**Агроинженерия. Текст 1.**

**Construction and development of an automatic sprayer for greenhouse**

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**Abstract:** This paper presents design and construction of an autonomous robot for using in greenhouse condition. The robot designed to prevent human hazards involved in spraying potentially toxic chemicals in the confined space of a hot and steamy

glasshouse. In order to navigate the robot, hot water piping rails along the rows were used as a method of guidance for autonomous robot. The robot is able to force and back along the hot water piping rails of rows in greenhouse avoiding the expensive and complicated navigation systems. Power was transmitted from two DC motors to two driving wheels through a gearbox and shaft system. The AVR microcontroller controls all of the inputs and outputs of the system. To program the micro used from BASCOM-AVR version 1.11.9.8 and for circuit simulating used from PROTEUS 7 professional. The obtained Results indicated that the robot is capable to cover more than 90% of surface which needed to spray.

**Keywords:** Autonomous robot, human hazards, design, spraying, greenhouse, AVR Microcontroller.

**Introduction**

The function of a greenhouse is to create the optimal

growing conditions for the full life of the plants

(Badgery-Parker, 1999). The favorable atmosphere

created inside greenhouses for plant growth causes pests

and undesirable organisms to thrive as well, making

necessary the use of pesticides and other chemical

products that must be sprayed directly on the plants.

Today solutions massively depend on heavy chemicals,

plentifully distributed at given time intervals, making the

greenhouse indoors highly toxic, with operator health

shocks and forbidden re-entry long lasting delays.

Recent studies reported confirmation that spraying

operations have hazardous effects on the health of

knapsack sprayer human operators, who are specially

exposed when working inside greenhouses, in conditions

of high temperature and poor ventilation (Gan-Mor et. al.,

1997). The ideal time to spray plants within a

greenhouse is in the early evening as a result of some

chemicals used on plants adversely reacting to ultraviolet

light and intense heat. An automatic spraying system

could be set to begin operation at night avoiding

out-of-hours work whilst ensuring that the plants are

sprayed in conditions that cause the least amount of

damage to the plants (Sammons et. al., 2005). Figure 1

shows a typical crop of greenhouse tomatoes.

Contemporarily, a human worker would walk down these

confined rows with a pesticide spraying gun, in an

attempt to cover the foliage of the plants with an even

coat of spray.

**Агроинженерия. Текст 2.**

Sammons et al. (2005) described an autonomous

spraying robot with navigation control based on inductive

sensors which detect metal pipes buried in the soil.

Shariati (2004) described the mechanical arm robot for

fruit detection in a particular direction. Mandow et al.

(1996) described an autonomous vehicle (Aurora) for

spraying tasks. The navigation control of this robot

depends on a previous sequence of behavior established

by an operator. Subramanian et al. (2005) and Singh et

al. (2005) also described a mini-robot to perform spraying

activities, for which navigation is controlled by

algorithms based on fuzzy logic (Singh et al., 2005 and

Subramanian et al., 2005). Some of researcher

presented the Agrobot Project, a robotic system for

greenhouse cultivation of tomatoes (Sandini et al., 1990

and Dario et al., 1994). This involved a mobile robot

with a color stereoscopic vision system plus an

anthropomorphic arm with a gripper/hand and six degrees

of freedom.

This paper presents the design and construction of an

autonomous robot that seeks to address some of the

human health concerns associated with greenhouses.

The robot is designed to enable the automation of

greenhouse spraying of pesticides.

**Methods and Material**

The constructed robot consists of three main parts: a

controller unit, a chassis with motor unit and a sprayer

unit, see Figure 2a. The chassis (platform) carries all of

the main parts of the robot including power supplies,

electrical pump, electronic hardware for data-acquisition,

the camera and the spraying units (Figure 2b).

The spray system consists of a large tank for holding

the pesticides (Figure 2a), vertical spray booms with

several nozzles, two pump and four valves to direct the

allocated spray to the sections of plant either side of the

robot as it moves past the desired spray area. The valves

are electronically controlled by the on-board

microprocessor which receives input signals from micro

switch on the underside of the robot. As the robot

passes over reflective markers placed on the ground, the

pump is turned on and off to enable selective spraying of

the greenhouse plants. During spraying, micro switches

can shut down the right or left side of the vertical spray

boom by actuating solenoid valves. This allows the

robot to spray rows next to walls without wasting

chemicals. Also a pesticide level control was designed

using a L6D Single Point Load cell with 10 kg capacity.

**Агроинженерия. Текст 3.**

Gan-Mor et al. (1997) and Michelini et al. (1998)

realized the potential of steel pipes as a method of

guidance for their autonomous robots. The hot water

piping shown in Figure 3, is a standard installation for

most modern greenhouses; therefore the same method

was used in this study for the movement and guidance of

the constructed robot. During a spraying operation, the

constructed robot moved on the hot water pipes with 4

linearly actuated struts, driven by two 12V DC motors,

see Figure 3b. The two sets of wheels were arranged in

a way that there was a seamless transition in moving onto

the rails, allowing the robot to drive along without the

need for any expensive and complicated navigation

ability

The user interfaces have control over the running of

the microcontroller and are fed back information about

the status of the robot. In the constructed robot, An

ATmega32 microcontroller from ATMEL Company

reads the information and controls the movements of the

robot and actions of the spraying system. The

microcontroller was used as the arithmetic and logic unit

of the robot, see Figure 4.

Autonomous control and operation of the mobile

robot relies on the external sensor information; therefore

the performance of the navigation and spraying controller

depends significantly on the installed sensors on the

platform, see Figure 5. For this aim, several sensors

were installed on the platform. The position of each

sensor has also been studied in order to determine the best

location of the sensors depending on the mechanical

structure and the environment. For the commercial

version of this mobile robot, only the most useful and

appropriate sensors will be installed. The LCD/Keypad

module shows the user relevant information on the robots

status and allows the user to easily control the robot.

The AVR microcontroller controls all of the inputs

and outputs of the system. The software running on the

controller is Dynamic basic. The BASCOM-AVR

version 1.11.9.8 and PROTEUS 7 professional were used

for programming the micro and for circuit simulating,

respectively.

**Агроинженерия. Текст 4.**

**Results and discussion**

The robot was tested in the research greenhouse at

The Tehran Technical and Vocational Center where

tomato plants were grown. Each experimental test

consisted of a single run down to the end of a row and

back to the starting point while spraying the plants with

water. Along the run, sections of tomato plants were

marked out to be sprayed on both sides of the robot.

Water sensitive papers shown in Figure 6 (which turns

from yellow to blue when water contacts it) were placed

in three locations in the tomato canopy: directly behind

the fruit and facing the sprayer, upside down (exposing

only the edge of the card to the sprayer) and sideways

(exposing the thin edge of the card to the sprayer).

When the spraying system engaged, the sprayer flew

down the 125 meter alley, riding on the hot water pipes

and emitting a spray pattern that appeared to completely

envelop the target row. Summary of the obtained results

are shown in Table 1. The presented results in this table

were obtained during the spraying of two independent

tomato rows, labeled with “Test 1” and “Test 2” in this

table. Each experiment was conducted in 20

replications (placement of the 3×7 cm2 water sensitive

carts with distance of 50 cm in row) for the statistical

certainty. During the spraying, correct triggering of the

sensors and microswitches were evaluated. Every fault

operation of the sensors and fluid flow microswitches

were recorded. For the proper operation of the robot,

microswitshes should detect the start and end triggers and

immediately turn on/off the fluid flow from pump to the

nozzles. At the end of the row, microswitshes should

turn off the water flow. After every spraying test, water

sensitive papers were collected and photographed with a

canon digital camera (SX150 IS). The photographed

images then transferred to the ACDSee Pro 3 software for

evaluation of the spray quality and uniformity. From

each photograph in the software, a 1×1 cm2 area were

randomly cropped for counting the sprayed pixels. The

ratio of blue-to-yellow pixels indicated the sprayed area,

see Table 1. Preliminary results obtained in this study

for evaluation of the constructed robot indicated the

proper and trustable operation of the robot for the

greenhouse applications. More details of the generated

spray by the constructed robot can be found in Kalantari

et al., (2014).

**Агроинженерия. Текст 5.**

**Selection of fertilization method and fertilizer application rate on corn yield**

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**Abstract:** A field experiment was carried out on the silty clay soil of Lack-Lack agricultural research field during two years to select the most suitable fertilization method (fertilizer broadcasting, fertilizer pouring in the furrow, fertilizer banding

placement in one side and both sides of seedling) and application rate (30, 60 and 90 kg of net nitrogen from source of urea fertilizer/ha) on corn yield and yield components in Hamedan province in Iran. Corn yield components evaluated were plant

height, corn height, percentage of corncob, thousand-kernel mass and net yield. A factorial experiment with 12 treatments (four methods × three levels) was replicated three times in 36 test plots. By analysis of variance and comparison of treatment

means using DMRT (Duncan’s new Multiple Range Test), application methods had no significant effect on plant height, corn height and percentage of corncob, but net yield and thousand-kernel mass were highly influenced. In addition, effect of fertilizer application rate on plant height, corn height, and percentage of corncob was not significant but was highly significant on net yield and thousand-kernel mass. Interactional effects of method × level on plant height, corn height, percentage of

corncob and thousand-kernel mass were not significant but their effects on net yield were very significant. In this study, fertilizer banding on one side of seedling with 60 kg of nitrogen/ha applied 10 cm from the seedling at 5 cm soil depth was

selected as the most suitable treatment.

**Keywords:** fertilization methods, nitrogen, fertilizer application rates, corn, placement fertilizer, Iran.

**Introduction**

Corn (*Zea mays* L.) is extensively cultivated more

than other crops as a nutrient food for human and

favorable forage for animals all over the world.

Bio-energy industries strongly believe that corn is a

powerful energy source for living beings (Xu et al., 2004).

Corn is the third most strategic cereal crop throughout the

world after rice and wheat, and has been recognized as a

premier cereal crop (Muthukumar et al., 2005).