Persistence and Effectiveness of Atrazine Herbicide in Sweet Corn (Zea mays saccharata Sturt) Cultivation with Different Organic Ingredients in Doses

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Article

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Abstract

The presence of weeds in sweet corn is one of the obstacles that can reduce crop yields, this is due to competition in taking nutrients, light, growing space, and water. Weed control is mostly done by using the herbicide atrazine. Herbicide persistence in the soil is strongly influenced by the organic matter content in the soil. The research objectives were to obtain the highest yield of sweet corn with the application of the herbicide Atrazine, as well as to determine the persistence of the herbicide used at each prescribed application dose. The results showed that atrazine herbicide treatment starting at a dose of 1–2,6 kg a.i./ha had an effect on reducing total weed dry weight and corn cob weight. The application of organic matter can increase the rate of herbicide degradation in line with the increased activity of microorganisms in the soil.

Introduction

Sweet corn is a food crop commodity that plays an important role in the agricultural sector. Corn is the second main source of carbohydrates and protein after rice. Corn plants can be used as food, animal feed and also fuel. Based on data from the Ministry of Agriculture of the Republic of Indonesia, corn production in 2018 was 30.05 million tons, then in the same year it increased by 3.9%, but decreased to 0.7% in 2019–2023. This causes an increase in the demand for corn by 3%/year. Based on Belawan Agricultural Quarantine data, in 2019 the need for sweet corn exports was 91 tons with an economic value of 892 million, then increased in 2020 to 111 tons with an economic value of 1.2 billion. This shows an increase in the volume of sweet corn exports in Indonesia.

The low productivity of maize due to the presence of plant-disturbing organisms has slowed agriculture in Indonesia. Various factors that play an important role are the presence of plant pests, such as pests, diseases, and weeds. The presence of weeds can inhibit the increase in sweet corn production. In addition, weeds can also act as hosts for plant pests and diseases (Maharani et al., 2018).

The presence of weeds in sweet corn can affect the growth and yield of the crop. Weeds are plant competitors in the utilization of nutrients, water and space. Some weeds also become a place to live and shelter pests and plant diseases, and clog waterways. The results showed that the loss of maize yields due to competition with weeds was 31% (Purba *et al.*, 2009). Weed control using herbicides is in great demand by farmers, especially for large areas of land, but efforts are made so that it does not have a negative effect on cultivated plants.

Soil is a factor that can affect the effectiveness of a herbicide. Herbicides in the soil are strongly influenced by various processes, namely physical, chemical, and biological which are very complex and dynamic processes, adsorption, photodecomposition, evaporation, leaching, degradation in the soil (Tu et al., 2001). Herbicide efficacy is influenced by the adsorption process in the soil, the loss of herbicides and their behavior in the soil as well as side effects in the form of residues that affect environmental health. Herbicide adsorption by soil particles determines the persistence of a herbicide in the soil, which is related

to the unit of time the herbicide remains in an active state. Herbicides will be effective in controlling weeds, if the herbicide is in the soil for a long time. The determining factor for the effectiveness of herbicides, one of which is the active time of the herbicide in the soil is called persistence. Herbicide persistence is influenced by various factors such as organic matter content in the soil, volatilization, photodecomposition, adsorption, leaching, microbial degradation, and absorption by plants (Rahman et al., 2011).

Organic matter is a component of soil that can improve soil properties, both physical, chemical and biological properties of the soil (Afandi et al., 2015). Subowo (2010) reported that intensively cultivated soils in Indonesia have low organic matter content. The low content of organic matter in the soil will interfere with the availability of water, air, nutrients for plants, and soil buffers to be reduced so that most of the inorganic fertilizers applied to the soil become unavailable to plants. Low organic matter will result in low land productivity.

Organic matter is the key to integrated crop farming management, in line with priority programs to increase production and productivity of strategic food commodities. The availability of organic matter is very useful for increasing the nutrient and organic matter content of the soil, as well as improving soil properties (Wihardjaka, 2021). Organic matter plays an important role in the adsorption of herbicides in the soil. Herbicide adsorption by organic matter in soil is an important process influencing environmental fate on biological activity, persistence, biodegradation, volatilization, bioaccumulation and leaching (Li et. al., 2003). The application of organic matter is the basis of the effectiveness of herbicides to suppress weed growth in the field and the impact of residues on the environment.

Herbicide atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine) is one of the herbicides used in grain production, one of which is sweet corn. The herbicide atrazine is environmentally persistent, with a half-life of approximately 57 weeks (Scott *et al.*, 2009), accumulation of atrazine residues in the soil lasts longer than natural degradation (Udikovic-Kolić *et al.*, 2012). Atrazine herbicide is widely used for weed control in sweet corn plantations, but until now it is not known how long atrazine persists in the soil.

Based on the foregoing, it is necessary to investigate how the effect of the application of the herbicide Atrazine with organic matter on herbicide persistence in sweet corn plantations.

Materials And Methods

The experiment was carried out from July to October 2021 in Baleendah District, Bandung Regency, West Java Province, Indonesia. The location of the land is located at an altitude of about 660 meters above sea level with inceptisol soil types. Laboratory analysis was carried out at the Laboratory of Soil Fertility and Plant Nutrition, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang Regency.

The materials used in this experiment were compost, corn seed, and herbicide with the active ingredient atrazine. Fertilization is done using straw compost which is left for about 1 year, urea (45% N), TSP fertilizer (46% P2O5), and KCl (50% K2O). The tools used in this research are analytical balance, oven,

knapsack, knife, scissors, plastic bag, ruler/meter, sickle, hoe, bucket, and laboratory tools to measure microorganism activity.

The field experiment used a two-factor experiment with a split-plot design in a randomized block design. The main plot factor is organic matter, consisting of three levels, namely:

b1 : Low C-organic content (1.02%)

b2 : Medium C-organic content (2.50%)

b3 : High C-organic content (3.50 %)

The subplot factor was the dose of the herbicide Atrazine, consisting of five levels:

d0 : No herbicide

d1 : Atrazine dose 1.0 kg a.i./ha

d2 : Atrazine dose 1.4 kg a.i./ha

d3 : Atrazine dose 1.8 kg a.i./ha

d4 : Atrazine dose 2.2 kg a.i./ha

d5 : Atrazine dose 2.6 kg a.i./ha

The data from the analysis of variance was further tested with the Scott-Knott test at a 5% significance level.

Response Variable:

1. Total weed dry weight

Total dry weight of weeds was the total dry weight of weeds in each treatment plot and each replication. Weed dry weight was observed on weeds taken from sample plots at 2, 4, and 6 weeks after application. The weeds were cut above the soil surface, then dried in a drying oven at a temperature of 80^0C until they reached a constant weight and then weighed. Weed dry weight observed per species, other weeds, and total weeds.

2. Sweet Corn Crop Yield

Observation of sweet corn weight per experimental plot was carried out at harvest time.

3. Observation of Microorganism Activity in Soil

Observations of microorganism activity were carried out at the Laboratory of Soil Fertility and Plant Nutrition, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang Regency. Observations in the soil were indicated by the respiration of microorganisms in the soil, observed at 30, 60, and 90 days after application.

4. Herbicide Persistence in Soil

Observation of the persistence of atrazine herbicide was carried out by bioassay with an indicator plant, namely cucumber, in the Greenhouse of the Faculty of Agriculture, Universitas Padjadjaran. Observations were made on herbicide persistence in the soil at 30, 60, and 90 days after application.

Results And Discussion

Total Weed Dry Weight

The total dry weight of weeds was the dry weight of all weed species found during observations. Based on the data presented in Table 1 at observations 2, 4, and 6 weeks after application, it can be seen that all treatments of atrazine herbicide starting at a dose of 1.0-2.6 kg b.a./ha showed a smaller total dry weight of weeds and significantly different compared to treatment without herbicide either at low, medium or high organic C content. This indicates that the application of the herbicide atrazine starting at a dose of 1.0-2.6 kg b.a./ha is effective in controlling total weeds. In line with the research results of Mustajab et al. (2014) that the herbicide atrazine was able to suppress total weed growth well in maize cultivation for up to 6 weeks after application.

Table 1
Total Weed Dry Weight Data

	2 Weeks After Application			4 Weeks After Application			6 Weeks After Application		
	b1	b2	b3	b1	b2	b3	b1	b2	b3
d0	5.83 a A	13.4 a A	16.53 a A	22.73 a A	33.13 a A	33.33 a A	38.63 a A	55.83 a A	16.43 a A
d1	2.75 a B	1.50 a B	1.53 a B	18.83 a A	10.33 a B	6.57 a B	31.73 a A	22.93 a B	16.40 a A
d2	1.97 a B	1.03 a B	0.83 a B	7.17 a B	4.87 a C	4.03 a B	11.50 a B	10.83 a B	12.33 a B
d3	1.67 a B	0.67 a B	0.80 a B	3.15 a B	2.97 a C	2.13 a B	8.77 a B	9.37 a B	9.27 a B
d4	1.60 a B	0.60 a B	0.53 a B	2.47 a B	2.30 a C	1.47 a B	3.60 a B	6.03 a B	8.23 a B
d5	0.70 a B	0.30 a B	0.17 a B	1.90 a B	1.83 a C	1.27 a B	2.50 a B	3.60 a B	1.47 a B

Information: b1: Low organic C content (1.02%); b2: Medium organic C content (2.50%) b3: High organic C content (3.50%); d0: No herbicide; d1: Atrazine dose 1 kg a.i./ha; d2: Atrazine dose 1.4 kg a.i./ha; d3: Atrazine dose 1.8 kg a.i./ha; d4: Atrazine dose 2.2 kg a.i./ha; d5: Atrazine dose 2.6 kg a.i. /ha. Numbers followed by the same letter were not significantly different according to Scott Knott's follow-up test at the 5% level (numbers followed by uppercase letters were read in vertical notation indicating the interaction of levels of organic matter content with various doses of herbicides, while those followed by lowercase letters were read in horizontal notation). interaction of herbicide doses with various levels of organic matter content.

Corn Cob Weight Per Plot

Based on the data presented in Table 2, it can be seen that the independent effect of treatment with low organic C, medium organic C, and high organic C content did not show different weights of corn cobs per plot that were significantly different from each other. This is in line with the research results of Sitepu *et. al.* (2017) that the treatment of straw compost does not have a direct effect on plant growth and yield.

The herbicide atrazine treatment showed an average weight of the corn cobs which tended to be higher than the treatment without herbicide. The herbicide atrazine treatment at a dose of 2.2 kg a.i./ha resulted in the highest average weight of corn cobs per plot and was significantly different from the treatment without herbicide. This indicated that the herbicide atrazine was able to suppress weed growth and had a good effect on plant growth. According to Zami et. al. (2021) Atrazine herbicide is a pre-emergent herbicide that has selective properties for maize, so it can be applied without poisoning the plants. Furthermore, Garfansa et. al. (2021) revealed that the translocation of photosynthate which was quite large to the reproductive organs caused the formation of cob and seed filling to take place well and the seeds formed were pithy with a larger size.

Table 2
Data on the weight of corn cobs per plot

Treatment	**Variable (kg/12m^2)**
C-organic content	Cob Weight
b1	156.5 a
b2	150.5 a
b3	150.5 a
Herbicide Dosage	Cob Weight
d0	138.5 a
d1	155.5 ab
d2	151.0 ab
d3	153.5 ab
d4	163.5 b
d5	153.5 ab

Information: b1: Low organic C content (1.02%); b2: Medium organic C content (2.50%) b3: High organic C content (3.50%); d0: No herbicide; d1: Atrazine dose 1 kg a.i./ha; d2: Atrazine dose 1.4 kg a.i./ha; d3: Atrazine dose 1.8 kg a.i./ha; d4: Atrazine dose 2.2 kg a.i./ha; d5: Atrazine dose 2.6 kg a.i. /ha. The numbers followed by the same letter were not significantly different according to Duncan's follow-up test at the 5% level.

Conclusion

1. Atrazine herbicide treatment from a dose of 1,0 kg a.i./ha to 2.6 kg a.i./ha affected the reduction in total dry weight of weeds, and weight of corn cobs without husks.

2. Atrazine herbicide treatment at a dose of 2.2 kg a.i./ha was able to produce a weight of 163.5 kg/plot without corn cobs.

3. The content of C-organic can increase the activity of microorganisms in the soil at observations 30, 60, and 90 days after application.

4. The application of organic matter can increase the rate of herbicide degradation in line with the increased activity of microorganisms in the soil. The moderate C-organic treatment of 2.50% gave the lowest herbicide persistence yield based on the largest cucumber plant dry weight yield.

Abbreviations

a.i. = active ingredients

mg. = milligram

Declarations

- **Ethics approval and consent to participate** : Not applicable
- **Consent for publication** : Not applicable
- **Statement on experimental research and field studies on plants :** This research was conducted in the field and laboratory belonging to the University of Padjadjaran using the herbicide atrazine, sweet corn seeds, and cucumber seeds that are already on the market, in accordance with applicable regulations and obtaining permission from the relevant agencies.
- **Data availability statements :** Data supporting the findings of this study are available upon request from the concerned authors.
- **Competing interests :** The authors declare that they have no competing interests
- **Funding** : This research was funded by a grant from the Universitas Padjadjaran
- **Authors' contributions :**

YS is the main author (main contributor) in the journal manuscript

DW assisted in the preparation of results and discussion

UU performs data analysis

AF conducts research in the field

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- Authors' information : All authors are lecturers at the Faculty of Agriculture, Universitas Padjadjaran

References

1. Afandi, F. N., B. Siswanto, dan Y. Nuraini. 2015. Pengaruh Pemberian Berbagai Jenis Bahan Organik Terhadap Sifat Kimia Tanah Pada Pertumbuhan Dan Produksi Tanaman Ubi Jalar Di Entisol Ngrangkah Pawon, Kediri. *J. Tanah dan Sumberdaya Lahan,* Vol 2 No 2 : 237-244.
2. Fenoll J, Vela N, Navarro G, Pérez-Lucas G, Navarro S Assessment of agro-industrial and composted organic wastes for reducing the potential leaching of triazine herbicide residues through the soil. *Sci. Total Environ*, Vol. 493:124-32.
3. Ferhatoglu, Y., & Barrett, M. 2006. Studies of clomazone mode of action. *Pesticide Biochemistry and Physiology*, 85: 7-14.
4. Garfansa, M. P., K. Perdana, W. Sukma. 2021. Translokasi asimilat tanaman jagung (Zea mays L.) hasil persilangan varietas Elos dan Sukmaraga pada cekaman garam. J*. Agroekoteknologi*, 14(1): 61–65.
5. Li, H. Guangyao, S. Brian, J.T. Cliff, Stephen, A.B. 2003. Sorption and Disorption of Pesticides by Clay, Materials, and Humic Acid-Clay Complexes. *Soil Sci. Am.J.* 67:122-131.
6. Loganathan VA, Feng Y, Sheng GD, Clement TP. 2009. Crop-residue-derived char influences sorption, desorption and bioavailability of atrazine in soils. *Soil Sci Soc Am J.* 73:967-74.
7. Maharani, Y., P. Hidayat, A. Rauf, N. Maryana. 2018. Kutudaun (Hemiptera: Aphididae) pada gulma di sekitar lahan pertanian di Jawa Barat beserta kunci identifikasinya. *J. Entomologi Indonesia*, Vol. 15 No. 2, 74–84.
8. Mandelbaum RT, Allan DL, Wackett. 1995. Isolation and characterization of a pseudomonassp. that mineralizes the s-triazine herbicide atrazine. *Appl. Environ. Microbiol.*, 61(4):1451–1457.
9. Mustajab, Dad R. J. Sembodo , dan Herawati Hamim. 2014. Efikasi Herbisida Atrazin terhadap Gulma Umum pada Lahan Budidaya Tanaman Jagung (Zea mays L.). *J. Penelitian Pertanian Terapan*, Vol. 15 (1): 8-14.
10. Purba, E. 2009. Keanekaragaman herbisida dalam pengendalian gulma mengatasi populasi gulma resisten dan toleran herbisida. Pidato Pengukuhan Jabatan Guru Besar Tetap dalam Bidang Ilmu Gulma pada Fakultas Pertanian Universitas Sumatera Utara. Medan, 10 Oktober 2009. www.usu.ac.id. (diakses tanggal 10 Maret 2012).
11. Rahman, A., T.K. James, M.R. Trolove, and C. Dowsett. 2011. Factors affecting the persistence of some residual herbicides in maize silage fields. New Zealand Plant Protection Society (Inc.) Available at www.nzpps.org Refer to http://www.nzpps.org/terms_of_use.htm (diakses November 2013).
12. Riva, Juli & Juarez, Ana & Yudi, Lidia. 2011. Interactions between Herbicides and Humic Acids present in soils.
13. Scott C., C.J. Jackson, C.W. Coppin, R.G. Mourant, M.E. Hilton, T.D. Sutherland, R.J. Russell, J.G. Oakeshott .2009. Catalytic improvement and evolution of atrazine chlorohydrolase. *Appl. Environ. Microbiol.*, 75(7):2184–2191.

14. Sitepu, R.Br., I. Anas, S. Djuniwati. 2017. Pemanfaatan Jerami Sebagai Pupuk Organik Untuk Meningkatkan Pertumbuhan Dan Produksi Padi (*Oryza sativa*). *Buletin Tanah dan Lahan*, Vol 1 (1) : 100-108.
15. Sriyani, N. dan A.K. Salam. 2008. Penggunaan Metode Bioassay untuk Mendeteksi Pergerakan Herbisida Pascatumbuh Paraquat dan 2,4-D dalam Tanah. *J. Tanah Trop.*, Vol. 13 (3): 199-208.
16. Subowo. 2010. Strategi Efisiensi Penggunaan Bahan Organik untuk Kesuburan dan Produktivitas Tanah Melalui Pemberdayaan Sumberdaya Hayati Tanah. *Jurnal Sumberdaya Lahan* Vol. 4 No. 1 : 16-25.
17. Sumekar, Y., D. Kurniadie, D. Widayat and A. Yuniarti. 2021. Effectiveness and Persistence of Metsulfuron-Methyl Herbicide in Rice Fields with Compost Organic Materials. *Asian Journal of Plant Sciences*, Vo. 20 (4): 610-619
18. Udiković-Kolić N, Scott C, Martin-Laurent F (2012) Evolution of atrazine-degrading capabilities in the environment. *Appl. Microbial. Biotechnol.*, 96:1175–1189
19. Uko, Ibeabuchi, Onunwa, Akudo, Ndukwe, Okorie, P.C., Nwadike, O.I., Ezennia. 2019. SOIL Physico-Chemical Properties, Cucumber (*Cucumis sativus* L.) Growth And Yield As Influenced by Land Preparation And Weed Control Methods. 6. 14-20.
20. Wihardjaka, A. (2021). Dukungan Pupuk Organik Untuk Memperbaiki Kualitas Tanah Pada Pengelolaan Padi Sawah Ramah Lingkungan. *J. Pangan*, Vol. *30*(1), 53-64.
21. Tu, M., C. Hurd, and J. M. Randall. 2001. Weed Control Methods Handbook: Tools & Techniques for Use in Natural Areas. Utah State University.
22. Zami, Z., H. Susanto, K.F. Hidayat, H. Pujisiswanto. 2021. Efikasi Herbisida Atrazin Terhadap Gulma dan Pertumbuhan Serta Hasil Tanaman Jagung (Zea mays L.). *J. Agrotropika* Vol. 20 (1): 9-16.

Figures

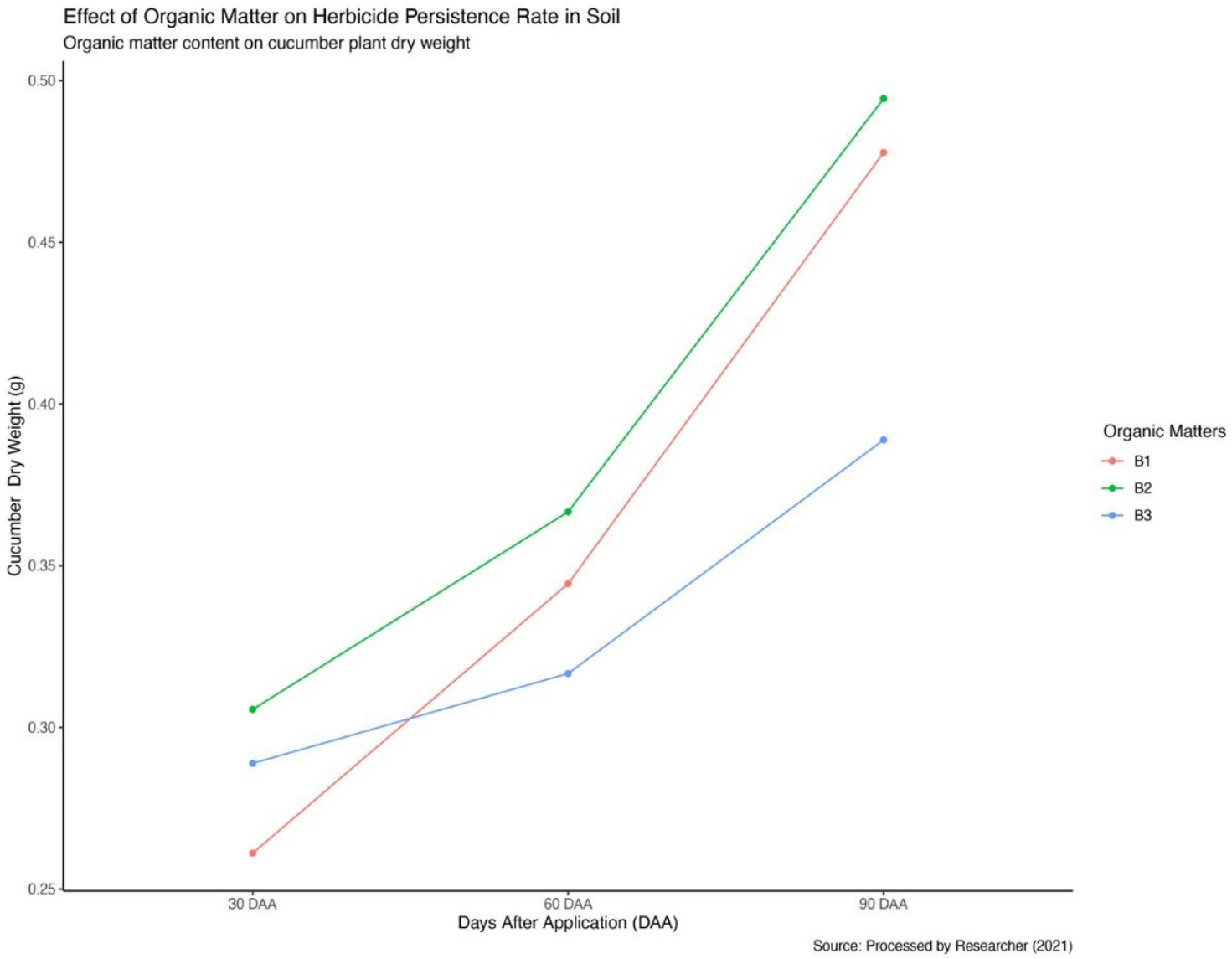

Figure 1

Effect of Organic Matter Content on Herbicide Persistence Rate

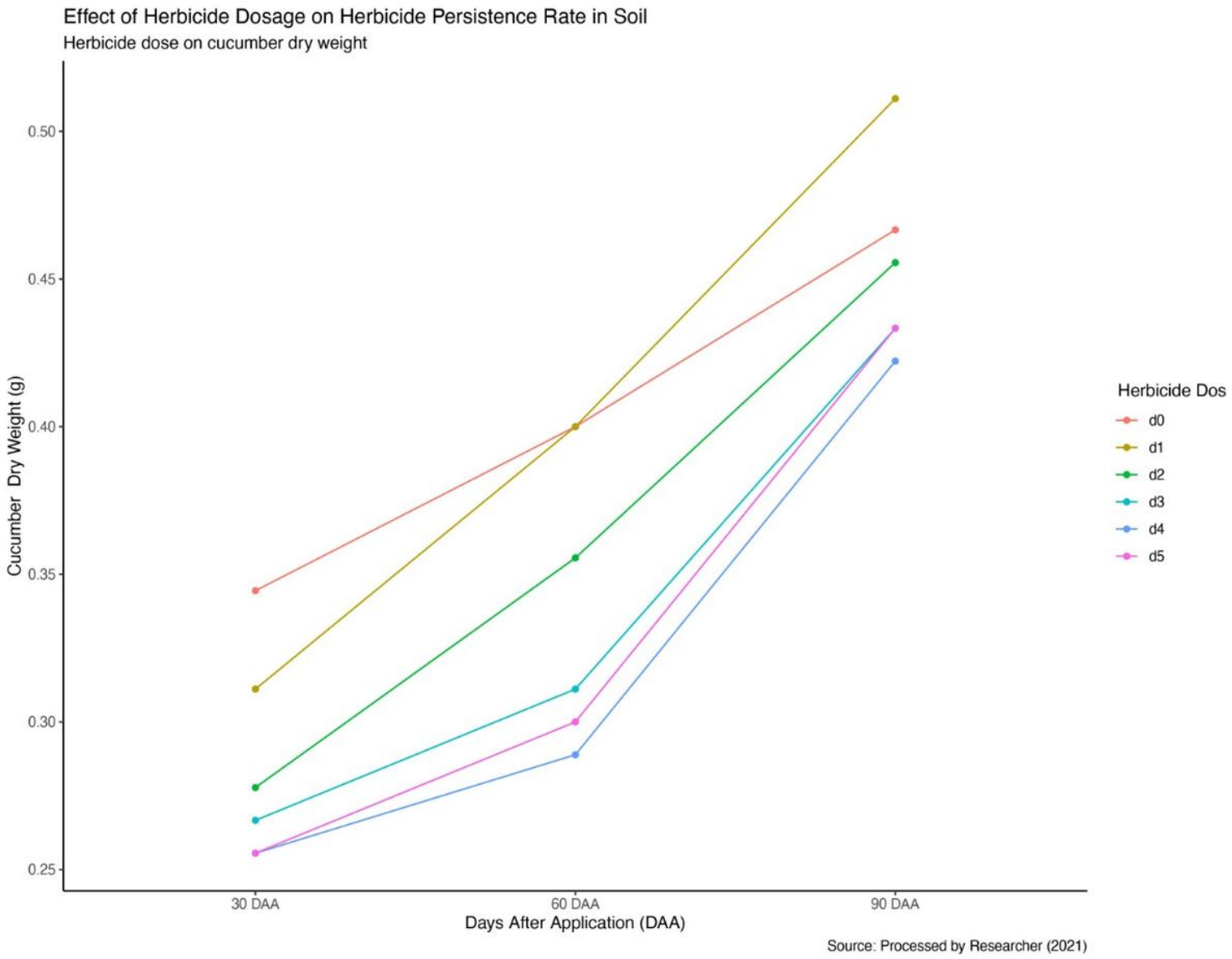

Figure 2

Effect of Organic Matter Content on Herbicide Persistence Rate

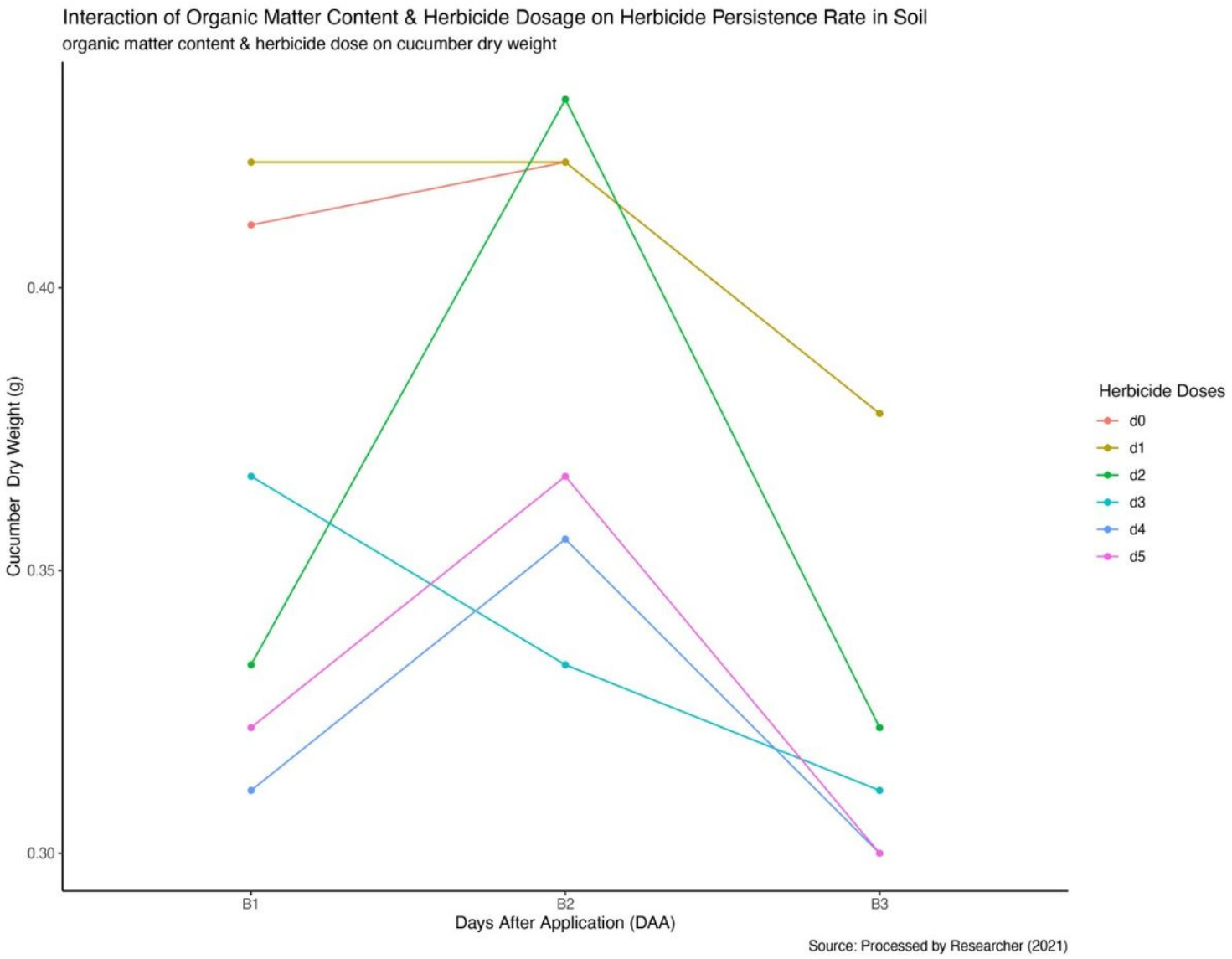

Figure 3

Interaction of Organic Matter Content & Herbicide Dosage on Herbicide Persistence Rate