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Pest Management of Hemp

Introduction

Hemp (*Cannabis sativa* L.) is one of the oldest (ancestral) crops and reached a peak of population size at ~1 million years ago (Guangpeng Ren et al., 2021). Due to its high-yield characteristics (10,117 kg/acre of biomass), hemp is being grown to obtain fiber, seed, and oil (Deng et al., 2019). About 25,000 products have been manufactured from industrial hemp, including textiles, automotive (composites for interior applications and motor vehicle parts), food and beverages, paper, furniture, construction (insulation) and personal care products (Cherney and Small, 2016; Johnson, 2018; Crini et. al., 2020). Hemp is being produced in almost 50 countries, its cultivation area reached 468,304 acres in 2019 (Schluttenhofer and Yuan, 2017; Cruz et. al., 2021), and Aloo et al. (2022) projected global income of hemp at $7.08 billion by 2027.

Hemp production began several hundred years ago in the U.S. (Cherney and Small, 2016) and reached its production peak between the 1930s and 1950s, with 146,200 acres planted in six Midwestern states in 1943 (Mark et al., 2020). However, due to the Marihuana Tax Act, hemp production decreased. No hemp records were available between 1951 and 2014 (Cranshaw et al., 2019). Colorado, Indiana, Kentucky, and Vermont planted hemp as a pilot program in 2014. Indiana grew hemp for research purposes on 5 acres in 2015 and 16 acres in 2018 (11 acres for fiber and 5 acres for seed) (Mark et al., 2020). Hemp products in the U.S. reached $824 million in sales in 2021 (USDA NASS, 2022).

By 2019, legislation governing a pilot program for industrial hemp had been passed in 39 states. Until more federal guidance was provided, Indiana was the only state to pass legislation expressly forbidding hemp production. Although 11 states do not have an industrial hemp pilot program, seven have proposed legislation to establish one (Adesso et al., 2019). However, in 2021, the Indiana State Department of Agriculture (ISDA) issued 79 licenses in 45 of the state's 92 counties to grow hemp on 1,945 acres outdoors and 181,688 square feet indoors (ISDA 2022).

Hemp has been replacing cotton – the world's largest natural fiber supplier – due

to cotton's higher pesticide and water requirements and subsequent environmental impacts (Esteve-Turrillas and de la Guardia, 2016). One of the key advantages of hemp is that its fiber contains 73%-77% cellulose, a higher cellulose content than other energy crops (Schluttenhofer and Yuan, 2017). Moreover, hemp can be planted under high density (35-50 plants/square feet), grows rapidly, and has high average yields of fiber (1 to 5.5 tons dry matter per acre) and seed/grain (800 to 1,000 lbs./acre) (Johnson, 2019). However, hemp is susceptible to diseases, weeds, and insects (Bakro et al., 2018). Mark et al. (2020) noted other challenges, including establishing state legislation that permitted hemp cultivation or growth; obtaining necessary production inputs (such as seeds, insecticides, and herbicides); inconsistent state requirements; and a lack of fundamental data and information for decision-making.

This publication will address pest and pest management practices on hemp in six states in north central United States. A second publication will provide information on agronomics and marketing barriers, challenges and opportunities on hemp in the same six states. To gain a greater understanding of hemp production, and pest management practices and their impact, we conducted an online survey of 119 farmers from Illinois, Indiana, Michigan, Ohio, Oregon, and Wisconsin in 2021. To increase the participation rate, a $10 gift card incentive was offered to farmers who completed the survey. We categorized respondents who were growing hemp as *growers* (N=82) and those considering growing hemp in the future as *potential growers* (N=29). Farmers neither growing nor considering growing hemp were categorized as *uninterested growers* (N=8). Our goal was to identify needs for future research in hemp integrated pest management and to develop Extension information to address pest management concerns of hemp producers.

Hemp Pests and Pest Management

The most common pests to manage among all hemp growers were weeds (49% of growers), followed by insects (45% of growers), and diseases (32% of growers). We further categorized growers as those growing hemp for seedling, rooted cutting, or tissue culture propagules as seedling (N=35), growing mother or stock plants as stock (N=15), or growing crop for harvest as harvest (N=68). Insects were the most difficult pest for seedling and stock growers, while weeds were the major concern for growers for harvest. Forty-three percent of seedling growers, 13% of stock growers, and 54% of growers for harvest reported weeds were somewhat or extremely difficult to manage.

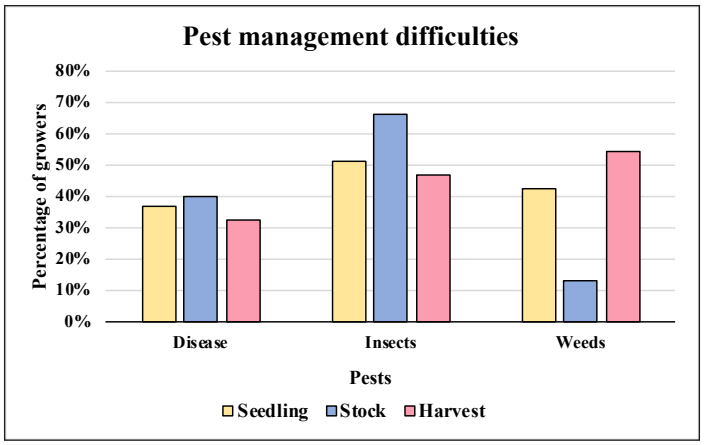

Figure 1. *Percentage of growers in Illinois, Indiana, Michigan, Ohio, Oregon, and Wisconsin who perceived management of disease, insect, and weed pests as somewhat or extremely difficult in 2021.*

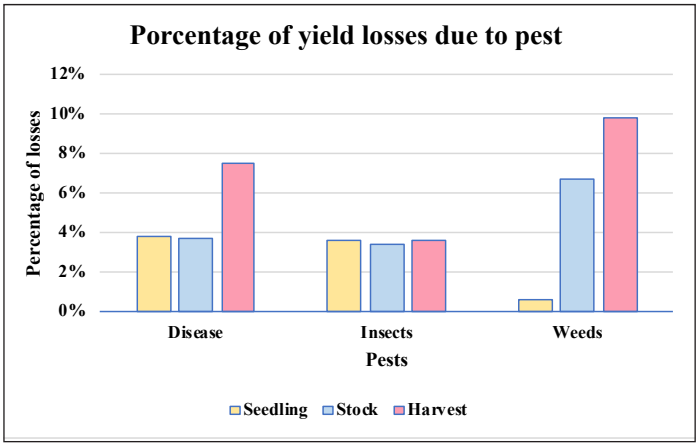

Figure 2. *Percentage of yield loss attributed to disease, insect, and weed pests by growers in Illinois, Indiana, Michigan, Ohio, Oregon, and Wisconsin in hemp production in 2021.*

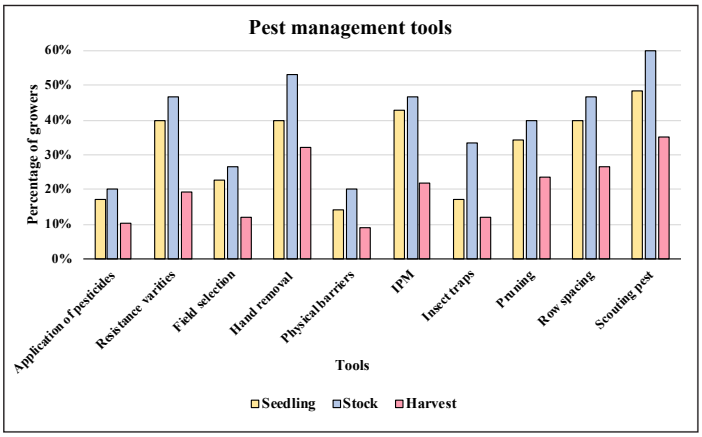

Figure 3. *Percentage of growers in Illinois, Indiana, Michigan, Ohio, Oregon, and Wisconsin who reported using pest management tools in hemp production in 2021.*

Half of seedling growers (51%) and growers for harvest (47%), and 67% of stock growers reported that insects were difficult to manage (Figure 1).

Yield loss due to weeds was rated the highest among growers for harvest (10%), followed by seedling growers (6%) (Figure 2). The largest cause of yield loss for stock growers was disease (4%). Insects caused less than 4% yield loss among all growers' categories.

As shown in Figure 3, scouting for pests was the most common pest management tool used for stock growers (60%), seedling growers (49%), and growers for harvest (35%). Hand-removal was another popular tool for pest management, used by 53% of growers for stock, 40% for seedling, and 32% for harvest. Two common pest management tools were row spacing and planting pest-tolerant varieties; 47% of growers for stock, 40% for seedling, and less than 25% of growers for harvest selected these techniques. Incorrect row spacing impacts pest management through air circulation, light penetration, pest monitoring, movement, and spread, etc. Similarly, Vera et al. (2006) found that weed density was affected by hemp seeding rate and row spacing.

A larger percentage of growers for stock reported using all pest management tools (39%), when compared to growers for seedling (32%) or harvest (20%). Growers for seedling reported using IPM practices (43%), followed by using resistance varieties (40%), hand removal (40%), and row spacing (40%). Among growers for harvest, the top three pest management tools included scouting for pests (35%), hand removal of weeds (32%), and row spacing (27%).

Disease Management

As we can see in Figure 4, a larger percentage of stock growers reported experiencing hemp root and crown diseases compared to growers for seedling or harvest. The most common diseases in roots and crowns were white mold (*Sclerotinia sclerotium*) and Botrytis (*Botrytis cinerea*). Twenty-six percent of seedling growers, 27% of stock growers, and 18% of growers for harvest reported having white mold in their hemp crowns. A fifth of growers have had Botrytis in their hemp crown. Six percent of seedling growers, 13% of stock growers, and 4% of growers for harvest reported Pythium in hemp roots. Less than 7% of growers reported Phytophthora and southern blight (Sclerotium rolfsii) in hemp. Likewise, Punja (2021) found that the principal pathogens that caused the most significant impact in roots and crown on indoor hemp production were Botrytis, Fusarium, and Pythium (*Pythium ultimum*), and losses due to the last two diseases can be as high as 30% of the crop.

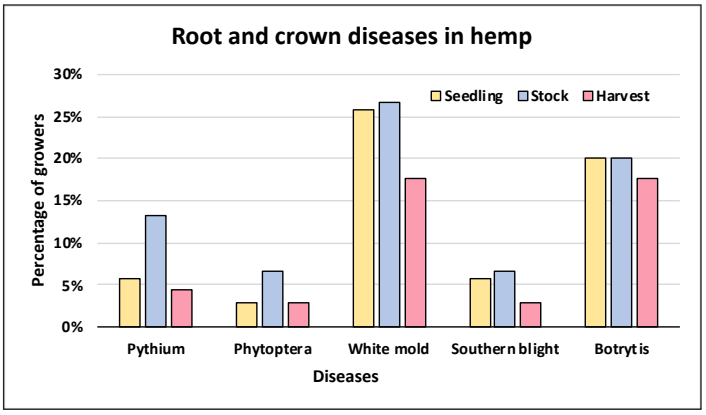

Figure 4. *Percentage of hemp growers in Illinois, Indiana, Michigan, Ohio, Oregon, and Wisconsin who reported experiencing root and crown diseases in 2021.*

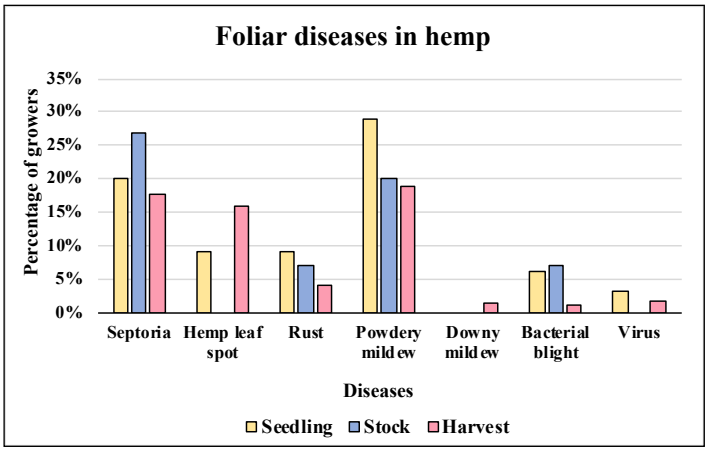

Figure 5. *Percentage of hemp growers in Illinois, Indiana, Michigan, Ohio, Oregon, and Wisconsin who reported experiencing foliar diseases in hemp in 2021.*

Among hemp leaf diseases, most growers have experienced powdery mildew and Septoria as a disease on leaves. Twenty-nine percent of seedling growers, 20% of stock growers, and 19% of growers for harvest experienced powdery mildew. Twenty-seven percent of stock growers, 20% of seedling growers, and 18% of growers for harvest have had Septoria. Similarly, Dixon et al. (2022) found that the most frequent disease in cannabis is powdery mildew, and there is no resistant variety for this disease yet (Stack et al., 2021). Sixteen and 9% of growers for harvest and seedlings, respectively, have experienced hemp leaf spot, and less than 9% of all grower types have experienced rust and bacterial blight in their hemp. No more than 3% of growers for seedlings and harvest reported viruses in hemp. Only 1% of growers for harvest reported downy mildew in their hemp. In our survey, we inquired about the presence of Cercospora, Pphoma, and Phomopsis in hemp, and none of the participating growers reported any encounters with these diseases (Figure 5).

The most common disease management tools among hemp growers were hand-removal, pruning, and use of resistant varieties (Figure 6). Sixty-seven percent of stock growers, 60% of seedling growers, and 42% of growers for harvest use hand-removal of diseased tissue or plants. Similarly, Punja et al. (2021) found that the main management options for powdery mildew were removing and destroying diseased leaves, using disease-free vegetative cuttings, and applying biological controls. Seedling growers (40%) and stock growers (33%) were more likely than growers for harvest (19%) to choose varieties based on their disease tolerance. Stock growers (47%) were more likely to prune as a disease management practice than seedling growers (37%) and growers for harvest (28%). Fungicide applications, field selection (i.e., avoidance of fields with disease history), and wider row spacing were selected by less than 30% of growers. The least employed tool was crop rotation, reported by less than 20% of hemp growers.

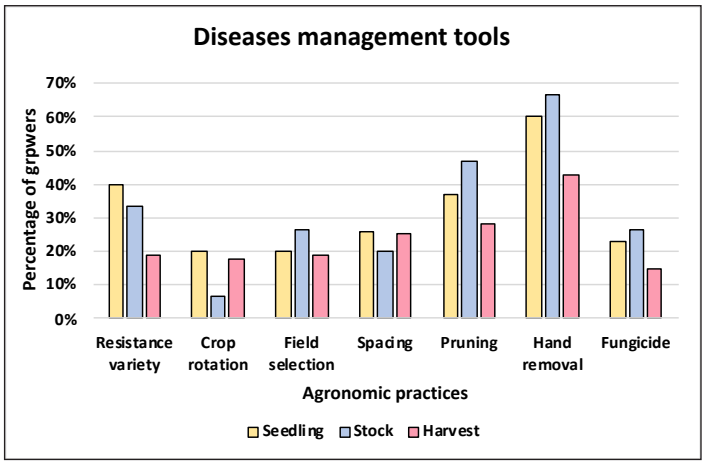

Figure 6. *Percentage of hemp growers in Illinois, Indiana, Michigan, Ohio, Oregon, and Wisconsin who reported using disease management tools in hemp production.*

Insect Management

A larger percentage of stock growers reported observing insects on their hemp compared to growers for seedling or harvest (Figure 7). Over half of all growers of each hemp category observed grasshoppers, butterflies, bees, and caterpillars on their hemp. Cranshaw et al. (2019) found in eastern Colorado that the principal defoliator in hemp production was grasshoppers. Between 40% and 50% of growers responding to the survey have observed beetles, aphids, and plant bugs on their hemp. Flies and moths have been observed by more than half of stock growers and less than 43% of growers for seedlings and harvest.

The most common insect management tool among hemp growers was bioinsecticides, which were used

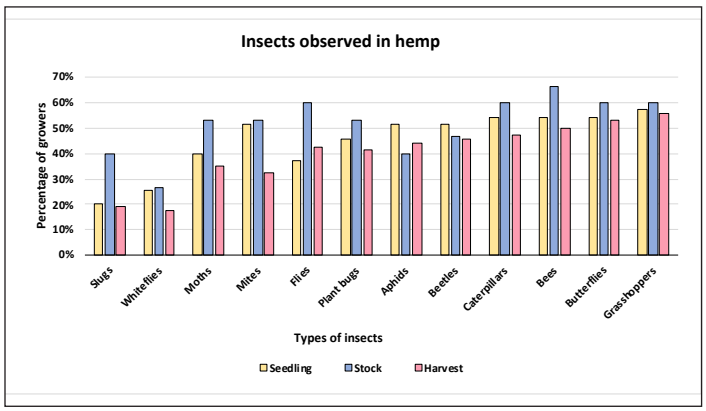

Figure 7. *Percentage of hemp growers in Illinois, Indiana, Michigan, Ohio, Oregon, and Wisconsin that reported observations of insects on their hemp in 2021.*

by 53% of stock growers, 37% of seedling growers, and 29% of growers for harvest (Figure 8). Britt et al. (2021) reported that agrochemical companies have been slow to register chemicals for hemp protection. Thirty-one percent of seedling growers, 27% of stock growers, and 19% or growers for harvest have used natural enemies (biological control) to protect hemp from insect pests. Across all grower types, less than 30% eliminated insect harboring weeds as an insect pest management practice. A fifth of seedling and stock growers and 13% of growers for harvest have sprayed plants with water to knock off insects. Meanwhile, less than 7% have placed physical barriers over plants. Consequently, 52% of respondents across all hemp grower categories had a pest management plan, 27% did not have any plan, and 21% mentioned maybe. Across all hemp grower categories, insect pest pressure was greatest in the summer (30%) followed by the fall (10%).

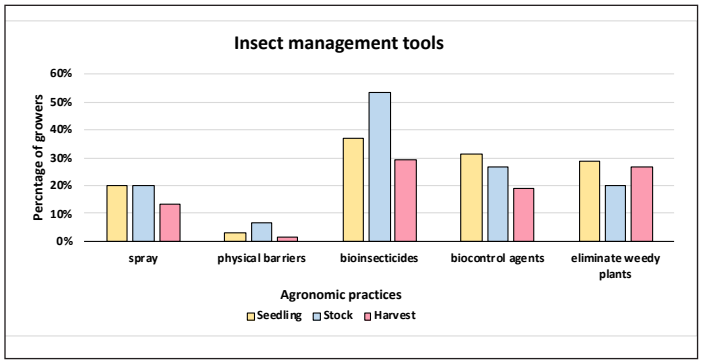

Figure 8. *Percentage of growers in Illinois, Indiana, Michigan, Ohio, Oregon, and Wisconsin that reported use of pest management tools for insects in hemp production during 2021.*

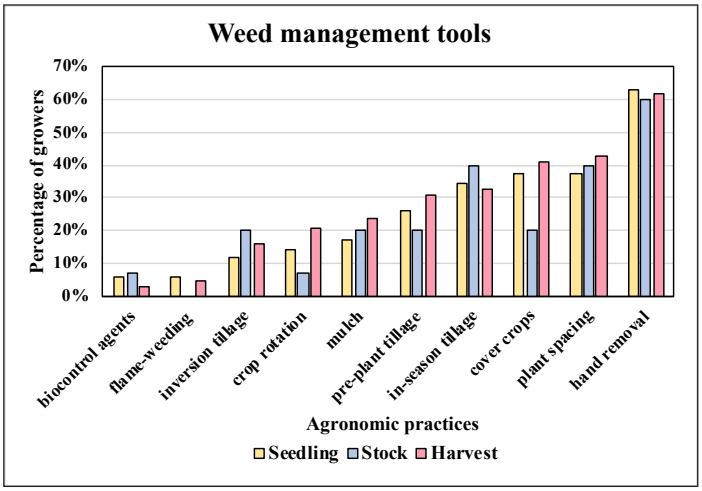

Figure 9. *Percentage of growers in Illinois, Indiana, Michigan, Ohio, Oregon, and Wisconsin that reported use of pest management tools for weeds in hemp production during 2021.*

Weed Management

The most common weed management strategies among hemp growers were hand-removal, which was utilized by 60 to 63% of growers (Figure 9). Plant spacing was used by 37 to 43% of growers. Cover cropping for weed control was used by 41% of growers for harvest and 37% of seedling growers, but only 20% of stock growers. Pre-plant tillage was used slightly more by seedling growers (28%) and growers for harvest (31%) than stock growers (20%). However, stock growers used in-season tillage (40%) somewhat more than seedling growers (34%) and growers for harvest (32%). Inversion tillage (moldboard plowing) was used most by stock growers (20%) followed by growers for harvest (16%) and seedling growers (11%). The use of mulches for weed suppression was similar among all grower categories and ranged from 17 to 24% of respondents. As with other pests, the hemp grower-respondents of this survey generally did not use crop rotation as a weed management strategy (7 to 21%). Less than 7% reported using flame weeding or biological agents. In addition, a significant majority of growers, approximately 73%, firmly believe that weeds can significantly decrease yields, while an even higher percentage of 78% are convinced that weeds have a detrimental effect on crop quality. Furthermore, 72% of growers recognize that weeds can interfere with crucial farming operations and the overall harvest process. Additionally, a substantial 68% of growers acknowledge that weeds can act as hosts for insects and pathogens.

Take-home Message

Our findings show that a sizable number of hemp growers are adopting pest management practices. By prioritizing the use of biopesticides, growers can effectively manage insect populations while minimizing the risk of harm to beneficial organisms, human health, and the environment. It is important for growers to find agronomic information about available biopesticide options and integrate them into their pest management strategy for sustainable and profitable hemp production. Something to consider is that some plant protectants that are more easily labeled for use on hemp may have reduced efficacy compared to conventional alternatives. Because registrants are reluctant to register plant protectants for use in hemp, there may be challenges for growers that typically use conventional pesticides in other crops. This study offers some important information for policymakers and current and future hemp growers regarding pest management practices.

Our findings suggest that there is room for improvement in the adoption of pest management practices, particularly among growers for seedling and harvest. One of the least adopted pest management practices by respondents to this survey is crop rotation. Some hemp growers produce only this crop, resulting in continuous production in the same sites. It is important for growers to recognize the value of a multi-faceted approach to pest management. By utilizing a variety of tools and techniques, including crop rotation, growers can effectively manage pest populations while minimizing the risk of pesticide resistance and reducing the environmental impact of their operations.

Our survey revealed that yield losses due to weeds were rated high by hemp growers. This finding underscores the significant impact that weeds can have on crop productivity and emphasizes the importance of effective weed management strategies. It is critical for growers to prioritize weed control efforts to minimize losses and maximize profitability in agricultural production. While growers rated the perceived difficulty of controlling diseases lower than weeds and insects overall, yield losses due to disease was higher than yield loss caused by insects.

Scouting for pests has emerged as the most commonly used pest management tool among all growers' categories, and these results highlight the importance of regular scouting to identify and manage pest populations effectively. In other words, it is important for growers to adopt regular scouting practices as a fundamental component of their pest management strategy. This will enable them to detect and address pest issues early, while ensuring a more sustainable and profitable agricultural system. However, one of the challenges is accurate identification or diagnosis. Correctly identifying certain pathogens, especially those causing root rots, is an example. Growers should also be aware of diagnostic laboratories that can provide correct

diagnosis of plant problems to ensure that correct management tools are being implemented.

Our findings provide valuable insights for researchers, growers, and policymakers in the hemp industry. Regardless of grower type, physical management was rated in our survey as 79% important, cultural management at 77%, herbicide drift from neighbors at 54%, biological management at 52%, chemical management at 36%, and herbicide carryover from crops at 34%. These results emphasize the need for further research, education, and policy considerations related to crop management for hemp.

Using our findings, researchers can identify knowledge gaps, develop new research questions, and drive advancements. Growers can optimize hemp production by focusing on the most important aspects of weed management. Policymakers can support the industry based on growers' priorities. Future research should look at nationwide sample of growers and potential growers. Policymakers can use our findings to develop policies that support the growth of the hemp industry while also ensuring the sustainability of the hemp industry. Hemp growers can utilize our findings to optimize production practices and develop effective marketing strategies while ensuring compliance with regulations and increasing their chances of success in this competitive industry. Also, future hemp growers can understand the potential benefits and challenges of entering the hemp industry.

Finally, our survey sheds light on the perceived usefulness of various information sources for knowledge and pest management in the hemp industry. Our data reveals that sources such as seeking advice from other growers (49%), pest bulletins (45%), webinars (39%), and site visits by university Extension specialists (39%) were highly regarded as extremely or very useful. In contrast, sources like field days (38%) and social media (30%) were considered relatively less useful.

Acknowledgements

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