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Use of Gramoxone 20SL (Paraquat) Prior to Land Preparation in Controlling Aquatic Weeds in Wetland Areas of Bangladesh

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ABSTRACT

Emergent aquatic weeds present in the monocropped fresh water wetland area of Bangladesh create a hazard in land preparation by developing dense stands. A field experiment was conducted at the farmers' field of two villages namely Mahilara and Kashemabad under Gournadi Upazila of Barisal district, Bangladesh during October 2012 to evaluate the efficacy of Gramoxone 20SL (Paraquat) in controlling emergent aquatic weeds and to find out an appropriate dose of this herbicide. Three doses of Gramoxone 20SL at 1.96 l·ha^{-1}, 2.00 l·ha^{-1} and 2.04 l·ha^{-1} were tried with an untreated control. All treatments were laid out in a randomized complete block design and replicated thrice. There were 8 different emergent weed species infesting the field among which the most dominant weed species were *Eichhornia crassipes*, *Pistia stratiotes*, *Enhydra fluctuans*, *Monochoria vaginalis*, *Echinochloa crus-galli*. The results revealed that, weed control efficiency was significantly affected by different herbicidal treatments. The treatments, Gramoxone 20SL at 2.00 l·ha^{-1} and 2.04 l·ha^{-1} were controlled in all the emergent aquatic weeds more than 85% infesting both the sites. Application of non-selective herbicide Gramoxone 20SL at 2.00 l·ha^{-1} prior to land preparation was most effective to suppress weed dry masses in both the site resulting reduced land preparation cost up to 78.93% as compared to manual weed control.

KEYWORDS

Aquatic Weeds; Gramoxone 20SL; SDR; Weed Control Efficiency

1. Introduction

In Bangladesh, there is enormous area of wetlands including rivers and streams, freshwater lakes and marshes, haors, baors, beels, water storage reservoirs, fish ponds and flooded cultivated fields. More than two thirds of Bangladesh may be classified as wetland according to the definition enunciated in the Ramsar Convention [1]. About 6.7 percent of Bangladesh is always under water, 21 percent is deeply flooded (more that 90 cm) and 35 percent experiences shallow inundation [2]. The haors, baors, beels and jheels are of fluvial origin and are commonly identified as freshwater wetlands. Characteristics being located in the lower edge of the topography, wetlands are subject to periodic inundation/flooding, shallow to deep, during wet monsoon. Bangladesh being situated in the sub-tropical region, the annual rainfall and humidity and the temperature is also relatively high. As such it offers a favourable environment for growth of aquatic weeds. Bodies of water in Bangladesh, therefore, are usually infested with a broad spectrum of aquatic weeds [3]. The major aquatic weeds of Bangladesh are *Eichhornia crassipes*, *Pistia stratiotes*, *Nymphaea nouchalli*, *Monochoria hastate*, *Monochoria vaginalis*, *Sphenoclea zeylanica*, *Azolla pinnata*, *Marsilea quadrifolia* [4].

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Wetland areas of Gournadi upazila (90˚13.8'E longitude and 22˚58.4'N latitude) under Barisal district are very rich in depository of vegetations, aquatic plants, reeds and algae. A total number of 20 aquatic weeds are found in this area and its surrounding belong to 11 families having 1 shrub, 4 grasses and 15 herbs species. The wetland areas of Bangladesh covered by water almost 6 (six) months of a year starting from the monsoon. These are important monocropped area of *rabi* crops and boro rice cultivation of the country. The farmers of wetland area usually start their land preparation for *boro* rice and *rabi* crops in the Month of September-October after receding of flood water. In that time, the emergent aquatic weeds create a hazard in land preparation by developing dense stands on the surface of water bodies and soil. The farmers usually physically removed the emergent aquatic weeds before ploughing with country plough or power tiller. It is estimated that more than 45 man-days ha^{-1} is required for physical removal of aquatic weeds due to the high biomass of these weeds. Frequent physical removal of the aquatic weeds before land preparation is highly expensive, labor intensive and time consuming process. Worldwide there are 14 numbers of herbicides registered for aquatic use. These include: 2, 4-D, Acrolein, Bispyribac-sodium,Carfentrazone-ethyl, Coppers (chelate, sulfate), Diquat, Endothall, Flumioxazin, Fluridone, Glyphosate, Imazamox, Imazapyr, Penoxsulam and Triclopyr [5]. Herbicidal control of aquatic weeds seems to be a better option since it is an effective and fast acting as reported by several studies [6]. Gramoxone 20SL formulation of paraquat, manufactured by Syngenta, is used as a broad spectrum of weed control in a number of crop and non crop areas for numerous years. Paraquat is a fast-acting, non-selective contact herbicide that is absorbed by the foliage. It destroys plant tissue by disrupting photosynthesis and rupturing cell membranes, which allows water to escape leading to rapid desiccation of foliage [7]. Using paraquat for aquatic weed control enables savings in time, cost and labor by reducing or eliminating the need for manual removal of aquatic weeds in monocropped wetland areas before preparing fields for boro rice or rabi crops. Limited research information is available on use of Gramoxone 20SL for controlling emergent aquatic weeds before land preparation in wetlands of Bangladesh. Therefore, the present experiment was undertaken to evaluate the efficacy of Gramoxone 20SL in controlling emergent aquatic weeds and to find out an appropriate dose of this herbicide.

2. Materials and Methods

This study was conducted at the farmers' field of two villages namely Mahilara (90˚24'E longitude and 22˚92'N latitude) and Kashemabad (90˚23'E longitude and 22˚97'N latitude) under Gournadi Upazila of Barisal district (**Figure 1**) during October 2012. The area belongs to the agro-ecological zone of Low Ganges River Floodplain (AEZ 12). The climate of the area is subtropical. The experiment was carried out with four treatments; 1) W_1 = Gramoxone 20SL at 1.96 $l{\cdot}ha^{-1}$, 2) W_2 = Gramoxone 20SL at 2.00 $l{\cdot}ha^{-1}$, 3) W_3 = Gramoxone 20SL at 2.04 $l{\cdot}ha^{-1}$ and iv) W_4 = Untreated Control. The active ingredient is 20% in commercial products of Gramoxone 20SL. All treatments were laid out in a randomized complete block design with three replications. The plot size was 4 m × 5 m and the total number of plot was 12. The treatments were applied on 5 October 2012 (Site 1: Mahilara village) and 15 October 2012 (Site 2: Kashemabad village) in the undisturbed post harvest fallow land (prior to land preparation) having 5 - 7 cm standing water. The spray solution was made by mixing commercial product of Gramoxone 20SL at 4 ml per litre water. Fresh water was used to make the spray solution. Spraying was done with the support of a knapsack sprayer in a sunny day along with good spray coverage to increase the efficacy. Data on weed density and dry weight were taken from each plot on 10 days after spraying. The weeds were identified species-wise. Weeds were sampled with the help of quadrat method and recorded. The quadrat was placed at random in the unit plot and all the weeds within each 1 m^2 were uprooted, dried first in the sun and thereafter, for 72 hours in an electric oven maintaining a constant temperature of 60˚C. After drying weight of each sample were taken. The average weed dry weight was expressed in $g{\cdot}m^{-2}$. Relative weed density (RWD), relative weed biomass (RWB) and weed control efficiency (WCE) of different treatments were calculated with the following formulas:

$$\mathrm{SDR}(\%) = \frac{\mathrm{RWD}(\%) + \mathrm{RWB}(\%)}{2} \quad (3)$$

$$\mathrm{RWD}(\%) = \frac{\text{Density of individual weed species in the community}}{\text{Total density of all weed species in the community}} \times 100 \quad (1)$$

$$\mathrm{RWB}(\%) = \frac{\text{Dry weight of a given oven dried weed species}}{\text{Dry weight of all oven dried weed species}} \times 100 \quad (2)$$

$$\mathrm{WCE}(\%) = \frac{(\mathrm{DWC} - \mathrm{DWT})}{\mathrm{DWC}} \times 100 \quad (4)$$

where; DWC = Dry weight of weeds in control plots, DWT = Dry weight of weeds in treated plots.

Data pertaining to WCE were analyzed statistically for analysis of variance (ANOVA) following the method described by [8].

MSTAT C computer software was used to carry out statistical analysis [9]. Partial economic analysis was done based the labour wage and herbicide cost.

3. Results and Discussion

3.1. Weed Infestation

In the experimental site 1, seven different weed species with their families were identified in control plot (**Table 1**). Among the seven weed species, five were broad-leaved, one was grasses and the rest of one was sedges. The dominant broad-leaved weed species were *Eichhornia crassipes*, *Pistia stratiotes*, *Enhydra fluctuans*, *Monochoria vaginalis* and *Ludwigia adscendens*. *Echinochloa crus-galli* was the only grasses present in the experimental field. The experimental results showed that, *Pistia stratiotes* possessed the highest relative weed density (40.453%) followed by *Eichhornia crassipes* (16.696%), *Monochoria vaginalis* (13.313%) *and Echinochloa crus-galli* (9.493%). On the other hand, the highest relative weed biomass (RWB) possessed by *Eichhornia crassipes* (41.820%) followed by *Monochoria vaginalis* (12.760%) and *Pistia stratiotes* (12.427%). The number of infesting weed species was slightly different in Site 2 compared to Site 1. These weed flora were ecologically categorized into five broad leaved and a grass species (**Table 1**). The weed species were *Eichhornia crassipes*, *Pistia stratiotes*, *Enhydra fluctuans*, *Monochoria vaginalis*, *Echinochloa crus-galli and Nymphaea nouchali*. The major weed was *Pistia stratiotes* which relative weed density (RWD) and relative weed biomass (RWB) was at 43.700% and 14.534%, respectively. The second top weed was *Eichhornia crassipes* which RWD and RWB value was at 20.013% and 55.760%, respectively. Among the weeds *Nymphaea nouchali* was the minor weed with 4.170% of RWD and 3.473% of RWB, respectively. Among the weed species *Eichhornia crassipes*, *Pistia stratiotes*, *Monochoria vaginalis* had showed the highest RWB values in fresh water lowland ecosystem due to higher frequency of these weeds, favourable environment for persistence and easy movement of propagating materials. This is a partial conformity with the results of Sushilkumar [10] who found that 20% - 25% of the total utilizable water in India is currently infested with water hyacinth (*Eichhornia crassipes*).

3.2. Weed Ranking

The summed dominance ratio (SDR) of infesting weeds in both the experimental sites are shown in **Figure 2**. In the experimental Site 1, the higher rank of dominant weed was *Eichhornia crassipes* (SDR 33.568%)

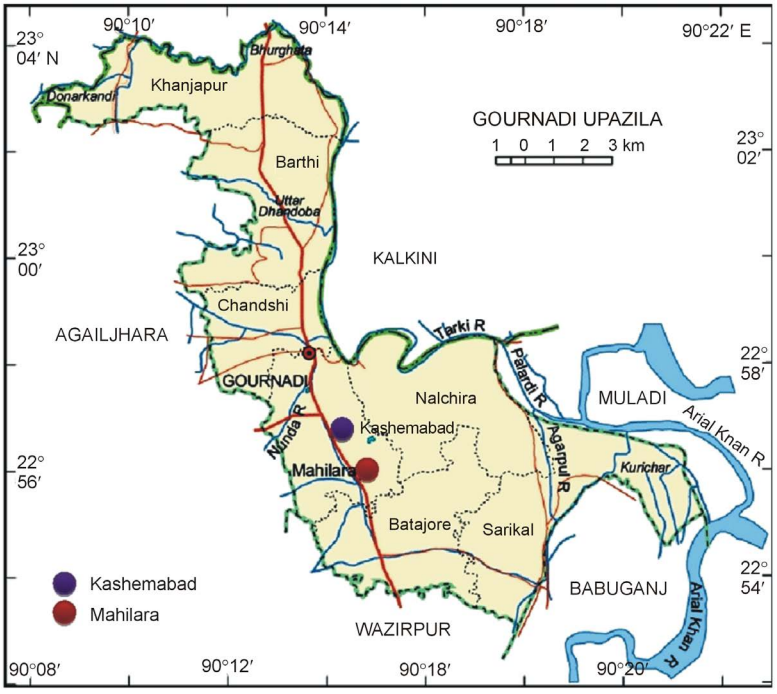

Figure 1. Study area.

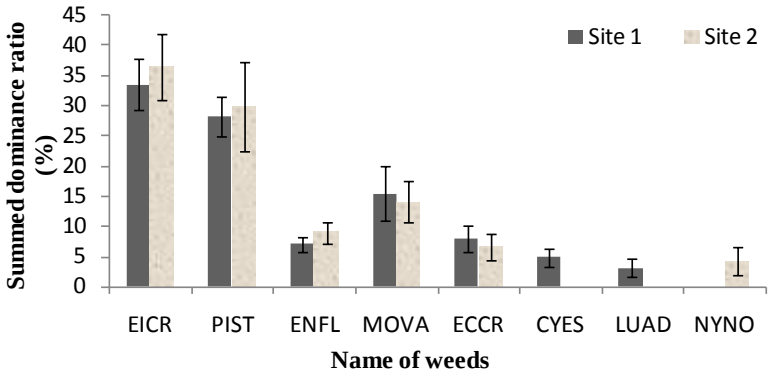

Figure 2. Summed dominance ratio (SDR) of infesting weeds. [EICR = *Eichhornia crassipes*, PIST = *Pistia stratiotes*, ENFL = *Enhydra fluctuans*, MOVA = *Monochoria vaginalis*, ECCR = *Echinochloa crus-galli*, CYES = *Cyperus esculentus*, LUAD = *Ludwigia adscendens*, NYNO = *Nymphaea nouchali*].

Table 1. Weed composition, Relative density (%), Relative weed biomass (RWB) and Summed dominance ratio (SDR) in the untreated control plots.

Name of Weed Species	Family	Class	RWD (%)	RWB (%)	SDR (%)
		Site 1			
Eichhornia crassipes	Pontederiaceae	Broad leaf	16.696	41.820	33.568
Pistia stratiotes	Araceae	Broad leaf	40.453	12.427	28.176
Enhydra fluctuans	Asteraceae	Broadleaf	9.056	4.088	7.029
Monochoria vaginalis	Pontederiaceae	Broad leaf	13.313	12.760	15.394
Echinochloa crus-galli	Poaceae	Grass	9.493	5.354	7.888
Cyperus esculentus	Cyperaceae	Sedge	7.286	1.628	4.812
Ludwigia adscendens	Oragraceae	Broad leaf	3.686	1.884	3.128
SE			8.637	5.354	4.561
		Site 2			
Eichhornia crassipes	Pontederiaceae	Broad leaf	20.013	55.760	36.453
Pistia stratiotes	Araceae	Broad leaf	43.700	14.534	29.752
Enhydra fluctuans	Asteraceae	Broadleaf	11.197	6.107	8.913
Monochoria vaginalis	Pontederiaceae	Broad leaf	12.987	16.240	14.075
Echinochloa crus-galli	Poaceae	Grass	7.920	5.752	6.616
Nymphaea nouchali	Nymphaceae	Broad leaf	4.170	3.473	4.185
SE			7.825	8.035	5.435

followed by *Pistia stratiotes* (SDR 28.176%) and *Monochoria vaginalis* (15.394%). In site 2, similar SDR pattern was found with the value of *Eichhornia crassipes* (36.453%), *Pistia stratiotes* (29.752%), *Monochoria vaginalis* (14.075%). The highest SDR values of these weed species are due to the high infestation, more weed biomass and favourable ecosystem for growth and development. SDR is an important indicator for showing the ranking of weeds [11].

3.3. Weed Control Efficiency (WCE)

Weed control efficiency was significantly affected by different herbicidal treatments. Weed density was highest in control plots (W_4). Gramoxone 20SL exhibited by lower weed biomass as well as higher weed control efficiency in both the experimental site (**Table 2**). In Site 1, weed control efficiency was increased with the increases of herbicide dose irrespective of weed species. Treatments W_2 and W_3 were controlled all the weeds more than 85%. Treatment of W_2 controls *Eichhornia crassipes by* 89.092%, *Pistia stratiotes* 86.047%, *Enhydra fluctuans* 98.740%, *Monochoria vaginalis* 96.436%, *Echinochloa crus-galli* 88.499%, *Cyperus esculentus* 85.877%, *Ludwigia adscendens* 87.903%. Sharma and Singh [12] found that, application of Gramoxone Inteon showed almost completely control of grasses and broadleaf weeds even at the lower rate.

Table 2. Effect of Gramoxone 20SL on weed control efficiency.

Treatments	*Eichhornia crassipes*	*Pistia stratiotes*	*Enhydra fluctuans*	*Monochoria vaginalis*	*Echinochloa crus-galli*	*Cyperus esculentus*	*Ludwigia adscendens*	*Nymphaea nouchali*
				***Site* 1**				
W_1	85.373	81.463	95.639	93.038	85.773	81.712	88.000	-
W_2	89.092	86.047	98.740	96.436	88.499	85.877	87.903	-
W_3	90.887	84.046	98.785	96.619	89.679	84.954	90.889	-
Control	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-
LSD (0.05)	11.276	5.899	1.649	8.373	12.075	4.603	6.686	-
CV (%)	8.5	4.8	1.1	5.9	9.2	3.7	5.0	-
				***Site* 2**				
W_1	86.076	82.210	99.967	87.146	80.950	-	-	96.708
W_2	89.228	87.629	99.690	99.409	86.882	-	-	99.155
W_3	88.721	86.689	99.817	98.659	84.987	-	-	99.692
Control	0.000	0.000	0.000	0.000	0.000	-	-	0.000
LSD (0.05)	17.606	9.437	0.680	9.747	11.289	-	-	2.482
CV (%)	13.4	7.4	0.5	6.8	8.9	-	-	1.7

W_1 = Gramoxone 20SL at 1.96 l·ha^{-1}, W_2 = Gramoxone 20SL at 2.00 l·ha^{-1} and W_3 = Gramoxone 20SL at 2.04 l·ha^{-1}.

The trend of weed control efficiency in Site 2 was almost similar as Site 1. All Gramoxone treatment controlled most of the weeds more than 80%. Treatment of W_2 was controlled *Eichhornia crassipes by* 89.228%, *Pistia stratiotes* 87.629%, *Enhydra fluctuans* 99.690%, *Monochoria vaginalis* 99.409%, *Echinochloa crus-galli* 86.882% and *Nymphaea nouchali by* 99.155%, which was comparable to the treatment W_3.

Linscott *et al.* [13] found that Paraquat (plus surfactant) applied at 1.1 and 2.2 kg·ha^{-1} to emerged weeds prior to the seeding of legumes controlled *Agropyron repens* and *Lotus corniculatus*. It was evident in the study that the non selective herbicide Gramoxone 20SL at 2.00 l·ha^{-1} and 2.04 l·ha^{-1} were becoming to effective for controlling aquatic weed than lower dose of that herbicide.

3.4. Economic Analysis

Partial economic analysis of weed control by Gramoxone 20SL vs. hand weeding for one hectare of land is presented in **Table 3**. By economic analysis it was observed that the maximum cost of weeding (BDT 11250.00) was involved in case of hand weeding. The treatment Gramoxone 20SL at 2.00 l·ha^{-1} needed the lowest cost (BDT 2370.00) which was 78.93% lower than manual weed control cost. Maximum cost was incurred in manual weed control due to the requirement of more number of labour. This result may be supported with findings of Raju and Reddy [14] who found that, the cost of Paraquat at 1 l·ha^{-1} for controlling water hyacinth was Rs. 460.00 ha^{-1} which was 61% lower than that of manual removal costing Rs. 1200.00 ha^{-1}.

Table 3. Economic analysis of weed control by Gramoxone 20SL vs. hand weeding for 1 hectare of land.

Gramoxone 20SL		Hand weeding	
Heads	Cost (BDT)	Heads	Cost (BDT)
Gramoxone 20SL (2.00 l·ha^{-1})	870.00	Labor (45 man-days)	11250.00
Labour for spraying (2 man-days)	500.00		-
Labour for removing remaining weeds (4 man-days)	1000.00		-
Total	2370.00		11250.00
Cost Reduction			78.93%

Labour wage at BDT 250.00 man-day^{-1}, Price of Gramoxone 20SL at BDT 435.00 l^{-1}.

4. Conclusion

From this experiment it may be concluded that, Gramoxone 20SL (Paraquat) at 2.00 l·ha^{-1} applied at prior to land preparation in monocropped fresh water wetland areas of Bangladesh is effective for controlling emergent aquatic weeds. However, further research should be conducted on impact of Gramoxone 20SL on water quality, biodiversity and aquatic life in wetland areas of Bangladesh.

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List of Abbreviations

AEZ	Agro-ecological zone
ANOVA	Analysis of variance
BDT	Bangladeshi Taka (Currency of Bangladesh)
cm	Centimeter
CV	Coefficient of variation
et al.	And others
FAO	Food and Agriculture Organization
g	Gram
ha^{-1}	Per hectare
l	Litre
LSD	Least significant difference
m^2	Square metre
Rs	Indian Rupee
RWB	Relative weed biomass
RWD	Relative weed density
SDR	Summed dominance ratio
SL	Soluble liquid
SE	Standard error
t	Ton
WCE	Weed control efficiency
%	Percent