Determining the Digital Mapping Sample Area for an Accurate Measure of Weed Infestations

Emma J. Lagerhausen[1], Alexander R. Mueth[1], Siddhartho S. Paul[2], Bryan G. Young[1]

Department of Botany and Plant Pathology[1] | Purdue University | West Lafayette, IN
Department of Agronomy[2] | Purdue University | West Lafayette, IN

North Central Weed Science Society

PURDUE WEED SCIENCE

Introduction

- Restrictions placed on herbicide applications can make the logistics of performing effective postemergence applications challenging.
- Innovations in unmanned aerial vehicles (UAVs) have sought to alleviate challenges farmers may face when making these applications (Hardin and Hardin, 2010).
- The use of UAV technology for weed scouting and herbicide applications has increased due to advancements in carrying capacity, flight time, and user interface. UAV technology still has drawbacks in limited operating conditions and hardware capabilities (Bishop et al., 2018).
- Camera resolution on UAVs to detect small weeds may require a frame area of only 1.5 by 1.5 m and one image may be used to represent 0.4 ha of a field to increase the speed of aerial scouting.
- Accurate mapping of weed species and spatial distribution are critical for weed management (York, 1994).
- Concerns of UAV accuracy in scouting for weed presence and average density have been raised.

Hypothesis

The small sampling area used by UAV scouting operations will not accurately describe field weed populations.

Objective

Quantify the accuracy of random, small sample plots for UAVs compared with the true weed population.

Results

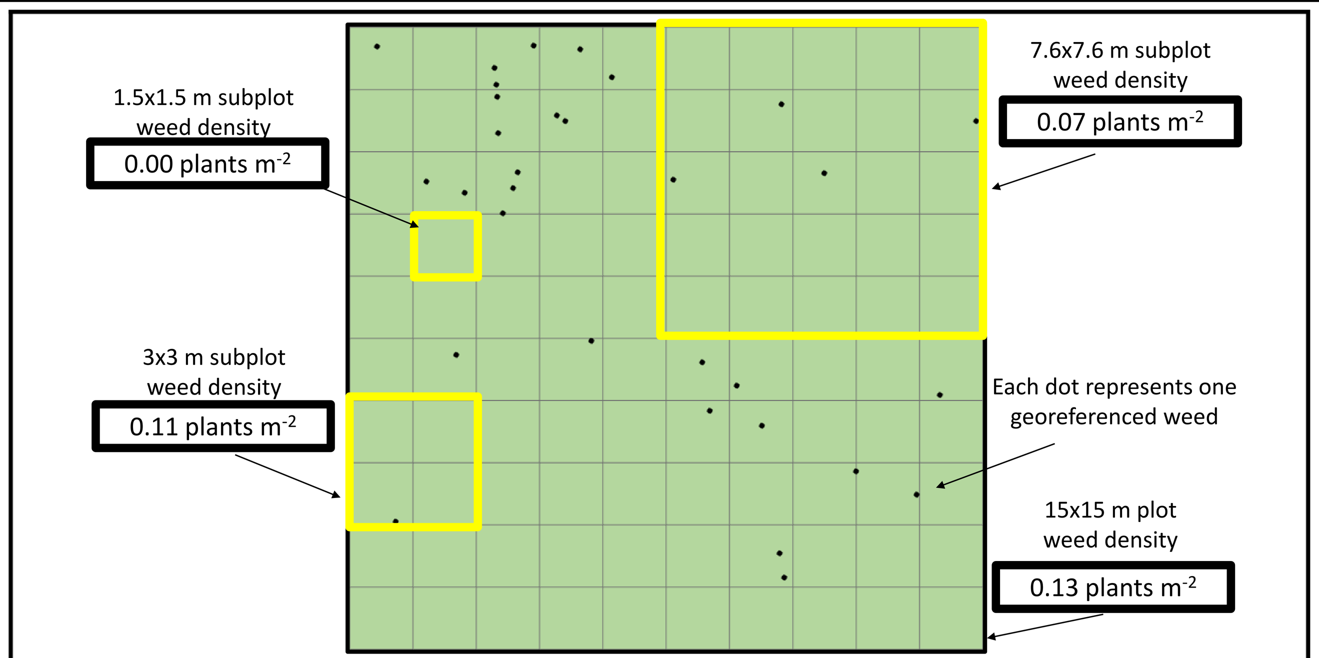

Figure 1. Example of subplot areas used for data generation.

Table 1. Frequency for inaccurate estimate from subplot areas for overall weed abundance.

Frequency of inaccurate estimates for weed abundance by subplot size			Total Abundance
1.5x1.5 m	3x3 m	7.6x7.6 m	15x15 m
---------------%---------------			plants m^{-2}
30	10	3	0.17

Table 2. Frequency of inaccurate weed estimates for abundance of individual weed species.

Weed Species	Subplot Size			Total Abundance
	1.5x1.5 m	3x3 m	7.6x7.6 m	15x15 m
	--------------------%--------------------			plants m^{-2}
Ivyleaf morningglory	100	100	77	0.28
Venice mallow	100	100	100	0.09
Prickly sida	97	93	23	0.03
Honeyvine milkweed	50	53	53	0.02
Yellow nutsedge	0	0	0	0.01
Common cocklebur	93	80	53	0.01
Giant foxtail	63	63	63	0.01

Overall Weed Abundance

- The abundance of weeds present in each subplot grouping was different from that of the actual plot in 30% of the 1.5x1.5 m plots, 10% of 3x3 m plots, and 3% of 7.6x7.6 m plots (Table 1). Thus, sample areas of at least 7.6m by 7.6m were required to reach 95% estimate accuracy.

Weed Abundance by Species

- Inaccurate estimates greater than 90% was observed for ivyleaf morningglory (*Ipomoea hederacea*), prickly sida (*Sida spinosa*), Venice mallow (*Hibiscus trionum*), and common cocklebur (*Xanthium strumarium*) for at least one of the subplot areas.
- Accuracy of weed abundance estimates did not change for Venice mallow, yellow nutsedge (*Cyperus esculentus*), honeyvine milkweed (*Cynanchum laeve*), and giant foxtail (*Setaria faberi*).
- The accuracy of the estimates were not directly related to weed abundance in the entire plot area.

Materials and Methods

- Field corn was planted May 5, 2023 in West Lafayette, IN using conservation tillage methods and a preemergence herbicide program with acetochlor (1514 g ai ha^{-1}) and atrazine (1592 g ai ha^{-1}).
- Four 15 by 15 m plots were established at the V3 stage.

Data Collection

- Georeferenced data was collected for each plant: species identification, height, and width.

Data Analysis

- Geographic coordinates were uploaded to ArcGIS Pro (3.0.3), plots were subdivided to represent scouting areas of 1.5x1.5, 3x3, and 7.6x7.6 m (Figure 1).
- Using RStudio(4.3.1), 30 random subplots were selected from each plot and scouting area, with 360 subplots total.
- Subplots were grouped by size of scouting area and selection order, data were analyzed using a two-sided t-test in RStudio with the actual weed data for the entire plot.
- Weed species composition of each subplot were analyzed using RStudio (4.3.1) and means were separated using Tukey's HSD (α=0.05) and appropriate transformations to meet assumptions of ANOVA.

Discussion and Conclusions

- In low weed densities the likelihood for a random 1.5x1.5 m subplot to indicate no weed infestation may result in a false report to the farmers on the presence or absence of weeds in the field and cause inadequate weed control measures to be taken.
- The smaller subplot areas were more accurate for estimating total weed abundance than for any individual weed species.
- The lack of a relationship between estimate accuracies and weed abundance levels indicates that the randomness of weed infestations and emergence limits the effectiveness of using subsample areas.

Implications and Future Research

- Areas larger than 1.5x1.5 m must be used if accurate weed scouting is desired.
- The integration of artificial intelligence and advanced image detection techniques may improve weed scouting by seeking out green, weedy patches for targeted sampling, and more closely simulate manual scouting of a field.

Acknowledgements

Special thanks to the Purdue Weed Science Program for support and resources, and especially Dr. Zhe Ren for assistance with statistical analysis.

References

A.C. York (1994) Weed management in soybeans
P.J. Hardin, T.J. Hardin (2010) Small-scale remotely piloted vehicles in environmental research
M.P. Bishop et al. (2018) High resolution UAS imagery in agricultural research: concepts, Issues and research directions