | 50.20    | 47.82    | 48.42    |
| T6        | 52.93   | 53.65   | 47.93   | 50.05    | 48.94    | 51.11    | 49.98    | 55.97    | 56.67    | 57.38    | 54.66    | 55.34    |
| T7        | 52.85   | 53.92   | 46.31   | 45.13    | 47.29    | 46.09    | 48.29    | 50.36    | 50.99    | 51.63    | 49.18    | 49.79    |
| SEM±      | 0.15    | 0.31    | 0.12    | 0.16     | 0.12     | 0.12     | 0.13     | 0.14     | 0.12     | 0.11     | 0.16     | 0.11     |
| CD(P=0.05)| 0.48    | 0.98    | 0.38    | 0.51     | 0.37     | 0.49     | 0.46     | 0.45     | 0.38     | 0.35     | 0.58     | 0.34     |

* Observation recorded after herbicide application

T1: Glyphosate @ 2.0 litre/ha, T2: Glyphosate @ 1.0 litre/ha, T3: Paraquat @ 2.0 kg/ha, T4: Paraquat @ 1.0 kg/ha, T5: 2,4-D @ 2 litre/ha, T6: 2,4-D @ 1 litre/ha, T7: Absolute control
Table 5 Monthly variation in Bicarbonate (HCO₃⁻) content of water at Dalpatasgar reservoir

| Treatment  | 0.30 DAS | 0.60 DAS | 0.90 DAS | 1.20 DAS | 1.50 DAS | 1.80 DAS | 2.10 DAS | 2.40 DAS | 2.70 DAS | 3.00 DAS | 3.30 DAS | 3.60 DAS |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| T1         | 276      | 271      | 255      | 249      | 261      | 254      | 266      | 277      | 281      | 284      | 271      | 274      |
| T2         | 306      | 304      | 285      | 282      | 302      | 279      | 279      | 309      | 313      | 317      | 302      | 305      |
| T3         | 291      | 293      | 276      | 269      | 282      | 275      | 288      | 296      | 300      | 304      | 290      | 293      |
| T4         | 302      | 310      | 282      | 273      | 288      | 279      | 294      | 309      | 313      | 317      | 302      | 305      |
| T5         | 279      | 276      | 257      | 246      | 263      | 251      | 268      | 275      | 279      | 282      | 269      | 272      |
| T6         | 297      | 302      | 269      | 281      | 275      | 287      | 281      | 315      | 319      | 323      | 307      | 311      |
| T7         | 297      | 303      | 260      | 254      | 266      | 259      | 271      | 283      | 287      | 290      | 276      | 280      |

* Observation recorded after herbicide application

T1: Glyphosate @ 2.0 litre/ha, T2: Glyphosate @ 1.0 litre/ha, T3: Paraquat @ 2.0 kg/ha, T4: Paraquat @ 1.0 kg/ha, T5: 2,4-D @ 2 litre/ha, T6: 2,4-D @ 1 litre/ha, T7: Absolute control

Table 6 Effect of weed control treatments on weed control efficiency and economics

| Treatment   | Eichhornia crassipes | Pistia stratiotes | Ipomoea aquatica | Nelumbo nucifera | Alternanthera philoxeroides | Nymphaea rubra | Cyperus javanicus | Mean       | Cost of weed control (Rs.) |
|-------------|----------------------|-------------------|------------------|------------------|-----------------------------|----------------|-------------------|------------|--------------------------|
|             | 5 DAS | 20 DAS | 5 DAS | 20 DAS | 5 DAS | 20 DAS | 5 DAS | 20 DAS | 5 DAS | 20 DAS | 5 DAS | 20 DAS | 5 DAS | 20 DAS | 5 DAS | 20 DAS |
| T1          | 30.03 | 78.01 | 65.27 | 81.27 | 51.25 | 70.31 | 33.57 | 81.26 | 29.89 | 58.15 | 52.81 | 75.53 | 76.59 | 76.30 | 63.80 | 6684 |
| T2          | 17.20 | 55.14 | 52.15 | 69.06 | 37.53 | 57.01 | 26.00 | 64.58 | 13.60 | 45.38 | 28.23 | 54.56 | 50.49 | 45.37 | 45.45 | 5626 |
| T3          | 27.05 | 65.50 | 51.22 | 74.63 | 40.72 | 61.57 | 28.13 | 65.44 | 17.71 | 47.94 | 31.36 | 53.92 | 56.19 | 52.78 | 50.51 | 5697 |
| T4          | 5.78  | 38.88 | 27.06 | 64.54 | 12.47 | 35.34 | 3.23  | 45.66 | 6.52  | 3.93  | 8.39  | 31.25 | 21.79 | 29.63 | 23.89 | 5347 |
| T5          | 28.69 | 76.78 | 52.52 | 80.27 | 41.69 | 62.48 | 34.52 | 69.79 | 23.94 | 51.67 | 50.91 | 66.31 | 72.89 | 74.35 | 51.70 | 5747 |
| T6          | 12.28 | 61.91 | 43.55 | 68.79 | 36.01 | 50.09 | 21.67 | 63.13 | 11.76 | 33.40 | 20.79 | 53.07 | 39.31 | 13.43 | 37.80 | 5280 |
| T7          | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |

SEm ± 0.15 | 0.38 | 3.54 | 1.67 | 2.65 | 2.20 | 0.37 | 3.98 | 3.06 | 2.57 | 0.61 | 5.44 | 2.87 | 10.95 | - | 235 |

CD (P=0.05) 3.01 | 2.51 | 14.05 | 6.64 | 10.53 | 7.84 | 2.44 | 13.83 | 7.18 | 8.22 | 1.93 | 9.32 | 6.81 | 43.52 | - | 987 |

T1: Glyphosate @ 2.0 litre/ha, T2: Glyphosate @ 1.0 litre/ha, T3: Paraquat @ 2.0 kg/ha, T4: Paraquat @ 1.0 kg/ha, T5: 2,4-D @ 2 litre/ha, T6: 2,4-D @ 1 litre/ha, T7: Absolute control
Weed Control Efficiency and economy

Weed control efficiency was significantly higher in *Pistia stratiotes* (81.27%) and *Nelumbo nucifera* (81.26%) with Glyphosate @ 2.00 litre/ha whereas the lowest weed control efficiency was observed (Table 6) in *Alternanthera philoxeroides* (3.93%) under Paraquat at lower dose (1 kg/ha) on 20 DAS. At 5 and 20 DAS, Glyphosate @ 2.00 litre/ha gave higher (63.80%) weed control efficiency followed by 2,4-D @ 2.00 litre/ha with response to all the weed species. The lowest weed control efficiency was observed with lower dose of Paraquat (1.00 kg/ha). The weed control efficiency was increased with *Eichhornia crassipes* (30.03 and 78.01), *Pistia stratioides* (65.27 and 81.27) and *Ipomoea aquatica* (51.21 and 81.26%) at 5 and 20 DAS, respectively with Glyphosate @ 2.00 litre/ha. The higher cost of weed control (Rs. 6684 per ha) was recorded significantly with Glyphosate @ 2.00 litre/ha followed by 2,4-D @ 2.00 litre/ha (Rs. 5747 per ha). Lower dose of Glyphosate (1.00 litre/ha) and 2,4-D (1.00 litre/ha) were (Rs. 5626 per ha and Rs. 5280 per ha respectively) found approximately similar in cost of weed control. Whereas, lowest cost of control was observed with lower dose of 2,4-D (1.00 litre/ha).

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