Evaluating the performance of rope-wick herbicides applicator to control common reed

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Abstract This study was carried out in an ordinarily field of common reed Phragmites australis (Cav.) Trin, one of invasive perennial weed in Iraq, originally focused on investigating the feasibility of an applied herbicide treatment by using systematic herbicides of glyphosate (N-(phosphonomethyl glycine) and fluazifop-butyl to control the common reed. Doses of glyphosate and fluazifop-butyl were used and experiments were set using complete randomize block design (CRBD) with three repetitions. Seven treatment methods of herbicides (T1–T7) were involved. Results indicated the superiority of T7 to control common reed compared to other treatment methods and showed highest control rate of 61.74% using T7. More specifically, T7, T6, and T5 presented the lowest average regrowth rates of Phragmites australis that reached up to 61.74%, 57.94%, and 52.47%, respectively. The positive contribution of herbicides was continued around 180 days after the treatment. Moreover, T7 has accomplished a significant difference in the reduction of the plant height compared to other treatments. Also, the application of rope-wick of T7 has depicted the lowest total dry weight of vegetative (480.67 g/m2) compared to T1, T5, and T6. In the contrast, insignificant differences of the total dry weight of vegetative were noticed for T3, T4, and T5. The lowest rhizomes dry weight was observed for T2, T5, and T3 221.33 g/m2, 248.33 g/m2, and 270.67 g/m2, respectively. Glyphosate presented a prosperous controlling of common reed compared to fluazifop-butyl. The application of rope-wick has also gave a promising controlling of common reed compared to sprayers, which in turn reduced the usage of herbicides concentration that would be in line with mitigating the environmental pollution.

1. Introduction

Phragmites australis (Cav.) Trin. is a predominant weed that belongs to Poaceae family and grows in warm regions and spread along the Middle Eastern Countries and West Africa. Phragmites australis can be considered as a most noxious weed infesting the orchards, non-croplands and...
roadsides [19; 39]. Also, the common reed is one of the hardiest weeds when spreads in the irrigation channels due to possessing high degree of competitiveness and resistance among other associated plants [21]. This enables the weed to rapid growth and high density of rhizomes under soil surface, which in turn can reach to 4 m in addition to its capacity of re-growing when exposed to unnatural circumstances [18]. For instance, the rhizomes aid to increase the resistance towards the drought in a competitive manner to any adjacent weeds [22]. [27; 3] demonstrated that these plants can produce enormous amounts of seeds with high viability to be settled during the coming seasons. Common reed has an allelopathic effect as it contains several phenolic compounds, which deter other plants to grow around it [33]. Common reed is one of the noxious weeds in Iraq and widely spreading [1]. Therefore, the subject of common reed has attracted the attention of many researchers to explore an efficient treatment method to control this weed. Glyphosate (N-(phosphonomethyl) glycine) can be considered as one of the successful herbicides used to abate the growth of common reed compared to other herbicides. This herbicide is commonly associated with hindering the plant enzyme 5-enolpyruvylshikimate-3-phosphate synthase [29] and aid to kill weeds that compete crops. Specifically, the employment of 2 kg/ha of glyphosate has been nominated to competently control common reed [14]. It is noteworthy to mention that the efficiency of any herbicide is mainly dependent on the total absorbed amount that being translocated to the active site of the weeds [4; 12]. Therefore, it is not surprising to notice a progressive research to increase the performance of glyphosate or fluazifop-butyl. This is totally relying on improving the rate of their penetration, absorption, and translocation in order to attain higher rates of common reed controlling [1; 35]. The deployment of herbicide, especially glyphosate is noticeably increased in several invaded large areas with common reed. However, spraying herbicide was not-welcomed due to less accuracy and direct common reed targeting especially for the case of dense vegetation of other plants. Additionally, several treatment methods were investigated to control common reed including burning, cutting, or chopping. However, these methods are also suffering from serious issues of insufficient targeting crops [24].

Up to the others; knowledge, the feasibility of using rope-wick-applicator to apply herbicides of glyphosate and fluazifop-butyl to control common reed growth in corn crops, sugar can and freshwater river has not been yet investigated. Thus, the generic aim of this study was to distinguish the efficiency of different herbicides in controlling common reed with accommodating the perspectives of clean environment.

2. Materials and methods

The study was carried in a heavily infested field with common reed at University of Diyala, Iraq to investigate the feasibility of using the rope-wipe herbicides applicator with herbicide application of glyphosate and fluazifop-butyl. This include the finding of the proper concentration of herbicides, which can produce the highest degree of controlling the growth of weed. Furthermore, the performance of rope-wick applicator has been compared to spraying treatment method with portable pressure equipment. An area approximately 40 x 40 m was divided into 21 plots 2.5x3 m each. The soil was cleaned from vegetation to within 10cm using a hand-heldsaw blade. Table 1 demonstrated the commercial and common names of the herbicides used with their active ingredient percentage. Also, Table 2 presents the description of seven applied treatment methods of herbicides (glyphosate and fluazifop-butyl) with their concentration used and applied method. This is originally involved four applied treatment methods (T2, T3, T5, and T6) using the rope wick herbicides applicator for herbicides spraying. However, T4 and T7 methods were accomplished using foliar spraying approach compared to the use of spraying only water in T1 method. T1 used 0.360 kg a.i./L of only water, T2 used 1liter fluazifop_butyl + 1 liter of water (v/v), T3 used 1liter fluazifop_butyl+ 2 liters of water (v/v), T4 used 150 mg / liter of fluazifop_butyl and 1 liter sprayed, T5 used 1liter glyphosate + 1 liter of water (v/v), T6 used 1liter glyphosate + 2 liter of water (v/v), T7 used 1.8 Mg /liter of glyphosate and 1 liter sprayed, and finally the herbicides of T8, T4, and T7 treatment methods were
sprayed using pressure sprayer on the common reed. The registered observations of each treatment have considered the following:
The herbicides effectiveness during post-treatment periods.
The degree of herbicide effectiveness and re-growth of common reed.

Table 1. Commercial and common names of herbicides used with their active ingredient percentage (a. i.)

| Commercial name           | Common name     | (a.i.) percentage g/l | Average use of a. i. g/ha for the perennial weed |
|---------------------------|-----------------|------------------------|-----------------------------------------------|
| Touchdown S4              | Glyphosate      | 360                    | 1,440 to 1,800 (Age 1-2 years) 1,160 to 2,880 (Age 2 years and older) |
| Fusilade Forte® 150EC     | Fluazifop-p-butyl | 150                    | 1,500 (Growing actively at 5 leaf to early tillering) (DO YOU MEAN TAILORING) |

Table 2. Classification of applied herbicides concentration, equivalent and applied methods

| Treatment method | Concentration / Rate          | Equivalent       | Applied method    |
|------------------|------------------------------|------------------|-------------------|
| T1               | Control treatment            | Only water       | Spraying          |
| T2               | 1 liter glyphosate + 1 liter of water (v/v) | 0.15 kg/L       | Rope-wick         |
| T3               | 1 liter glyphosate + 2 liters of water (v/v) | 0.15 kg/L       | Rope-wick         |
| T4               | Glyphosate 1.8 g/liter -1 *   | 0.15 kg/L       | Foliar spray      |
| T5               | 1 liter fluazifop-butyl in 1 liters of water (v/v) | 0.36 kg/L       | Rope-wick         |
| T6               | 1 liter fluazifop-butyl in 2 liters of water (v/v) | 0.36 kg/L       | Rope-wick         |
| T7               | Fluazifop-butyl 1.5 g/litre-1 * | 0.36 kg/L       | Foliar spray      |

*Collected from Syngenta Company, the manufacturer of glyphosate and fluazifop-butyl to treat one hectare in 1-2 years old perennial weeds.

The percentage of controlling common reed depend on the total dry weight of vegetative growth. Therefore, experiments focused on estimating three main parameters including total dry weight vegetative, rhizomes, and the average of common reed height 180 days after treatment. The experimental design used was the complete randomized block design of three repetitions. The observations on the herbicides effect were recorded on plants in 30, 60, 90, 120, and 150 days after treatment application by visual estimation (32; 34). 1-100 scale was used as 1 = means no effect and 100 = means complete death of the weed. The control of each treatment method was compared to control treatment that has 100% water as a new growth and 1% as no regrowth. Accordingly, the height and total dry weight of the common reed was measured in one square meter area at the end of the season (150 days after treatment). The rhizomes dry weight was also measured by digging one-
quarter square meter surface area up to the soil depth of 30 cm. The percentage of regrowth inhibition of the weed was calculated by employing the equation of (10) as follows;

\[
\text{Ratio pf Inhibition(\%)} = \frac{\text{Control reading} - \left( \frac{\text{Treatment reading}}{\text{Control reading}} \right) \times 100}{1}
\]

Glyphosate and fluazifop-butyrsolutions were prepared at 5.8 to 6.4 l/h to be used in controlling common reed by applying rope-wick applicator. This is originally calculated based on the covered area, which is also based on the capacity of the tool user, associated work time, and weed type and density. Time of wiping was 124 min/h at the speed of 3.66 km/h. The data obtained was analyzed using SAS software suite according to the complete randomized block design as factorial experiment. Test Duncan multiple was also considered to determine the differences significance at 5% of probability.

3. Results and Discussion

3.1 Effect of different treatment application on controlling the common reed

Basically, the action of herbicides in the treatment of weeds can be relatively denoted as the scale of killing weed. This research has applied different methods of herbicides treatments as illustrated in the previous sections. Table 3 shows a significant difference in the impact of all tested treatment methods to control common reed. Specifically, T3 (2-liter fluazifop-butyrs) showed a superior impact of controlling weeds up to 68.26% compared to T2 of 62.20%, T4 of 48.53%, T5 of 45.06%, T6 of 39.60%, and finally T7 of 35.80. This in turn would confirm 40.65% as the difference of effect degree between T3 and T4 (fluazifop-butyrs 1.5 g/litre-1). This is a significant percentage difference that emphasizing the successfulness of the applied rope-wick applicator to carry out the herbicides treatment of common reed compared to foliar spray.

Moreover, Table 3 presents another significant difference in the control of common reed after specified days of herbicides treatment. This is interestingly showing that the control of common reed was at its maximum level at the periods of 150 and 120 days after applying the treatment method to abate the growing of common reed. Statistically, this entails 53.36% and 51.75% as the percentage difference in the control degree if compared to only 33.76% for 30 days of operation. Results indicate a higher performance of controlling can be achieved for the herbicides as a result to increasing the operation time. This is also in line with the findings of [17], which showed a progressive treatment after a long time of operation.

A deep looking at the results presented in Table 3 confirmed an interference effect between the tested treatment methods to control the common reed based on the period of application. For instance, T3 treatment (1-liter fluazifop-butyrs in 2 liters of water (v/v)) showed the highest average of effective degree of weed control after 150 days, which significantly reached 82.00%. The foliar spraying treatment method T7 of glyphosate 1.8 g/liter-1 has accomplished the lowest effective degree of controlling the common reed where it attained only 44.5% after 150 days of operation. Again, these results indicate the progressive herbicide treatment for prolonged time of operation. This can be attributed to the influence of herbicide on the plant metabolic system, which is mainly increased with the time as a result to providing enough quantity of herbicide to attach the active parts of the weed and then accumulate to damage it. One of the main conclusions of this research that the application of rope-wick applicator aids the herbicide solution to easily reach these active parts of the weed compared to the spray method. The rope-wick applicator provides a complete covering of the herbicide solution, which diffidently helps to move the solution onto the surface of the leaf (wiping method) without causing ant surface tension [11]. In contrast, herbicide-spraying method such as foliar spray produces drift by wind and equipment pressure, which causes the loss of a large amount of the herbicide and also reduces the efficiency of control [30;7].
Table 3. Effect of different doses of glyphosate and fluazifop_butyl on the control of common reed (% after periods of operation

| Treatment | Common reed control (%) | (DAT) Days after treatment | Treatment effects |
|-----------|--------------------------|-----------------------------|------------------|
|           |                          | 30 | 60 | 90 | 120 | 150 |
| T1        |                          | 1.0 p | 1.0 p | 1.0 p | 1.0 p | 1.0 p | 1.0 g |
| T2        |                          | 50.66 fgh | 54.33 defg | 58.0 cde | 70.66 b | 77.33 ab | 62.2 b |
| T3        |                          | 57.66 cdef | 62.66 c | 61.66 cd | 77.33 ab | 82.0 a | 68.26 a |
| T4        |                          | 39.33 jkl | 41.0 ik | 43.00 ij | 58.33 cde | 61.0 cde | 48.53 c |
| T5        |                          | 32.33 lmnn | 37.66 jkm | 39.66 jkl | 54.0 efg | 61.66 cd | 45.0 d |
| T6        |                          | 30.33 mno | 33.66 klmn | 34.66 klm | 50.33 gh | 49.0 ghi | 39.6 e |
| T7        |                          | 25.0 o | 27.0 no | 34.33 klm | 50.0 ghi | 44.5 hij | 35.8 f |
| Effect of time period of operation | | 33.76 c | 36.76 b | 38.9 b | 51.75 a | 53.36 a |

T1: control treatment, T2: 1 liter glyphosate in 1 liter of water(v/v), T3: 1 liter glyphosate in 2 liters of water(v/v), T4: glyphosate 1.8 g / liter-1 *, T5: 1 liter fluazifop-butyl in 1 liter of water(v/v), T6: 1 liter fluazifop-butyl in 2 liters of water(v/v), T7: fluazifop-butyl 1.5 g/litre-1
*The values in a column and rows followed by superscripts do not differ significantly at P=0.05 level of significance.

3.2 Effect of different treatment methods to control the regrowth rate of common reed

The ability of common reed to produce new shoots after the chemical treatment during the treatment season and the following one is an important key indicator to assess the efficiency of the used herbicide. In other words, any significant decrease in the weeds’ regrowth ability would indicate the success of treatment. Table 4 shows a significant difference of the regrowth rate of the common reed between the herbicides treatments and the control treatment T1 (only water). However, T3 treatment method presented the lowest regrowth rate of 29.27 degrees followed by T2 of 35.34, T4 of 49.0, T5 of 52.47, T6 of 57.94, and T7 of 61.74 compared to T1, which produced the average regrowth of 100 degree. Also, results indicate that the efficiency of herbicides applied with a rope-wick applicator has the highest opportunity to control the regrowth of weeds due to efficient absorption and deposition of herbicide solution on the surface of weed which entirely involves the gaining of a sufficient amount of phytotoxic concentrates accumulated in the leaf tissue [16].

Table 4 also shows a significant difference of the herbicides’ treatment based on the applied period of treatment. Again, this is consistent with the findings of the previous section. More specifically, the period of 150 days showed the lowest regrowth of common reed reached to 44.64 degrees followed by 120 days of 46.30 degree. This in turn would affirm the capacity of the common reed plants to survive the treatment and survive by producing new shoots. This is specifically relying on the stored food found in the sub-soil parts such as rhizomes and buds, which can support the plant to grow as a response to the outside harm effects such as cutting or grazing. Unfortunately, this is one of the most complex factors affecting the successful control of common reed [5; 25]. Additionally, the dormant buds might have not been exposed to the chemical control because of the low concentration herbicide solution or the lake of metabolism of herbicide by the plant.

Table 4 also shows that deployment of the rope wick applicator using glyphosate or fluazifop-butyl would promote the performance of treatment and provide high effect of decreasing the weed regrowth if compared to other with applied spraying treatment methods. This is due to the noticeable
efficiency of the wiping method, which accelerates the contact between herbicides and plants. These results are in agreement with the results reported by [28] in relation of perennial weed control.

Table 4 also showed a significant interference between the performances of chemical treatment methods based on the operation time. T5 appears to have the lowest average regrowth at 150 days which reached 35.87. However, T7 gives the highest average regrowth up to 72.54. The same conclusion can be drawn that the prolonged operation time would guarantee the efficient herbicide treatment by mitigating the regrowth of the weeds. This would reasonably be accepted as it provides enough time to attack the vegetative parts of common reed resulting in weakening and reduction of its ability to produce new shoots. This is also in line with the outputs. (38 ; 2). On the contrary, limited movement of herbicide such as fluazifop-butyl in the weed tissues could probably lead to less damage of the vegetative parts and therefore encourages the regrowth of the healthy tissues.

To sum up, the applied treatment of rope-wick applicator showed a superior performance of herbicide spraying. The reason behind this is related to the ability of wiping, which allows the proliferation of the herbicide in perfectly way over the leaves of the weeds. This in turn leads to enhance the absorption of herbicide solution in a suitable amount to hinder the regrowth of common reed [37; 15; 1].

Table 4. Effect of different treatment methods to control the regrowth rate of common reed

| Treatment method | Average regrowth (g/m²) * | Days after treatment | Treatment effect |
|------------------|---------------------------|---------------------|-----------------|
|                  | 30 | 60 | 90 | 120 | 150 |                  |
| T1               | 100 a | 100 a | 100 a | 100 a | 100 a | 100 a |
| T2               | 46.87 ijk | 43.20 jklm | 39.54 klmn | 26.87 o | 20.20 op | 35.34 f |
| T3               | 39.87 klmn | n | 35.87 mm | 20.20 op | 15.54 p | 29.27 g |
| T4               | 58.20 efg | 56.54 fg | 54.54 gh | 39.20 lmn | 36.54 lmn | 49.00 e |
| T5               | 65.20 cde | 59.87 defg | 57.87 efg | 43.54 jkl | 35.87 mn | 52.47 d |
| T6               | 67.20 bcd | 63.87 cdef | 62.87 def | 47.20 ij | 48.56 ij | 57.94 c |
| T7               | 72.54 b | 70.54 bc | 63.20 def | 47.54 hij | 53.04 ghi | 61.74 b |
| Effect of time span after control | 64.27 a | 61.27 b | 59.13 b | 46.30 c | 44.4 c |

*The values in a column and rows followed by superscripts do not differ significantly at P=0.05 level of significance.

3.3 Effect of different treatment control on plant height, dry weight vegetative and rhizomes of common reed after 150 days of operation

A considerable difference in the plant height of common reed can be noticed in Table 5 as a result to applying different treatment methods of spraying and rope wick applicator using two herbicides of glyphosate and fluazifop-butyl. It is observed that rope-wick applicator can perform high rate of decreasing the plant height compared to the spraying method. T3 showed the lowest plant height of 81.0 cm. However, T7 (spray method) has attain the highest plant height of 160.0 cm. statistically, this affirmed 49.4 % as the difference between these two treatment methods. Furthermore, the results
clearly indicate that the glyphosate has an astonishing performance to decrease the plant height compared to fluazifop-butyl. The same findings were also observed by several researchers such as [6; 36; 26; 23].

Table 5 also shows a substantial difference in decreasing the dry weight vegetative amount of the common reed after 150 days of treatment. In this respect, T2 gave the lowest dry weight reached 328.33 g/m² compared to only water treatment method (T1), which produced dry weight reached 593.67 g/m². The spraying treatment method T4 and T7 produced dry weight vegetative amount of 401.00 g/m², and 480.67 g/m², respectively. This in turn confirmed the outstanding performance of the rope-wick applicator compared to the spraying method. Consequently, large portion of the weeds’ vegetative have been dead, which entirely inhibited the common reed to form new shoots. Therefore, this can essentially influence the dry weight of vegetative of weed plants. These conclusions are satisfied with the findings of [36].

Table 5 also exhibit that application of only water control treatment has significantly reduced the dry weight of rhizomes of common reed under the soil surface. T2 has also achieved a significant reduction of the dry weight of rhizomes of 221.33 g/m², which nominate it as the high-performance method compared to other tested methods. For instance, T1 and T7 methods have attained the worst performance of the dry weight of rhizomes of 384.67 g/m², and 296.0 g/m², respectively. The decrease in the dry weight of rhizomes defines the lowest content of carbohydrates stored in the rhizomes, which usually used by the plant to regrowth after the abnormal conditions such as the cutting or grazing (8). The stored CHO in common reed rhizomes is also used to regrowth in the following season after the dormancy during the winter (9). In general, the damage of total dry weight vegetative or rhizomes of the weed can affect the plant growth as a result to the depletion in nutrient.

Table 5. Effect of different treatment methods on plant height, dry weight of vegetative and rhizomes of common reed after 150 days of treatment

| Treatment method                                      | Height (cm) | Dry weight vegetative (g/m²) | Dry weight Rhizomes (g/m²) |
|-------------------------------------------------------|-------------|------------------------------|----------------------------|
| T1: Control treatment                                 | 196.00 a    | 593.67 a                     | 384.67 a                   |
| T2: 1 liter glyphosate in 1 liter of water (v/v)      | 87.00 de    | 328.33 e                     | 221.33 d                   |
| T3: 1 liter glyphosate in 2 liters of water (v/v)     | 81.00 e     | 375.33 d                     | 270.67 bc                  |
| T4: Glyphosate 1.8 g/liter -1*                         | 103.33 dc   | 401.00 d                     | 272.33 bc                  |
| T5: 1 liter fluazifop-butyl in 1 liter of water (v/v) | 108.66 c    | 383.67 d                     | 248.33 cd                  |
| T6: 1 liter fluazifop-butyl in 2 liters of water (v/v)| 111.67 c   | 433.67 c                     | 272.00 bc                  |
| T7: fluazifop-butyl 1.5 g/litre -1*                    | 160.0 b     | 480.67 b                     | 296.00 b                   |

The values in columns and rows followed by superscripts do not differ significantly at P=0.05 level of significance.

3.4 Effect of different treatment method on dry weight of common reed (150 days of operation)

The measurement of the reduction percentage of weed height represents the effectiveness of the herbicide used. This characteristic is readily depending on the reduction in the dry weight of plant caused by the effect of treatment method [40]. Fig. 1 confirms that the dry weight of the common reed has been remarkably reduced with the application of glyphosate and fluazifop-butyl solutions in wiping via the rope-wick applicator. The same trend of high performance has been registered to the spraying treatments of T2 and T7 compared to only water treatment method (T1). The treatment T2 gave highest percentage of common reed control reaching to 44.69% followed by treatments T3 (36.78%), T5 (35.37%), T4 (32.45%), T6 (23.95%) and T7 (19.03%). More importantly, T7
(fluazifop-butyl 1.5 g/litre-1) applied in sprayer has significantly gain the lower percentage of weed control (19.03%) if compared to T4 (glyphosate 1.8 g/liter -1). This can identify that glyphosate performance is favorable to control weeds. Also, results have conducted the usefulness of using the rope-wick applicator. T4 give superior on lower concentrations and spraying in both herbicides. High concentrations in wiping application seem to suit common reed control. This technique is also environmentally acceptable which entailed the reduction of using herbicide per unit area and to targeting only the weed plants in chemical control [40].

In this study, it was observed that the control of common reed did not hit 100%. This might be explained as a result to existing of some new shoots under the soil surface, which are not sufficiently treated by the herbicide solution. Also, it is fair to expect the occurrences of some other shoots that may resist the treatment and resumed their growth after the chemical treatment period. In addition, it is expected that the weed plants might have been metabolized the herbicide by specific enzymes in the weeds [20].Interestingly, this study showed that employing the rope-wick applicator method can enhance the control of common reed. This is quite similar to the results of [17] who adopted the control of perennial weeds (another type of the common reed) using the rope-wick applicator.

![Figure 1](image-url)

**Figure 1.** Effect of different treatment methods on dry weight of common reed after 150 days of operation

### 4. Conclusions
Results of current study showed that increasing rates of glyphosate and fluazifop-butyl volumes of application increases the efficiency of the herbicides in the control of common reed. Rope-Wick method would better control compared with application of herbicide with sprayer. Results also confirmed that the Rope-Wick applicator provide application directly on the surface of targeted weed without any risk of herbicide droplets to spread away from control weeds and reducing hazard of environmental contamination. The cost of management of common reed has been reduced and glyphosate gave a good control on common reed compared to fluazifop-butyl.
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