International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(Research Article)

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Identification of weeds resistant to glyphosate in corn growing areas of region 12

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International Journal of Science and Research Archive, 2026, 18(03), 1170-1178

Publication history: Received on 05 February 2026; revised on 12 March 2026; accepted on 14 March 2026

Article DOI: https://doi.org/10.30574/ijsra.2026.18.3.0376

Abstract

This study indentified the determined weeds resistant to Glyphosate of farmers from the Corn growing areas of South Cotabto,Nort Cotabato, Sarangani Province and Sultan Kudarat in Region 12 , Philippines. A descriptive observational, qualitative and experimental design was employed involving Focus Group Discussion with 20-30 Key informants from the province, Field Observation and gathering of weeds sample present in the field. Data were transcribed verbatim and analyzed using Thematical analysis from the response during FGD's. Experiment using different doses of herbicide was **also** conducted to the determined Glyphosate resistant weeds by the farmers. Frequency of weed occurrence were also gathered through quadrat. Findings indicated that farmers in particular provinces were adding adjuvants (additional mixtures to the) such as used cooking oil, fertilizers and other herbicide because of the farmer's belief of effective mitigation for determined weeds in the province,It was also observed in the Frequency of Weed Occurrence that Itch grass, banig-banig , tanglad-tanglad and Milk weed has the highest frequency. However, in the experiment of different doses including the recommended dose with 16TBSP/16 liters knapsack sprayer, 32TBSP/16liters knapsack sprayer and 8TBSP/16liters knapsack sprayer was observed that lower dose has significantly showed a higher survival rate while the over and recommended dose following the manufacturer's guidelines shows 0% survival rate. The study concluded that the presence of diverse weed species across Region 12's corn fields underscore the importance of region-specific weed management strategies. Consistent application of the recommended glyphosate dose effectively controls weed populations; however, the use of sub-lethal doses by farmers has led to significant survival of certain weeds, suggesting the emergence of glyphosate resistance. This resistance can compromise long-term weed control and crop productivity. Therefore, adherence to proper herbicide application rates and integrated weed management practices are critical to mitigate resistance development and sustain effective control measures. Further studies should investigate the genetic basis of resistance in prevalent weed species to develop targeted management strategies within Region 12.

Keywords: Glyphosate; Resistant weeds; Region 12

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1. Introduction

1.1. Technical description

1.1.1. Rationale

Glyphosate has become one of the most widely used herbicides in modern agriculture due to its broad-spectrum efficacy and cost-effectiveness, particularly in corn cultivation. However, the extensive and repeated use of glyphosate has led to the emergence of weed populations that are resistant to this herbicide, posing significant challenges to weed management and crop productivity (EPA,2017).

In Region 12 Philippines, where corn farming is a major livelihood and economic activity, the persistence of resistant weeds threatens to undermine the effectiveness of current herbicide practices, potentially leading to increased production costs, reduced yields, and environmental concerns. Despite the critical importance of this issue, there is a lack of localized data on the presence and distribution of glyphosate-resistant weeds within the region.

1.1.2. Potential Impact or Goal

This study aims to identify and document weed species in Region 12 that have developed resistance to glyphosate. The findings will provide valuable insights for farmers, agronomists, and policymakers to develop sustainable weed management strategies, mitigate the spread of resistance, and ensure the long-term productivity of corn farming in the area. Ultimately, this research seeks to contribute to the body of knowledge necessary for effective resistance management and sustainable agricultural practices in Region 12.

General Objective

To identify weeds resistant to glyphosate herbicide in corn growing areas of Region 12.

- **Specific Objectives**
- **To determine the** weeds, present in corn fields within Region 12
- To assess the factors contributing to the development of glyphosate-resistant weeds in the region.
- To provide recommendations for integrated weed management practices to mitigate resistance development in Region 12.
- **Expected Outputs per Objective**
- Provide valuable insights into weed resistant to glyphosate in corn growing areas.
- Provide list of weeds resistant to glyphosate.
- Determined factors contributing the development of glyphosate-resistant weeds in Region 12

2. Review of related literature

Glyphosate-usually known by many trade names, including Roundup has been the most widely used herbicide in the United State since 2001. It effectively controls, many weed species, and generally cost less than the herbicide that it replaced. Because several major crop varieties have been genetically engineered to tolerate glyphosate, crop grower can spray entire fields planted to glyphosate tolerant (GT) varieties, killing the weeds but not crops. This practice makes it easier to manage the weeds using less tillage, which can help reduce soil erosion and improve soil quality and water conservation. However, glyphosate's effectiveness is declining as weed resistance mounts-14 glyphosate-resistant (GR) weed species currently affect U.S. crop-production area GR weeds can reduce crop yield and increase weed-control costs, and recent surveys suggest that the amount of affected cropland is increasing. (Michael Livingsto, et.al 2015).

Kamalesh Sen Soumya, 2021 stated that, glyphosate (N-(phoshponomethyl) glycine) population is mainly due to industrial drainage and unnecessary use for agricultural and residential weed control purposes, which in turn creates ecosystem and environmental toxins. There are very important research fields needed for decontamination in a sustainable way. In this chap, She discuss an adsorption process of glyphosate from aqueous solution with influencing mechanisms, which are kinetics, isotherms, and thermodynamics. Reported results are depicted by consequence factors, namely PH, contact time, initial taken concentration, dose, Adsorbent preparation and active ingredient were applied by farmers and ranchers in the United State in 1974. The volume applied increased steadily.

Glyphosate or N-(phosphonomethyl) glycine is an active substance in commercial formulations for control of broadleaf weeds and grasses worldwide. Glyphosate disrupts the regulation of the synthesis of aromatic amino acids and secondary compounds in plants.

3. Methodology

3.1. Research Design

The team utilized descriptive observational, qualitative and experimental design.

3.2. Site identification

The research team identified corn growing farm in Region 12 based on the recommendation of Provincial Local Government Unit PLGU's of four (4) provinces.

3.3. Coordination with PLGU and MLGU

Coordination with PLGU and MLGU and identification of farm to survey was also conducted.

3.4. Focus Group Discussion and Interview

The team together with the Identified MLGU's by the PLGU's as corn growing areas of the four (4) provinces such as Carmen, North Cotabato, Glan, Sarangani Province , Bagumbayan, Sultan Kudarat and Banga, South Cotabato faciliated a Focus Group Discussion participated by identified corn farmers , key informants and AEWs.

3.5. Farm Survey, Collection and Identification of weeds

The team conducted farm survey and observation in the identified corn growing areas by the MLGU's in Carmen, North Cotabato, Sufatubo Glan, Sarangi Province, Surallah, South Cotabato and Bagumbayan,Sultan Kudar at, collected and identified weeds according to the local name called by the farmers. Identification of weed species was also done during the farm survey

3.6. Establishment of Experimental trial

The researchers established the experimental trial in Aroman Research and Experiment Station with three (3) plots measured at 5m x 5m replicated three times laid out using RCBD planted with the collected weeds from the sites identified as resistant to glyphosate according to the observation of farmers in the plot and applied glyphosate with different doses (lower dose, higher dose and recommended dose) as treatment follows:

- T1-Recommended dose (16 TBSP/16 liters knapsack sprayer)
- T2-(8 TBSP/16 liters knapsack sprayer)
- T3- (32 TBSP/ 16 liters knapsack sprayer)

3.7. Data to be gathered

Number of days to wilt: Following the application of the treatment, observations will be conducted daily until the onset of wilting symptoms.

- Survival rate: Survival Rate % = # of weeds after treatment/Initial number of weeds before treatment *100
- Plant Height: After 5 days of application gathering of plant height will be done.
- Resistant factor : RF= LD50(Resistant)/ LD50 (Susceptible)

4. Status of intellectual property application

No intellectual filed for the study, it focuses on the Identification of weeds resitsant ot glyphosate and its intended for research, academic and extension services only.

5. Result

Table 1 showed the list of seventeen (17) collected weeds of identified corn growing areas in the four (4) provinces of Region 12. It was observed that it doesn't have the same species however, some are with the same family.

Table 1 List of weed species present in corn fields within Region 12**.**

Common/Local Name	Corrected Scientific Name
Tapay-tapay / Plume cockscomb	*Celosia argentea* L.
Jute	*Corchorus olitorius* L.
Crab grass	*Digitaria sanguinalis* L.
Itch grass	*Rottboellia cochinchinensis*
Spindle top	*Cleome rutidosperma* DC.
Milk weed	*Euphorbia hirta* L.
Banig-banig	*Alysicarpus vaginalis* (L.) DC.
Day flower	*Commelina diffusa*
Mani-mani / Makahiya	*Mimosa pudica* L.
Kanding-kanding	*Commelina communis* L.
Poinsettia	*Euphorbia pulcherrima*
Trilobed morning glory	*Ipomoea triloba* L.
Tanglad-tanglad	*Cymbopogon citratus* (DC.)
Hagunoy / Devil weed	*Chromolaena odorata* (L.)
Carabao grass	*Paspalum conjugatum*
Para grass	*Brachiaria mutica*
Dilang-aso	*Pseudelephantopus spicatus*
Muti-muti / Bermuda grass	*Cynodon dactylon* (L.)

Table 2 shows presence and extent of glyphosate resistance among the identified weeds, determined factors contributing to the development of glyphosate resistant were assessed through farm surveys, interviews and focus group discussions facilitated by the researcher. Field observations conducted in the corn-growing areas of Kimadzil, Carmen, Cotabato; Sofatubo, Glan, Sarangani Province; Surallah, South Cotabato; and Bagumbayan, Sultan Kudarat, revealed consistent environmental conditions characterized by an average temperature of approximately 28°C, partial shaded sunlight exposure, and prior cultivation with corn based on actual field condition during the application of glyphosate. Notably, the soil types varied across these sites, with Kimadzil and Glan predominantly exhibiting sandy loam soils, whereas Surallah and Bagumbayan were characterized by clay loam soils. According to (Heap,2014) of his publication Herbicide resistance in weeds: a worldwide perspective of Pest Management Science Journal that soil differences may influence weed dynamics and the development of glyphosate resistance. Table 3 presents the application history of glyphosate. The findings indicate that farmers across the four provinces typically applied glyphosate twice within a single cropping cycle, initially at approximately three weeks after planting and subsequently at eight weeks. According to the farmers from Carmen, Cotabato they applied glyphosate one to two weeks prior to harvest, influenced by their available budget considerations. The application rate varied among provinces, with farmers in Carmen, North Cotabato, and Bagumbayan, Sultan Kudarat, using approximately 3-4 liters of glyphosate per hectare, while those in Surallah, South Cotabato, applied 2-3 liters, and in Glan, Sarangani Province, the application rate was between 2-4 liters. Furthermore, the farmers supplemented glyphosate with adjuvants which has been a culture to them: in Carmen, North Cotabato, adjuvants such as 30 ml of 16-20-0 fertilizer, 30 ml of 46-0-0 fertilizer, and 30 ml of motor oil were added. In Bagumbayan, Sultan Kudarat, and Surallah, South Cotabato, farmers incorporated 30 ml of 2,4-D herbicide, whereas in Glan, Sarangani Province, a complete fertilizer (30 ml) was added to 16 liters of solution in a knapsack sprayer. These application practices reflect site-specific management strategies and resource availability among the farmers in the respective regions. According to (Singh, Et.Al,2018) addition of fertilizers or herbicides to glyphosate formulations can influence weed resistance development through mechanisms such as reduced herbicide efficacy, sub-lethal dosing, and altered weed response. These practices may inadvertently select for resistant weed biotypes over time, complicating weed management efforts.

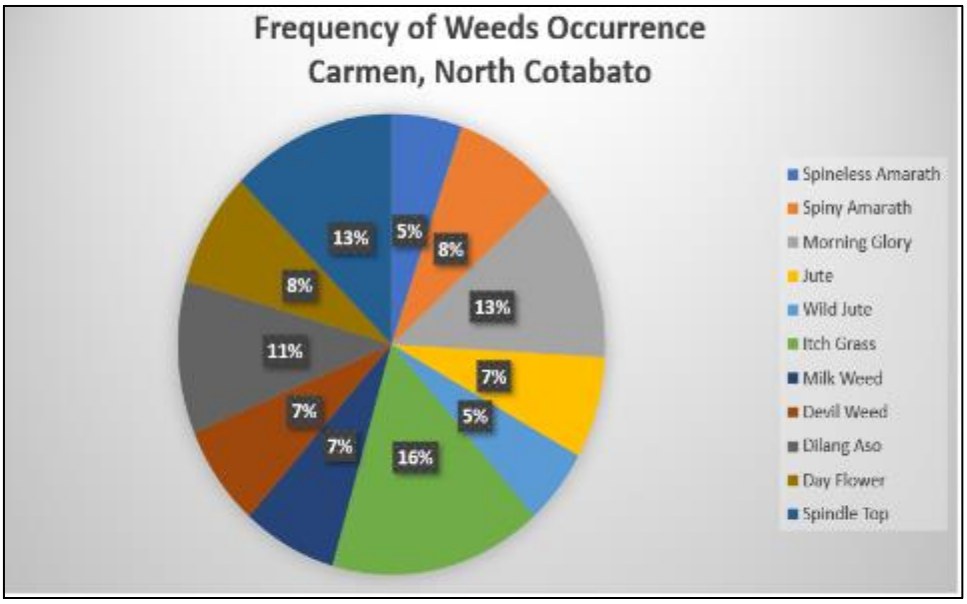

Figure 1 Frequency of weeds occurrence in Carmen,North Cotabato according to the actual farm survey.

The presented chart illustrates the frequency of weed occurrence within corn cultivation areas in North Cotabato. Data were collected on June 18, 2024, in Carmen, North Cotabato, from selected corn fields. Sampling involved the use of 1 m x 1 m quadrats, with a total of ten (10) plots sampled across the designated field.

The results indicate that itch grass exhibits the highest percentage of occurrence among the weed species assessed. Following this, morning glory (Ipomoea spp.) and spindle top accounted for 13% and 11%, respectively. Dilang Aso was observed at 13%, while spiny amaranth, jute, devil weed , and milkweed registered occurrence rates of 8%, 7%, 7%, and 7%, respectively. Spineless amaranth and wild jute demonstrated the lowest occurrence, each at 5%.

It highlights the prevalence of itch grass in the surveyed corn fields, showing its significant presence and potential impact on corn management in the province

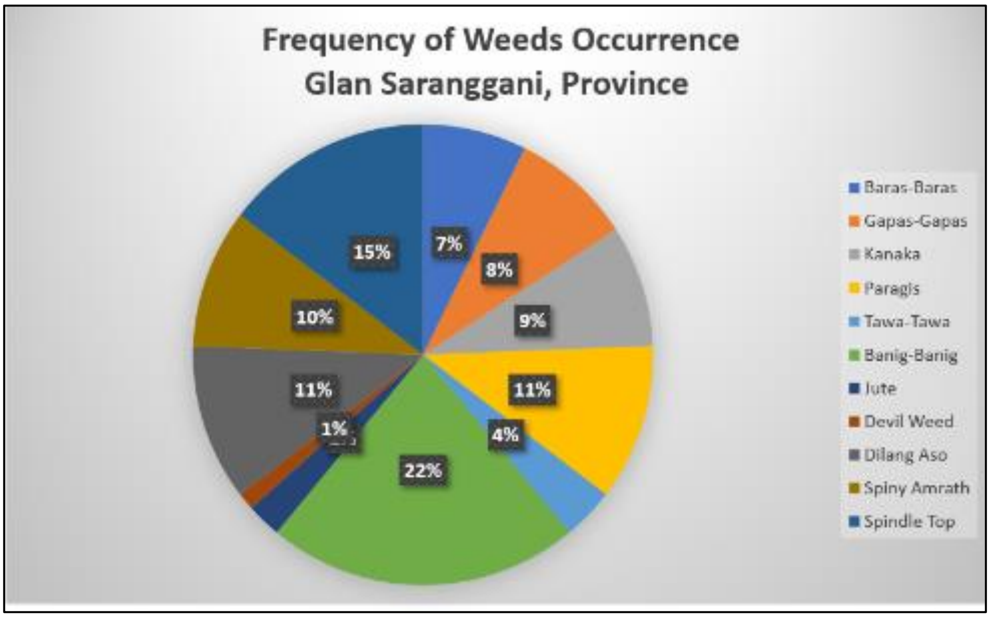

Figure 2 Frequency of weeds occurrence in Glan,Sarangani Province according to the actual farm survey

In Sarangani Province, Banig-banig exhibited the highest weed occurrence at 22%. This was followed by jute at 15%. Other notable species included Dilang aso and carabao grass , each with an occurrence of 11%. Spiny amaranth , kanaka , gapas-gapas , baras-baras

, spindle top , tawa-tawa , and devil weed were observed at 10%, 9%, 8%, 7%, 4%, and 1%, respectively. These data revealed that Banig-banig is the most prevalent weed species in the surveyed areas, with other species exhibiting varying degrees of occurrence.

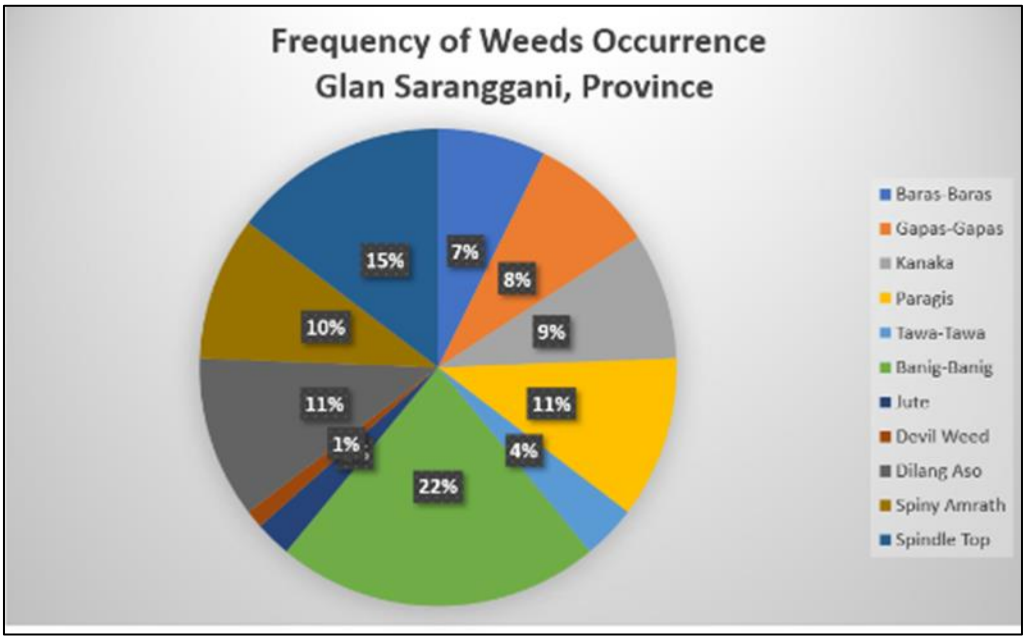

Figure 3 Frequency of weeds occurrence in Surallah,South Cotabato according to the actual farm survey

In South Cotabato, itch grass (Panicum spp.) demonstrated the highest occurrence at 20%. This was followed by tanglad-tanglad (and jute (Corchorus spp.), each with an occurrence of 16%. Dilang aso was observed at 14%, while paragrass (Brachiaria spp.) and muti-muti exhibited an occurrence of 12%. The species with the lowest observed occurrence was day flower (Commelina spp.), at 10%. This indicate that itch grass is the most prevalent weed species in the area, with other species showing moderate to low frequencies of occurrence.

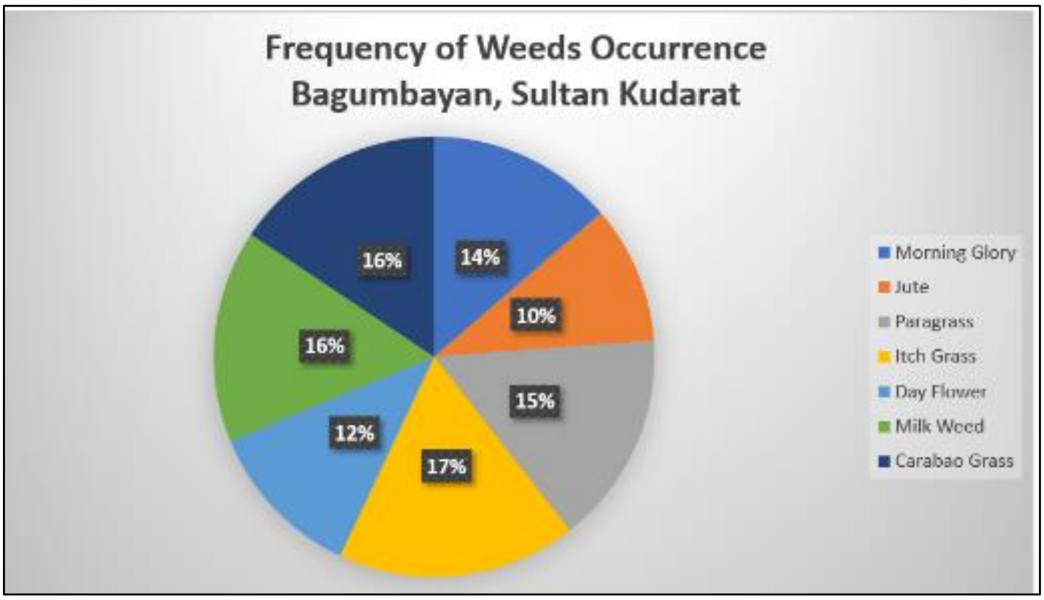

Figure 4 Frequency of weeds occurrence in Bagumbayan,Sultan Kudarat according to the actual farm survey

In Sultan Kudarat, itch grass (Panicum spp.) demonstrated the highest occurrence at 17%. This was closely followed by carabao grass and milkweed each with an occurrence of 16%. Paragrass was observed at 15%, while morning glory and day flower exhibited occurrences of 14% and 12%, respectively. Jute showed the lowest occurrence at 10%. These results indicate that itch grass is the most prevalent weed species in the region, with other species present at moderate to low frequencies.

Table 5 Determined Resistant Weeds by Farmers Across Region 12 Applied with Different Doses of Glyphosate

Determined Glyphosate Resistant	Lower Dose (8 TBSP/16 liters knapsack sprayer) (Weed Survival Rate % = # of weeds after treatment/Initial number of weeds before treatment *100	High Dose (32 TBSP/ 16 liters knapsack sprayer) Survival Rate % = # of weeds after treatment/Initial number of weeds before treatment *100	Recommended rate (Recommended dose (16 TBSP/16 liters knapsack sprayer) As per guidelines) Survival Rate % = # of weeds after treatment/Initial number of weeds before treatment *100
Tapay tapay	46.6	0	0
Crab grass	60	0	0
Banig-banig	93.3	0	0
Mani-mani	53.3	0	0
Kanding-kanding	73.3	0	0
Hagunoy/ Devil weed	86.6	0	0
Paragrass	87	0	0
Muti-muti	30.3	0	0
Dilang aso	48	0	0
Carabao grass	88.2	0	0

The data presented in the table illustrate the occurrence of glyphosate-resistant weed populations across Region 12, as determined by farmers and evaluated at the Aroman Research and Experiment Station, following application of varying glyphosate doses. Notably, applications at the higher dose (32 tablespoons per 16 liters of knapsack sprayer), aligned with the manufacturer's recommended rate, resulted in 0% survival across all weed species tested, indicating effective control at this concentration.

Conversely, the lower glyphosate dose employed by the researcher (8 tablespoons per 16 liters of knapsack sprayer) was associated with significantly higher survival rates among several weed species: Tapay-tapay (46.6%), Crabgrass (60%), Banig-banig (93.3%), Mani-mani (53.3%), Kanding-kanding (73.3%), Hagunoy (86.6%), Paragrass (87%), Muti-muti (30.3%), Dilang aso (48%), and Carabao grass (88.2%). These findings suggest that sub-lethal glyphosate doses may facilitate survival and potential development of resistance among weed populations.

This observation aligns with existing literature indicating that reduced herbicide application rates can contribute to the selection pressure favoring resistant weeds (Sammons & Gaines, 2014; Heap, 2020). Sub-optimal doses may not exert sufficient phytotoxic stress to eliminate resistant individuals, thereby allowing survivors to reproduce and potentially amplify resistance traits within the population. Moreover, the phenomenon of resistance development has been documented in various weed species subjected to repeated or sub-lethal herbicide applications (Powles & Yu, 2010).

6. Discussion

This study surveyed eighteen (18) weed species in corn fields across four provinces in Region 12, revealing diverse weed flora with some species sharing taxonomic families. Field assessments indicated that weed occurrence varies among regions, with itch grass being the most prevalent in North Cotabato, Banig-banig in Sarangani, and itch grass again dominant in South Cotabato and Sultan Kudarat. Farmers commonly applied glyphosate twice per cropping cycle, with application rates ranging from 2 to 4 liters per hectare, often supplemented with adjuvants or fertilizers, which may influence weed resistance development. Field observations demonstrated that while the recommended glyphosate dose (32 tbsp/16 L) effectively eliminated weeds, lower doses (8 tbsp/16 L) resulted in substantial survival rates, indicating potential resistance development. The findings support existing literature that sub-lethal herbicide doses can select for resistant weed biotypes, complicating weed management efforts.

7. Conclusion

The presence of diverse weed species across Region 12's corn fields underscore the importance of region-specific weed management strategies. Consistent application of the recommended glyphosate dose effectively controls weed populations; however, the use of sub-lethal doses by farmers has led to significant survival of certain weeds, suggesting the emergence of glyphosate resistance. This resistance can compromise long-term weed control and crop productivity. Therefore, adherence to proper herbicide application rates and integrated weed management practices are critical to mitigate resistance development and sustain effective control measures.

7.1. Recommendation

- -Farmers should be educated and encouraged to use glyphosate at the manufacturer's recommended dose (16 tbsp/16 L) to ensure effective weed control and reduce resistance selection pressure.
- Incorporate cultural, mechanical, biological, and chemical control methods to diversify weed control strategies and minimize reliance on herbicides alone.
- -DA RFO XII through the extension services should strengthen farmer awareness programs on the risks of sub-lethal glyphosate or any herbicide applications, adding of adjuvents and the benefits of integrated weed management.
- -Further studies should investigate the genetic basis of resistance in prevalent weed species to develop targeted management strategies within Region 12.
- -Chemical companies should consider soil types and environmental conditions in designing herbicide application schedules to optimize efficacy and reduce resistance development

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

The study involved the conduct of Focus Group Discussions (FGDs), and all participants provided informed consent prior to their participation. The confidentiality and anonymity of all participants were strictly maintained throughout the study.

Before the commencement of the research, coordination was undertaken with the Provincial Local Government Unit (PLGU), which granted permission to conduct the study in response to concerns raised by farmers regarding the presence of glyphosate-resistant weeds.

All data collected were securely stored and handled solely by the researchers. Information obtained from participants was treated with strict confidentiality, and only relevant data necessary for the study were presented.

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