Introduction

Weed infestation has been one of the most persistent challenges faced by farmers in Turkey despite agriculture being the cornerstone of the country's economy. Weeds has a significant impact on crops such as competing for nutrients, water, and sunlight which eventually leads to poor developments of crops, reduction in production, and high cost in production. Turkey ranks among the top potato producers in the world. Approximately 5.7 million tons of potatoes were produced in Turkey in 2023. Regions like Niğde, Kayseri, and Nevşehir were the top producers in the country with Niğde producing 757,480 tons alone (*Potatopro,2023*).

*Chenopodium album L. (*commonly known as Sirkens) *and Amarantus retroflexus L. (*commonly known as Red-Rooted Foxtail) are the most problematic weed species in *Solanum tuberosum (*potato) fields in Turkey. These weeds are herbicide resistance. The traditional methods of weed control, such as manual removal, or the chemical widespread applications, are labor-intensive, environmentally harmful, and cost ineffective. These both weeds are recognized among the most common dicotyledonous weeds in the world and are widely distributed in many agricultural areas where they cause significant problems (*Horak and Loughin, 2000; Alebrahim et al., 2012*). These weeds are aggressive in their development, thus competing for food, nutrients, and other growth requirements which is not good for the soil health and sustainability. These weeds are fast growers and they are successful in adapting to a wide climatical conditions. They severely reduce the yield of the crops in which they grow while their destructive growth and allelopathic activity make them very competitive resulting in significant decreases in crop yield and quality (Frontiers, *January 2017)*.

To address the challenges faced by farmers in Turkey, especially in Niğde and Nevşehir , the development of an artificial intelligence model could be a promising solution for weed detection and control in potato fields. This project aims to develop a reliable system for the accurate detection and classification of goosefoot (Chenopodium album L.) and pigweed (Amaranthus retroflexus L.) in potato fields using AI-driven image recognition technologies. The suggested AI model will facilitate early and accurate weed identification for farmers, diminishing reliance on excessive herbicide application and physical labor, hence resulting in increased yields, reduced costs, and enhanced environmental sustainability (*Remote Sensing, 2021, 13(21), 4486)*

The Agria potato (*Solanum tuberosum)* variety will be used for this project. The agria variety of potato is commonly found in Niğde and Nevşehir regions. These variety are commonly used due to their disease resistance and productivity in Niğde's soils (*Scientific Papers et al, 2019*). This project is intended for implementation solely in Turkey, concentrating on areas with significant potato production, such as Niğde and Nevşehir, given the climate circumstances that may influence the structure and other critical aspects of weeds during data collecting.

The AI models will be trained on localized data several times and the system will be adapted to the unique agricultural conditions in these areas, ensuring high accuracy and reliability. This initiative represents a critical step toward modernizing Turkey's agricultural practices, enhancing productivity, and contributing to sustainable farming methods that minimize environmental impact. By bringing together state-of-the-art AI with real-world agricultural applications, we hope to provide farmers a tool for more effective and sustainable weed management with this proposal.

Aim and Objectives

AIM

The aim of this project is to develop an Artificial Intelligence based model to detect weed in potato fields. It will focus more on identifying the two problematic weeds in potato fields: *Chenopodium album L. and Amarantus retroflexus L.* The project seeks to integrate advance AI technologies to differentiate between the potatoes and the harmful weeds. Farmers would be able to affordably use the technology to reduce the environmental and financial impacts of traditional weed control methods. In order to help farmers detect and control weed infestations, the model will be created to adapt to different environmental settings. This will increase production and farming sustainability.

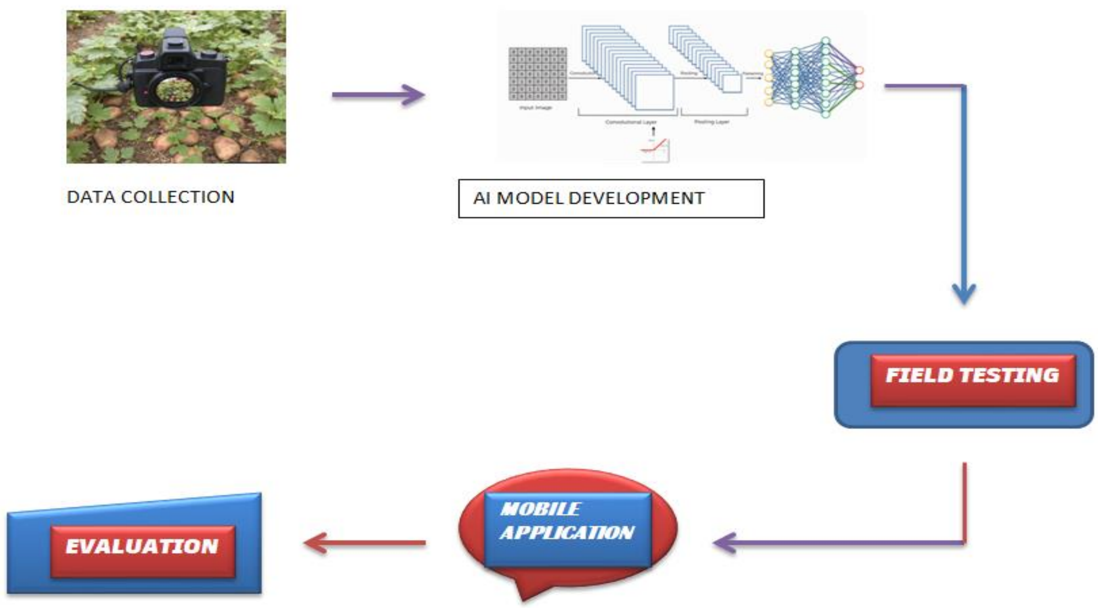
Objective

1. Data Collection Process
   - The first objective is to collect high-quality image data from a control environment like a greenhouse using RGB cameras. This dataset will include images of potato plants and the *Chenopodium album L. and Amarantus retroflexus L.* species.
2. AI Model Development
   - Train 80% of the data collected from the controlled environment to distinguish between the weeds and the potatoes. Convolutional Neural Networks (CNN) is an idea model for this project because of its high accuracy for image classifications. This model will distinguish features like the color, shape and other distinct traits. The other 20% of the data will be used for the validation and the testing stage.
   - Augmentation techniques such as flipping, rotating, and zooming will be used to expand the data and improve the performance of the model.
3. Field Testing
   - The model would be tested on different climatic conditions to ensure that it is adapted into different regions of the country. This would efficiently improve the performance on the field and would accurately distinguish the weeds from the potatoes based on the different climatic seasons of the crop growth stages.
4. Deployment
   - Develop an intuitive software interface that lets farmers take pictures of their fields, run them through an AI model, and get instantaneous results about the distribution and presence of weeds. For the benefit of all users, the online platforms will be developed.
5. Evaluation and Refinement

- Feedbacks will be collected from farmers to continuously train the model and improve its accuracy. This would eventually improve the model to deploy to larger customers for efficient use.

Material Methods

This project will undergo five stages to detect *Chenopodium album L. and Amarantus retroflexus L* from the *Solanum tuberosum (*potatoes): Data collection from a controlled environment(greenhouse) at Nigde Omer Halisdemir University, Faculty of Agricultural and Technologies, Artificial Intelligence model development, Field testing, User Interface Development, and Evaluation and Enhancement stages.



1. **Data Collection**

RGB camera will be used to collect an extensive image. RGB is well suited for distinguishing the color, and the shapes of the weed and the potatoes. RGB is relatively inexpensive compare to other technologies which would make it more affordable to small scale farmers.

Visual Differences for Image Recognition:

*Solanum tuberosum (*Potatoes): It has broad leaves, rich green foliage, and relatively thick and thee leaf edges are generally smooth. Potatoes produces small white to purple flowers with a characteristic star shape (*H. H. Hossain et al. (2020))*.

Chenopodium album L.: The leaves have diamond-shaped, it has a smooth or slightly crinkled texture. The color is typically green than potatoes. It has an upright height *(R. K. Prasad et al. (2022)).*

Amaranthus retroflexus L: The leaves are alternate and ovate with smooth margins. It has a dark green color and shows a reddish or purple color near the base of the plant. The flowers are small and it has an upright cluster *(R. K. Prasad et al. (2022)).*

Ten ports of each of the two weeds and the potato would be set up in a control environment (the greenhouse in Nigde Omer Halisdemir University) in a three different category.

- For each port, we will capture five high-resolution photos of both the target weeds and the potato plants. This procedure will be executed at all ten ports for each species, yielding:

Five photos for each ten ports of *Chenopodium album L.*

Five photos for each ten ports of *Amaranthus retroflexus L.*

Five photos for each ten ports of *Solanum tuberosum (*potato) cultivation.

This has a total of 450 images (150 for each category: Chenopodium album L., Amaranthus retroflexus L., and potatoes).
These photographs would represent the data to train the model. The RGB camera is capable of distinguishing the chlorophyll content, the developmental stages of each of the plant parts, and the morphological features.

The Agria potato (*Solanum tuberosum)* variety will be used for this project. The agria variety of potato is commonly found in Niğde and Nevşehir regions. These variety are commonly used due to their disease resistance and productivity in Niğde's soils (*Scientific Papers et al, 2019)*. This variety has a high yielding and it is adaptable to these region's climatic conditions which make it an ideal potato variety for this project.

1. AI Model Development

Citation Table for Weeds in Potato Fields in Turkey

Weed Name	**Method of Classification**	**Name of the Study**	**Reference/Source**	**Timeline**	**Accuracy (Output)**
Chenopodium album L. (Sirken)	Image-based deep learning (CNN-based AI model)	"Automated Weed Detection Using Deep Learning Techniques	Zhang, M., et al. (2020). Agricultural Systems Journal	6-9 months for model development	92% (field testing)

		in Agriculture"			
Amaranthus retroflexus L. (Red-rooted Foxtail)	UAV imagery and machine learning classification	"Application of UAV Imagery for Weed Detection in Crop Fields"	Pérez-Ruíz, M., et al. (2021). Precision Agriculture Journal.	12 months (data collection + analysis)	87-90% (field trials)
Chenopodium album L. & *Amaranthus retroflexus L.* (combined study)	AI-powered remote sensing with multispectral imaging	"Detection of Agricultural Weeds in Potato Crops Using AI and Multispectral Sensors"	Ali, M., et al. (2019). IEEE Transactions on Geoscience and Remote Sensing.	18 months (end-to-end)	85-93% (depending on environmental factors)
Amaranthus retroflexus L	Machine learning with hyperspectral image analysis	"Weed Identification in Potato Fields Using Hyperspectral Imagery and ML"	Silva, F., et al. (2022). Computers and Electronics in Agriculture Journal	9-12 months	90% (lab environment)
Chenopodium album L.	AI-based object detection model	"A Novel Deep Learning Approach for ts w Weed Detection in Potato Fields"	Gupta, P., et al. (2020). Agricultural Engineering International: CIGR Journal.	6 months	94% (controlled environment)

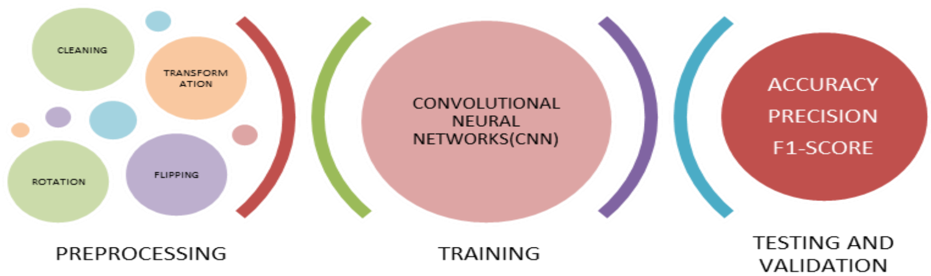
From the above studies, the *"A Novel Deep Learning Approach for Weed Detection in Potato Fields" by* ***Gupta, P., et al. (2020)*** has the highest performance accuracy of about 94% in a controlled environment.

Convolutional Neural Networks (CNN) and deep learning techniques will be used after the images has been collected. The image data will undergo three stages: Preprocessing, Training, and Validation and Testing phases.

- **Preprocessing:** The raw data will be undergoing cleaning, transformation, scaling, rotation or flipping stages to ensure model efficacy. The background, contrast improvement and light variations of the images will be taken into account too.
- **Training:** The CNN will be used to train the dataset. The images will be categorized into three set *(Solanum tuberosum, Chenopodium album L. and Amarantus retroflexus L).* The 80% of the total dataset will be used for the training and the 20% will be used for the

testing stages. The model will be train to discern the weeds and the potatoes based on their distinct features.

- **Validation and Testing Stage:** The 20% of the dataset will be used here. Accuracy, precision, and F1-score will be computed to evaluate the model efficacy. the model will undergo the common testing stages (unit, system, integration and acceptance testing) for proper learning.



3. Field Testing

The field-testing stage plays a crucial role in this project after the training and the validation stage. The model will be deployed into potato fields to make the differentiations. The sensitivity of the model will come into play under this stage were the different environmental factors such as the climate, soil type, plant density and other factors will be experimented. The model will be tested in Nigde and Nevsehir potato fields. This will help in the refinement and the assessment stage.

4. Deployment

An interface will be developed at the final stage to allow farmers to upload images from their field into the system. It will be user friendly to farmers and very affordable. This will help in future improvement of the model for herbicide applications, manual removal and other farm applications.

5. Assessment and Enhancement

The user inputs be used to assess the model. Correlations in the dataset will provide a clear idea of the accuracy and the learning rate of the model over time. This will help in improving and enhancing the model.

WORK-TIMELINE (*)

IP No	Name and Objectives of Work Packages	By Whom(s) It Will Be Performed	Timeframe (month)	Success Criterion and Its Contribution to the Success of the Project
1	Purchasing of equipment and consumables	Abass Issaka Mohammed Fatih Alperen Gılıç Sıla Aydln	1	It will be used for the development of each of the stages in the material methods. The AI model will be built successfully with it.
2	Data Collection Setup	Abass Issaka Mohammed Fatih Alperen GILIC Sıla Aydın	2 - 3	Ten different ports of each of the two weeds and the potato will be established in a greenhouse for its developments. This will enable us to obtain clear images of the samples
3	Installations and Operations of Hardware	Abass Issaka Mohammed Fatih Alperen GILIC Sıla Aydın Zeynep Unal	1	The hardwares such as the desktop will be be installed at the Faculty of Agricultural Sciences and Technologies at Nigde Omer Halidemir University. Trials will be done to make sure that all tools are working effectively.
4	Data Collection: Potato and weed images	Abass Issaka Mohammed Fatih Alperen GILIç SIla Aydln Zeynep Ünal	1	RGB camera will be used to collect the images of the plants.

5	AI Model Development	Abass Issaka Mohammed Fatih Alperen GILIç SIla AydIn Zeynep Ünal	2	The image data will undergo several stages here such as preprocessing, training and validation. The model will detect the potato from the weeds
6	Field Testing and Model Evaluation	Abass Issaka Mohammed Fatih Alperen GILIç SIla AydIn Zeynep Ünal	1	The model will be deployed in field for testing. This will enhance proper learning of the model in different environmental conditions.
7	User-Interface Development	Abass Issaka Mohammed Fatih Alperen GILIç SIla AydIn Zeynep Ünal	2	A user-friendly Interface will be developed for farmers to upload images of their field
8	Project Conclusion and Reporting	Abass Issaka Mohammed Fatih Alperen GILIç SIla AydIn I	1	Final report will be prepared to evaluate the outcomes and the future research opportunities of the project

RISK MANAGEMENT

IP No	Top Risks	Risk Management (Plan B)
1	Problem in Growing of Plants	Data collection from field
2	Promlem in Camera	Buy/Use different camera
3	Problem in Data	Data augmentation

4	Problem in Model	Model improvemend, add new layers, model tuning
5	Building of User Interface	Consulting Software Engineers

TABLE OF RESEARCH OPPORTUNITIES

Infrastructure/Equipment Type, Model in the Organization (Laboratory, Vehicle, Machinery-Equipment, etc.)	**Purpose of Use in the Project**
Plants growing will be established in Tarım Bilimleri ve Teknolojileri Fakültesi, Niğde Ömer Halisdemir Üniversitesi,	Data collection will be obtained, which will be used for the classification
Computer laboratories	It will be used for the purpose of taking pictures with the RGB camera, and the AI model development

WIDESPREAD IMPACT

Common Types of Effects	**Expected Output, Results and Effects of the Proposed Research**
Scientific/Academic (Article, Paper, Book Chapter, Book)	Publications and Presentations, New Agricultural AI models, Educational Resources
Economic/Commercial/Social (Product, Prototype, Patent, Utility Model, Production Permit, Variety Registration, Spin-off/Start-up Company, Audio/Visual Archive, Inventory/Database/Documentation Production, Copyrighted Work, Media Coverage, Fair, Project Market, Workshop, Training, etc. Scientific Activity, Institution/Organization to Use Project Results, etc. other common effects)	Weed Detection System for Farmers, Research database, Sustainable Agriculture
Researcher Training and Creating New Project(s) (Master's/Ph.D. Thesis, National/International New Project)	

BUDGET REQUEST CHART

Budget Type	**Requested Budget Amount (TL)**	**Justification for Request**
Consumables		

Machinery/Equipment (Fixtures)		
Service Procurement		
Transportation		
SUM		

OTHER MATTERS YOU WISH TO MENTION

7. APPENDICES

APPENDIX-1: REFERENCES

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