

EFFECTS OF DENSITY AND RELATIVE TIME OF PIGWEED EMERGENCE ON YIELD OF POTATO

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PIGWEED (*AMARANTHUS RETROFLEXUS*)
EMERGENCE ON YIELD OF POTATO
(*SOLANUM TUBEROSUM*)**A. YADAVI^{1*}, M. ASADI¹, E. MAGHSOUDI¹* E-mail: yadavi@yu.ac.ir

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ABSTRACT. For create of food security is essential increasing of efficiency and more productivity strategic products such as potato. In order to investigate the effects of density and relative time of pigweed emergence on potato, a factorial field experiment was conducted during 2014 based on randomized complete block design with three replications at the Research Station of Borojen, Chaharmahal and Bakhtiari, Iran. Treatments were combination of three different pigweed densities (5, 10 and 15 plants/m²) and relative time of pigweed emergence (4 and 8 days before potato, emerged with potato, 4 days after potato emergence). Results indicated that the effects of density and relative time of emergence of pigweed was significant on number of branches per plant, plant height, number of tubers per square meter, biological yield and tuber yield of potato. Also, the interaction of between experimental factors was significant on the biological yield and tuber yield of potato. The earlier emergence and pigweed density led to reduce number of branches per

node, biological yield and tuber yield and increase plant height of potato. The presence of weeds caused reduce the size and number of potato tubers. Procedure of decreasing biological yield and tuber yield potato was different with density increasing of pigweed in various relative time of emergence treatment. The highest (39.8 t ha⁻¹) and the least (18.4 t ha⁻¹) tuber yield were related to density of five plants/m² and emergence at 4 days after potato and density of 15 plants/m² and emergence at 8 days before potato treatments, respectively.

Keywords: competition; height plant; tuber yield; weed.

INTRODUCTION

Today is increasing produces of crops for response to requirement of human to foods. Potato as have high nutritional value is a strategic crop in nutrition of developing countries.

¹ Department of Agronomy and Plant Breeding, Faculty of Agriculture, Yasouj University, Yasouj, Iran

Therefore for create of food security; it seems necessary increasing of efficiency and greater productivity strategic products, such as potato. For achievement to in purpose, increasing of yield in scale of area with consideration of effective parameters usually been related part of the research to potato (Rezaee and Soltani, 2005). Weeds are one of the limiting factors in potato production. Today, instead of trying to weeds eradicate in farms emphasized on control of weed populations. Weed management systems require to comprehensive and accurate information of behavior of weeds and their effects on agricultural systems. This issue is include understanding the interaction of between crop and weeds during the growing season and weed population dynamics after of the growing season. Pigweed is an important dicotyledonous weed of potato in the world that due to indeterminate growth and to be C₄ biosynthetic pathway, in the high temperature and intense light particularly in the fields of summer crops and thermophile, such as corn and sunflower, indicated more competitive ability (Ronald, 2000). High competitive ability in different types of weed caused until evaluate negative impact of interference different species of them on summer crop yield to be consider weed scientists (Dieleman *et al.*, 1995). Weed density is one of the most important factors affecting on weed competition with crop (Blackshaw, 1993). In most studies comparative

was examined the relative time of emergence and duration of period weed competition with crop. Carranza *et al.* (1995) reported that early emergence of *Ridolfia segetum* made weeds about 1.5 times more competitive ability than late emergence due to higher height. Weed competition led to reducing of grain yield and thousand grain weight, and amount of decreasing in product depending on type of plant and density, emergence stage and duration of weed competition. Berry *et al.* (2006) demonstrated that presence of soft pigweed and gray pigweed by density equal 1 to 2 plants/m² led to cucumber yield reduction to 10%, and also damage threshold this two weeds is equal 6 and 8 plants/m². Mirshekari *et al.* (2006) determined damage threshold redroot pigweed in density of eight plants per meter of row bean to 6 first week of growth. Henderson *et al.* (2000) stated that pigweed by having morphology of flexibility has ability to compensate different levels of compression. Abassian *et al.* (2002) reported that pigweed due to high competitive ability, even at low densities could lead to economic yield reduction. The objective of this study was to investigate the potato yield in different pigweed densities and relative time of pigweed emergence.

MATERIALS AND METHODS

The field experiment was conducted as factorial based on randomized complete block design with three replications at the Research Station of Borojen, Chaharmahal and Bakhtiari,

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Iran. Treatments were combination of three different weed densities (3, 6, 9 plants per meter row equal with 5, 10 and 15 plants/m²) and relative time of emergence pigweed (4 and 8 days before potato, emerged with potato, 4 days after potato emergence). For relative time of pigweed emergence were planted pigweed seeds in times 2, 6, 10 and 14 days after planting potatoes, respectively. Land preparation operations was including deep plowing in autumn, adding of 20 t ha⁻¹ composted manure, disk harrows, plowing in the spring, adding of 72 kg ha⁻¹ from each of the phosphorus and potassium nutrients of resources ammonium phosphate and potassium sulfate respectively, second disk and finally furrower. Also, nitrogen fertilizer was used amount of 59.8 kg ha⁻¹ at planting and thinning time from urea resource. Plots were prepared with area of 15 m² with four rows and distance between rows 60 cm. Then were planted potato tuber varieties of Bourne with 20 distance from each other, on plant row in depth 17 cm in 20 April. Irrigation was done once in week based on plant requirement, temperature and atmospheric conditions. All weeds, except pigweed, were weeding at two times. Harvesting was carried out at time of reaping by hand. The potato harvest were carried individually on June 30th of each plots. Potato characteristics was including plant height, number of stem and lateral branches, number and size of tubers per square meter, biological yield and tuber yield. Plants were evaluated for measuring all traits and also avoid marginal effects, in each plot of middle rows and also of the middle row, finally was used mean of data each plant for analysis. From each plot were marked three plants. The potato harvest was carried out at end of the season and after drying about 50% shoot for all treatments.

For this purpose, after removal of 50 cm from each side edge of plot was harvested the level equivalent of 2 m² to compare of tuber yield. After harvest plant shoots and their weighing, tubers ground out and were collected by a shovel. In the next stage to obtain the total biological yield was collected tuber dry weight with shoot weight. Statically analysis was conducted by using SAS software. Also, mean comparison was done with test Least Significant Difference (LSD) at 5% probability levels.

RESULTS AND DISCUSSION

Number of main branches

Number of stem is one of the most important parameters for determining the density of plants, because by a seed tubers may generated 1 to 3 and even greater numbers of stem, and number of tubers produced by each plant is dependent on the number of stems. The effects of density and relative time of pigweed emergence was not significant on number of main branches (*Table 1*). Number of main branches in potato determined mainly by cultivar, presence and competition of weed cannot have influence on main stem.

Number of lateral branches

Analysis of variance (*Table 1*) showed that effects of density and relative time of pigweed emergence was significant on the number of lateral branches at 1% probability levels. Mean comparison of treatments showed that early relative time of emergence of pigweed led to

reduce the number of lateral branches potato. So, that the highest (27) and the lowest (17.9) number of lateral branches potato was obtained from emergence at 4 days after and 8 days before potato treatments, respectively (*Table 2*).

Increasing of pigweed density from 5 to 15 plants/m², number of lateral branches decreased from 26.3 to 19.2 (*Table 2*). By increasing the canopy of pigweed on potato, due to increasing of density and synchronicity of emergence, more allocation of produced dry matter allocated to main stem components and granted less allocation to branches (Gibson *et al.*, 2001).

Plant height

The results of variance analysis (*Table 1*) showed that the effects of density and relative time of pigweed emergence were significant on plant height at 1% probability levels, but their interaction was not significant. Mean comparison of treatments revealed that the highest plant height (60.7 cm) was obtained from emergence at 8 days before potato and the lowest plant height (45.3 cm), related to emergence, at 4 days after potato treatments (*Table 2*). In this experiment, increasing of pigweed density significantly increased plant height of potato, the reason of this subject related to more competition among the plants for get of light energy in higher densities. Plant height be controlled by genetic and environmental factors, such as climate region, plant density, planting date,

fertility, salinity and soil moisture. Studies conducted about interference weed on potato height indicated that weed interference led to reduce the potato height (Nelson and Thoreson, 1981).

Number of tubers/m²

After harvesting of potato, tubers were divided into two groups (Khaleghi, 2004), larger tubers than 70 mm (medium to high) and smaller tubers than 70 mm (average to low). Analysis of variance (*Table 1*) showed that the effects of density and relative time of pigweed emergence were significant on number of larger tubers than 70 mm and total number of tubers per square meter, but was not significant on number of smaller tubers than 70 mm. Mean comparison of relative time of pigweed emergence revealed that with delay in the pigweed emergence from 8 days before to 4 days after potato, number of larger tubers than 70 mm and total number of tubers/m² increased from 11.1 and 38.8 tuber to 17.1 and 35.7, respectively (*Table 2*). Also, observed that number of tubers smaller than 70 mm decreased by delay in pigweed emergence (*Table 2*). Hence presence of pigweed weed caused size and number of tubers potato reduction. In this study, mean comparison of pigweed densities indicated that with increasing of pigweed densities from 5 to 15 plants/m², number of tubers larger than 70 mm and number of tubers total decreased from 17.2 and 35.9 to 11.4 and 31.7, respectively (*Table 2*). With increasing of pigweed density, decreased size of tuber and

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number of tuber. Size and weight reduction of tuber at high density of pigweed probably is due to the occurrence of interspecies competition potato and pigweed (Syadat *et al.*, 2001).

Biological yield

Analysis of variance showed that effects of density and relative time of pigweed emergence and their interaction was significant on biological yield at 1% and 5% probability levels, respectively (*Table 1*). Mean comparison of interaction the experimental factors showed that trend of decrease the biological yield by increasing of pigweed density is various at different relative time of pigweed emergence treatments. As emergence at 8 days before potato there was no significant difference between 10 and 15 pigweed densities. But emergence at 4 days before potato and emerged with potato treatments, increasing of pigweed density significantly led to reduce of biological yield of potato. Ultimately, in treatments of emergence at 4 days after potato, increase the pigweed density from 5 to 10 plants/m² had not significant effect on biological yield of potato, and density of 15 plants/m² led to significant decrease the biological yield. Generally, delay in the relative time of pigweed emergence from 8 days before to 4 days after potato, increased biological yield to 56%. Also, increase the density from 5 to 19 plants/m², decreased biological yield of potato to 36% (*Table 2*). Since the researchers believe (Zimdahl, 1999; Robert, 1993)

response crop to competition induced of weed is like other environmental stresses, it seem this response of potato is kind of stress response. Henderson *et al.* (2000) stated that the pigweed has flexible morphology which ability to have compensated different levels of densities. Abasian *et al.* (2002) reported that pigweed have high competitive ability, as even in low densities be able to caused yield reduction. Bensch *et al.* (2003) at study competition of pigweed with soybean stated that increasing of pigweed density, reduced yield soybean, which this reduction depends on to weed species, density and time of its germination.

Tuber yield of potato

The effects of density and relative time of pigweed emergence and their interaction were significant on the tuber yield of potato at 1% and 5% probability levels, respectively (*Table 1*). Mean comparison showed that the highest (35.06 t ha⁻¹) and the lowest (22.50 t ha⁻¹) tuber yield was obtained from emergence at 4 day after and 8 days before potato, respectively. Also, with increasing of pigweed density from 5 to 15 plants/m², tuber yield potato decreased to 37% (*Table 2*).

Mean comparison of interaction the experimental factors showed that the highest (39.8 t ha⁻¹) and the lowest (18.4 t ha⁻¹) tuber yield potato related to density five plants/m² and emergence at 4 days after potato and density 15 plants/m² and emergence at 8 days before potato, respectively (*Table 2*).

Table 1 - Analysis of variance yield and its components of potato

| SOV | df | Number of main branches | Number of lateral branches | Plant height (cm) | Number of tuber/m ² (larger than 70 mm) | Number of tuber/m ² (smaller than 70 mm) | Number of tuber total/m ² | Biological yield (t ha ⁻¹) | Tuber Yield (t ha ⁻¹) |
|--------------------------------|----|-------------------------|----------------------------|-------------------|--|---|--------------------------------------|--|-----------------------------------|
| Replication | 2 | 0.0603 ns | 2.53 ns | 17.69 ns | 1.86 ns | 2.58 ns | 4.29 ns | 916614 ns | 9589978 ns |
| Relative time of emergence (A) | 3 | 0.0225 ns | 136 ** | 405 ** | 57.2 ** | 7.36 ns | 23.6 * | 15378037 ** | 244286667 ** |
| Pigweed density (B) | 2 | 0.0844 ns | 151 ** | 151 ** | 102.8 ** | 8.58 ns | 52.2 ** | 30644582 ** | 526732500 ** |
| A×B | 6 | 0.0022 ns | 4.05 ns | 3.97 ns | 2.19 ns | 0.36 ns | 1.05 ns | 1102355 * | 14129167 * |
| Error | 22 | 0.0475 | 2.41 | 18.69 | 3.07 | 2.83 | 5.47 | 357489 | 4557223 |
| CV (%) | | 6.47 | 6.78 | 8.18 | 12.35 | 8.58 | 6.92 | 8.30 | 7.34 |

** and * - significant at 5 and 1%, respectively; ns - not significant.

Table 2 - Mean comparisons of relative time of emergence and density pigweed on yield and its components of potato

| Treatment | Number of main branches | Number of lateral branches | Plant height (cm) | Number of tuber/m ² (smaller than 70 mm) | Number of tuber/m ² (larger than 70 mm) | Number of tuber total/m ² | Biological yield (t ha ⁻¹) | Tuber yield (t ha ⁻¹) |
|---------------------------|-------------------------|----------------------------|-------------------|---|--|--------------------------------------|--|-----------------------------------|
| Time of emergence pigweed | | | | | | | | |
| 8 days before potato | 3.34 a | 17.9 d | 60.7 a | 11.1 c | 20.7 a | 31.8 b | 5.62 d | 22.50 c |
| 4 days before potato | 3.34 a | 22.1 c | 55.7 b | 13.5 b | 19.9 a | 33.4 ab | 6.88 c | 28.40 b |
| Simultaneous with potato | 3.34 a | 24.6 b | 49.8 c | 15.0 b | 19.2 a | 34.2 a | 7.56 b | 30.43 b |
| 4 days after potato | 3.34 a | 27.0 a | 45.3 d | 17.1 a | 18.6 a | 35.7 a | 8.75 a | 35.06 a |
| Pigweed density | | | | | | | | |
| 5 plants/m ² | 3.46 a | 26.3 a | 49.3 b | 17.2 a | 18.7 a | 35.9 a | 8.87 a | 35.95 a |
| 10 plants/m ² | 3.29 a | 23.1 b | 52.8 ab | 13.9 b | 19.7 a | 33.7 b | 7.05 b | 28.62 b |
| 15 plants/m ² | 3.36 a | 19.2 c | 56.4 a | 11.4 c | 20.3 a | 31.7 b | 5.69 c | 22.72 c |

Means followed by the same letters in each column according to Least Significant Difference (LSD) test are not significantly ($p \leq 0.05$).

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In treatments of emergence at 8 days before potato, low density pigweed led to high economic damage, and by delay time of pigweed emergence is needed more number of weed to caused economic damage; and consequently the weed emergence as important as weed density, which should be considered in weed management. Also, other studies showed that dry and potato yield, more decrease with emergence acceleration of weeds (Love *et al.*, 1995). Of course by increasing of weed density decreased tuber dry matter and yield of potato (Wall and Friesen, 1990). Massinga *et al.* (2003) reported that with increasing of pigweed density from 0.5 to 8 plants/m², corn yield increased from 11 to 91%. Studies conducted on crop and weed competition for light indicates that more height could compensate the lower leaf area. So, that weeds with more height and lower leaf area have greater competitive ability for light absorption, compared with crop with less height and more leaf area (Nassiri Mahallati and Kropff, 1997). This issue indicates importance of plant height in the competition. Since high of species is one of the factors determining competition for light (Holt, 1995), it seem pigweed by having this feature has been strong competitor for potato. In this study, due to more height of pigweed than potato and also to be C₄, in less density is strong competitor for light absorption. Toler *et al.* (1996) reported that more height of pigweed

than soybean has been one of the success factors pigweed in competition with this plant.

CONCLUSION

The results of this experiment indicated that by increasing of pigweed density, increased plant height and dry pigweed. Increasing of density and relative time of pigweed emergence led to number of lateral branches, biological yield and tuber yield reduction and also plant height of potato increased. Presence of pigweed led to decrease of size and the number of tuber of potato. Trend of reduce the biological yield and tuber of potato with increasing of pigweed is various at different relative time of emergence treatment. Generally, results showed that pigweed due to more height than potato and also to be C₄, even at lower densities was a stronger competitor for light absorption, and could cause a lot of damage to potato production.

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