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EFFECT OF NITROGEN RATES ON CRITICAL PERIOD FOR WEED CONTROL IN POTATO

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ABSTRACT

The critical period for weed control (CPWC) is the period in the crop growth cycle during which weeds must be controlled to prevent unacceptable yield losses. A field research was conducted in 2007 in Ardabil, Iran, to evaluate the effect of nitrogen rates on critical period for weed control in potato. Nitrogen fertilizer was applied at rates equivalent to 0, 100 and 200 kg N ha^{-1}. A quantitative series of treatments of both increasing duration of weed interference and length of weed-free period (0, 20, 40, 60 and 80 DAE) were imposed within each nitrogen main plot. Application of 200 kg N ha^{-1} reduced weed density and increased weed dry mass compared with non-application of nitrogen. Results showed that the addition of 100 kg N ha^{-1} delayed the beginning of the CPWC in potato when compared with the 0 and 200 kg N ha^{-1}. The duration of CPWC in potato also decreased when 100 kg N ha^{-1} was applied. Maximum values for potato yield was recorded in weed free plots and100 kg N ha^{-1}. Practical implications of this study are that 100 kg N ha^{-1} could have been improving potato compatibility for weed control more than 0 and 200 kg N ha^{-1}.

Key words: Critical period, integrated weed management, weeds.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is an important crop and is grown for human and animal consumption in Iran. The Ardabil province locates in the northwest of Iran, and includes about 15% of the total cultivation area in Iran (Anonymous, 2008). Weeds are one of the most important factors in potato production in Ardabil, Iran. Weeds cause yield losses worldwide with an average of 15 to 20% despite weed control applications (Nouri-Ghanbalani, 2002). Therefore, weed control is an important management practice for potato production that should be addressed to ensure optimum yield. Weed

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control in potato in Iran is carried out by mechanical and/or pre-emergence application of herbicides.

Critical period for weed control (CPWC) is important steps in successful integrated weed management and in achieving the efficient use of management practice. The CPWC is the period in the crop growth cycle during which weeds must be controlled to prevent unacceptable yield losses. Weed interference before or after the critical period will not result in unacceptable decrease in yield. Knowledge of the critical period is essential for making decisions on the appropriate timing of weed control. The critical period can vary depending on weather and growing conditions. Some research also has indicated that the critical period may vary with weed density, time of weed emergence, and agricultural practices such as crop density, planting date and fertilizer (Evans *et al.*, 2003b; Zaharenka, 2000; Williams, 2006; Ahmadvand *et al.*, 2009). Ahmadvand *et al.* (2009) found that based on crop density the CPWC for potato in western Iran began 19 to 24 days after emergence (DAE) up to 43-51 DAE. Bairamkenga and Leroux (1994) reported that for obtaining maximum tuber yield, the maximum time allowed for weeds to grow after potato emergence was 15 days. Hall *et al.*, (1992) reported that the beginning of the critical period for corn varied from the 3- to 14- leaf stages of the crop, whereas Ferrero *et al.*, (1996) found that the critical period of corn to weed absence beginning with the one-and 7- leaf stages and ending with the 7- and 10- leaf stages of the crop. The weed free period for first 7 weeks was important for avoiding yield losses (Khan *et al.*, 2002a).

Previous researches have suggested that the exact outcome of crop-weed competition is dependent on availability of essential nutrients (Tollenaar *et al.*, 1994; Vengris *et al.*, 1995; VanDelden *et al.*, 2002; Khan *et al.*, 2002b; Evans *et al.*, 2003a; Liebman *et al.*, 2004; Mohammaddoust-Chemanabad *et al.*, 2009; Azeez, 2009). Numerous studies have shown that crop yields improve following the application of nutrients to soil, particularly nitrogen (N), potassium (K), and phosphorus (P) (Dusky *et al.*, 1996; Dhima and Eleftherohorinos, 2001). However, while nutrients promote crop growth, many studies have shown that weeds uptake fertilizer over crops and following the application of fertilizers increased weed density or their biomass (Tulikov and Sugrobov, 1984; Liebman *et al.*, 2004; Blackshaw *et al.*, 2005; Blackshaw and Brandt, 2008; Azeez, 2009). Certain weed species have a lower optimal rate of N fertilizer than crops, giving weeds a competitive advantage in some situations (Blackshaw *et al.*, 2003). Despite the fact that many weed species are more responsive to fertilizer than are crops, the phenomenon is not universal. Tollenaar *et al.*, (1994) found that effect of weed interference on corn grain yield was higher at low than at high N. These contradictory, relative to environmental conditions, weed composition, weed density, fertilizer management (method, type and rate) and crop species. Hence, nutrient management can influence the beginning and length of the CPWC. Evans *et al.*, (2003b) reported that addition of 120 kg N ha^{-1} delayed the beginning of the critical period of corn when compared with the 0 and 60 kg N ha^{-1}. They found that the addition of 120 kg N ha^{-1} also hastened the end of the critical period of corn when compared with reduced rates.

Therefore, nutrient management has been identified as a likely strategy for weed control (Vengris *et al.*, 1995; Van Delden *et al.*, 2002; Blackshaw *et al.*, 2005; Mohammaddoust Chamanabad *et al.*, 2009), but limited study has been conducted to determine the effect of nitrogen fertilization on potato-weed competition, particularly, on CPWC. Because most nitrogen rate experiments are conducted in weed-free environments, and there is a need to evaluate the effects of nitrogen on the critical period for weed control. Therefore, the objectives of this research were to (1) determine of the CPWC in potato under different rates of nitrogen fertilizer, and (2) determine potato yield response to weed under nitrogen rates application.

MATERIALS AND METHODS

Filed experiment was conducted in 2007 at the Alarogh Research Center in Ardabil, Iran. Primary moldboard tillage was used in fall and then in spring secondary tillage was done with disking. Before crop planting, triple superphosphate fertilizer was broadcast at rate 60 kg P_2O_5 ha^{-1}. Urea was broadcast at rates equivalent to 0, 100 and 200 kg N ha^{-1}. The half rate of nitrogen was applied before planting and the rest was broadcast at vegetative growth stage (40 DAE). Agria cv. of potato was planted at 53,000 plants ha^{-1} in 0.75-m rows (the recommended density and space for optimal yield in Iran).

Experiment was established as a split-plot with nitrogen application rates (0, 100 and 200 kg N ha^{-1}) as the main-plots. A quantitative series of treatments of both increasing duration of weed interference and length of weed-free period were imposed within each nitrogen main plot. Main plots were arranged in randomized complete block design with four replications. Sub-plots consisted of four potato rows, 10 m in length. For each main plot, two sets of treatment were imposed to represent both increasing duration of weed interference and weed-free period measured after planting. The weed infested treatments established five levels of increasing duration of weed interference by delaying weed control from the time of crop planting, DAP (0, 20, 40, 60 or 80 day after planting). In the weed-free sets, weeds were removed 0, 20, 40, 60 or 80 DAP by hand weeding, and then weeds were permitted to grow within the crop until harvest time.

In sub-plots weed grew until harvest time, weeds were clipped at the soil surface from within 0.75 × 0.50 m quadrate, counted and weighted after oven-drying at 85°C. Tubers were harvested by hand from the 2 central rows over 3 m of row on September 14, 2007 and total mass was recorded as potato yield. The logistic model and the Gomperts model were applied to describe the effect of weed-infested period and weed-free period on potato yield, respectively. MSTATc statistical program was used to analyze the data, including analysis of variance (ANOVA) and comparison of means was done based on Douncan test ($p \geq 0.05$).

RESULTS AND DISCUSSION

Weeds Dry Biomass (g m^{-2})

Weed species recorded were representative of common potato weeds. At many sampling events, redroot pigweed (*Amaranthus retroflexus*) and common lambsquarters (*Chenopodium album*) were the most abundant weeds species. Common purslane (*Portulacea oleracea*) and Russian knapweed (*Acropltilon repens*) were also recorded in the experimental field.

Nitrogen rates had a significant effect on weed density and their dry weight. Weeds dry weight was increased by 200 kg N ha^{-1} application (Fig. 1). Increasing in weed dry weight at 200 kg N ha^{-1} treatment can be caused of low weed density, because of reduce intra- or inter- species competition. Researchers have shown that nitrogen application improve crop canopy that may prevent light penetration on soil surface and therefore inhibit weed seed germination whose need light for germination (Evanse *et al*., 2003a; Williams 2006; Azeez, 2009). On other hand, nitrogen application has improved crop competitive ability, and may cause weed seedling mortality. Tulikov and Sugrobov, (1984) reported that doubling the rate of nitrogen applied, weed density strongly reduced. Conversely, they found that increasing the amount of nitrogen fertilizer, weed dry weight increased. Azeez (2009) also found that high nitrogen rate (90 kg N ha^{-1}) increased weed biomass, relative to low rates.

Critical period

Duration of weed interference had a significant effect on potato yield. Higher and lower yield loss in season-long weed interference was observed when 0 and 200 kg N ha^{-1} was applied, respectively (Fig 2). Duration of the weed-free period also had a significant effect on potato yield (Fig. 2). When potato had been maintained weed-free for 80 DAE higher tubers yield achieved in plots that received 200 kg N ha^{-1}.

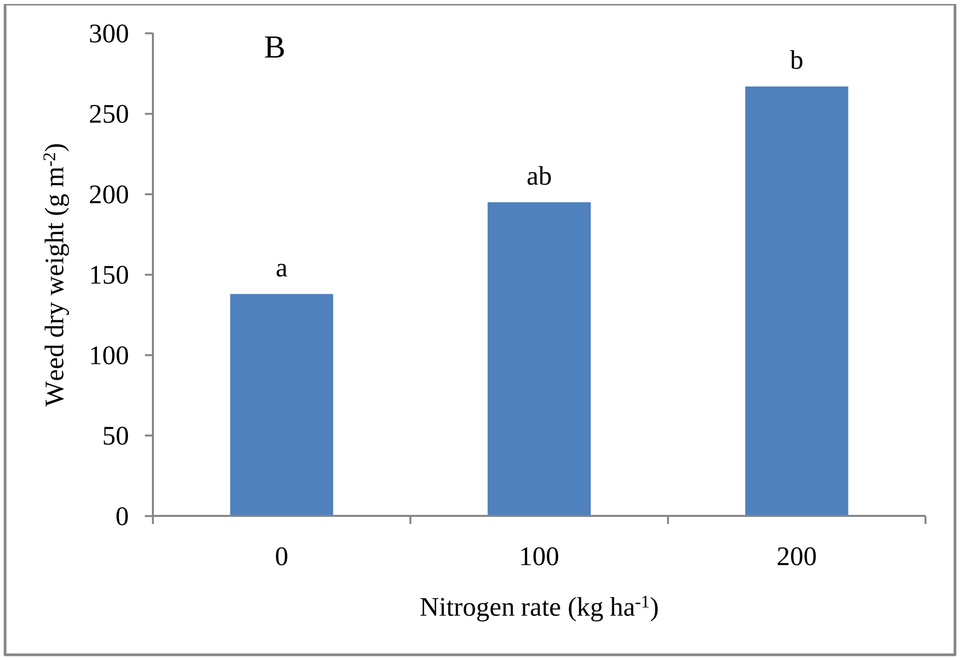

Figure 1. Mean weed dry weight at different levels of fertilizer in potato.

The logistic (weedy) and Gompertz (weed free) curves to identify the critical timing of weed removal and critical weed-free period overlapped in a manner that resulted in a CPWC where the critical timing of weed removal preceded the end of the critical weed-free period (Fig.2). Data showed that addition of 100 kg N ha^{-1} delayed the beginning of the CPWC in potato (Fig.2). In contrast, addition of 0 and 200 kg N ha^{-1} hastened the beginning of the CPWC in potato (Fig.2). For 0 and 200 kg N ha^{-1} the beginning of the CPWC based on 10% yield loss occurred 8 and 7 DAE, respectively, whereas for 100 kg N ha^{-1} occurred 13 DAE. These results indicate that 100 kg N ha^{-1} increased potato tolerance to the presence of weeds, due to likely increasing early-season potato growth rates. Addition of 200 kg N ha^{-1}, although may increase early- season potato growth rates, but additional nitrogen benefit weeds more than potato and increase weed competitiveness ability. The end of CPWC also varied between nitrogen rates and 100 kg N ha^{-1} hastened the end of the CPWC in potato when compared with 0 and 200 kg N ha^{-1} (Fig. 2). Zaharenka (2000) found corn competitive ability had increased by fertilizer application. Hence, when potato receives low or additional nitrogen rate requires more intensive weed management than corn received sufficient nitrogen. Evans *et al.* (2003) also reported that addition of 120 kg N ha^{-1}

delayed the beginning of the CPWC when compared with 0 or 60 kg N ha^{-1} rate. While Khan *et al.*, (2002a) reported that critical period of weed competition was 7-9 weeks after planting wheat. This study confirms that the supply of nitrogen available to a crop can significantly influence crop-weed interference and change CPWC. Differences in CPWC due to nitrogen rates documented in this research highlight the need for a greater understanding of integration decisions regarding nitrogen management and the timing of weed control.

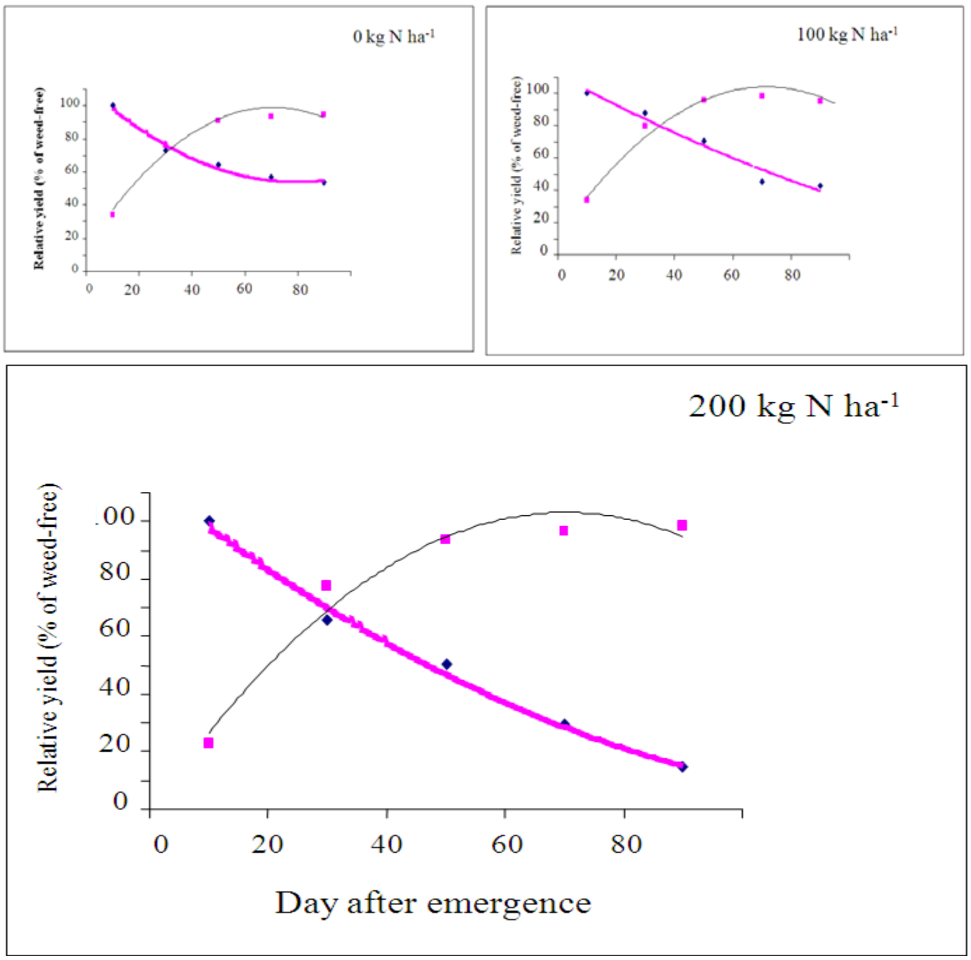

Figure 2. Potato relative yield expressed as a percentage of the weed-free control as a function of increasing duration of weed interference (weedy) or length of weed-free period (weed free) for three rates of nitrogen application.

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