Garlic *(Allium sativum)* response to weed control practices

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Reaktionen von Knoblauch auf Unkrautbekämpfungsmaßnahmen

1. Introduction

Garlic (*Allium sativum*) is a cool-season crop that is grown for its characteristic flavor (HARTMANN et al., 1981). A few garlic plants are easily grown in a home garden and are sufficient for the average family. Garlic has received limited attention by agrochemical companies in terms of developing effective herbicides for weed control. Only a few herbicides are registered for use in garlic (AHRENS, 1994). Thus, farmers rely on hand weeding to reduce the adverse effects of weed interference in the absence of other control tactics (QASEM, 1996a). The critical period for weed control in garlic was estimated to be from 21 to 49 days after crop emergence (QASEM, 1996b). This critical period is the time interval during which the crop should be free from weed interference to prevent yield losses (RADOSEVICH, et al. 1997). Therefore, weeds that emerge with the crop or shortly after garlic emergence continue to be a major problem in garlic production.

Fluazifop-P,{(*R*)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl] oxy]phenoxy]propanoic acid};oxadiazon, {3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3*H*)-one}; and oxyfluorfen, {2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene} were evaluated by many researchers for weed control in garlic (AHMED and KANDEEL, 1991; AL-KOTHAIRY, 1992; PANDEY et al., 1993). Fluazifop-P, is an aryloxyphenoxy propionate postemergence herbicide that is applied on garlic and other crops to control most annual and perennial grass weeds (AHRENS, 1994). Oxadiazon, an oxadiazole herbicide, is soil applied to control many broadleaf weeds and grasses. Oxyfluorfen, a diphenyl ether, is a selective preemergence or postemergence herbicide that is used to control many annual broadleaf weeds and grasses in several crops including

Zusammenfassung

Versuche loten die Möglichkeit der Einführung effizienter Unkrautbekämpfungsmaßnahmen in der Knoblauchproduktion aus. Während zweier Vegetationsperioden werden die Verfahren händisches Jäten, Oxyfluorfenanwendung vor Aufgang sowie Oxyfluorfen- gefolgt von Fluazifop-Phosphor-Anwendung nach dem Aufgang miteinander verglichen. Die Ergebnisse zeigen, dass Jäten die beste Unkrautkontrolle sicherstellt. Herbizidanwendungen vor dem Aufgang gewährleisten die Vegetationsperiode hindurch akzeptable Unkrautkontrolle, allerdings schmälert deren Phytotoxizität fallweise den Knoblauchertrag. Um die Kosten der Unkrautkontrolle zu minimieren ist eine Kombination der reduzierten Anwendung von Vorauflaufherbiziden mit sporadischem Jäten zu empfehlen.

Schlagworte: Unkrautbekämpfung, Knoblauch, Herbizideinsatz, Jäten.

Summary

Experiments were conducted to detect the possibility of adopting efficient weed control methods for garlic production. Treatments of hand weeding, oxyfluorfen applied preemergence, oxadiazon applied preemergence, oxyfluorfen applied postemergence, and oxyfluorfen followed by fluazifop-P applied postemergence, were evaluated in two seasons. Results indicated that hand weeding provided the best weed control. Preemergence herbicide applications provided acceptable season-long weed control; however, phytotoxicity occasionally reduced garlic yield. A combination of preemergence herbicides at reduced rates in combination with sporadic hand weeding was suggested to minimize weed control expenses.

Key words: Weed suppression, weed management, chemical weed control, hand weeding, crop injury.

garlic (ASHTON and MONACO, 1991). Oxadiazon and oxyfluorfen provided selective annual grass and broadleaf control in garlic with bulb yields comparable to hand weeded plots (MOHAMED and NOURAI, 1997), or slightly lower than hand weeded plots (AHMED and KANDEEL, 1991). Oxadiazon followed by hand weeding provided good (87 %) weed control (MADAN et al., 1994). Weed control achieved by high rates of oxyfluorfen (above 0.5 kg ha^{-1}) was 90 % when evaluated 90 days after treatment, with no observed crop injury (OLIVERA et al., 1994). However, injury was observed in garlic from the application of oxyfluorfen in other cropping situations (PALCZYNSKI and DOBRZANKSI, 1993).

In this research, the objective was to compare the weed control potential of preemergence and postemergence herbicides with the traditionally utilized approach of frequent hand weeding.

2. Materials and Methods

Experiments were conducted in the 1996/97 and 1997/98 seasons at the Jordan University of Science and Technology campus on a silty clay soil (very fine, montmorillonitic, thermic, Typic Chromoxeret) that has organic matter content of 1.0 % and a pH of 7.8. Calcium carbonate content is 14 % at the soil surface. Calcium is the most dominant extractable cation followed by potassium, magnesium and sodium (KHREASAT et al., 1998). The overall climatic conditions of the site are typical Mediterranean weather with average monthly temperatures ranging from 3° C in January to 34° C in August (JARADAT, 1988). The long term annual precipitation average for the site is 230 mm. Annual precipitation for the 1996/97 and 1997/98 growing seasons were 248 and 292 mm, respectively. Garlic cloves of a local variety (Chami) were planted 8 cm deep in 20 by 20 cm on both sides of 1-m spaced drip irrigation pipes.

Experiments were conducted in a randomized complete block design with three replicates. Plots of 2.5 by 4 m separated by 0.5 m buffer area were planted with garlic cloves on Dec. 7, 1996, and Nov. 25, 1997. Preemergence treatments were applied the following day. Irrigation was initiated one day after applying preemergence herbicides and continued as required throughout the growing season. Postemergence treatments were applied 40 days after garlic emergence when plant height was 20 cm for garlic and 10 cm for weeds. All herbicides were applied using a pressurized CO_2 backpack sprayer. Weed infestation was a natural stand of the prevailing weeds. The dominant broad leaf species were *Cardaria draba* L., *Diplotaxis erucoides* (L.) DC., *Anthemis palestina* Reut., and *Amaranthus* spp. The dominant grass weed was *Hordeum murinum* L. Treatments were weedy check (untreated), hand-weeding (practiced biweekly during the growing season), oxyfluorfen applied preemergence at 1000 g ha^{-1}, oxadiazon applied preemergence at 3000 g ha^{-1}, oxyfluorfen applied postemergence at 1000 g ha^{-1}, and the combination of oxyfluorfen (1000 g ha^{-1}) followed by fluazifop-P (300 g ha^{-1}) applied postemergence.

Measurements recorded each year included visual weed control ratings recorded 2 and 6 weeks after postemergence treatments on a scale from 0 (no weed control) to 100 % (complete weed control). Visual injury ratings on garlic were recorded at the same time on a scale from 0 (no injury) to 100 % (complete injury). Garlic height was measured from the ground to the uppermost leaf tip at 2 and 6 weeks after postemergence treatments. Before harvest, weed number and fresh above ground biomass were determined in four 0.25 of m^2 random quadrates per plot. One square meter of garlic bulbs was harvested from each plot and weighed immediately to determine fresh weight. Garlic dry weight was determined after subjecting the harvested bulbs to air drying for 40 days. The number of bulbs per m^2 was also determined. Garlic was harvested on June 15, 1997, and June 7, 1998.

Analysis of variance procedures were performed on all data collected. Visual weed control and injury ratings analyses were performed without including values for weedy check plots to avoid violating the assumptions of the ANOVA. Arcsin transformation was performed on proportional data, whereas square root transformation was performed on weed count data. Because no differences were observed, the untransformed data were used for analysis. Preplanned single degree of freedom contrasts were performed on variables that had significant treatment effects.

3. Results and Discussion

Visual weed control ratings estimated 14 days after applying postemergence treatments indicated variations among treatments only in the 1996/97 season (Tables 1 and 2). The best weed control was achieved by hand weeding, and to a less extent, by oxyfluorfen applied preemergence. The addition of fluazifop-P improved the level of weed control provided by oxyfluorfen applied postemergence alone in

1996/97, even though grass weeds were not abundant in the experiment. Visual weed control ratings estimated 6 weeks after postemergence treatments indicated significant differences among the various treatments in both seasons with preemergence applications being better than postemergence applications (Tables 1 and 2). Preemergence applications of oxyfluorfen or oxadiazon provided weed-free duration that exceeded the critical period estimated by QASEM (1996b), which suggest that these treatments may be used as replacements for hand weeding. Visual weed control ratings in both seasons indicated that hand-weeding continuously provided the best weed control.

Visual injury ratings recorded on garlic 2 weeks after postemergence treatments indicated that variations existed among treatments in both growing seasons (Tables 1 and 2). Considerable injury was observed in plots subjected to preemergence applications of oxyfluorfen. Garlic plants in part recovered from herbicide injury in all plots by the end of the season, except for those that received the preemergence applications of oxyfluorfen, which remained partially stunted and chlorotic. PALCZYNSKI and DOBRZANSKI (1993) observed similar phytotoxicity at equivalent oxyfluorfen rates. Garlic height data recorded either 2 or 6 weeks after postemergence treatments coincided with this observation, where garlic plants were stunted in both growing seasons in plots treated with oxyfluorfen applied preemergence (data not shown).

Differences in weed number and weed fresh weight were significant among the various treatments in both seasons (Tables 1 and 2). Hand-weeded and preemergence treatments were more effective than postemergence applications in suppressing weed growth. The number of weeds present at the end of the season was less informative than weed fresh weight in terms of the magnitude of weed interference.

Garlic fresh (data not shown) and dry yield weights varied significantly among the various treatments only in the 1996/97 season (Table 3). Hand-weeded plots produced the highest yield in the 1996/97 season. In the 1997/98 season, all weed-controlled plots had higher yield than the weedy checks. The number of bulbs per plant, which reflects the degree of mortality in garlic plants from weed interference, varied in both seasons (Table 3). Bulb numbers were less in weedy plots. In the 1996/97 season, the highest number of bulbs produced was observed in hand weeded plots. Variations were not observed in the second season among the weed control treatments. Although hand weeding was practiced biweekly in both seasons, personal errors could be considered liable for the lack of effective hand weeding in the 1997/98 season (as indicated by higher weed fresh weight and lower garlic dry weight and bulb number compared to 1996/97).

Results of this research suggest that frequent hand weeding could be replaced by preemergence herbicide applications. It is suggested to use lower herbicide rates, particularly from the herbicide oxyfluorfen, in combination with

Table 1: Weed control, garlic visible injury, weed numbers and weed weight in the 1996/97 season
Tabelle 1: Unkrautbekämpfung, sichtbare Beeinträchtigung des Knoblauchs, Unkrautdichte und -gewicht in der Vegetationsperiode 1996/97

Treatment	Time of Application	Weed control 2 WAT	Weed control 6 WAT	Visual Injury 2 WAT	Visual Injury 6 WAT	Weed No.	Weed fresh weight
		%		%		Weed m^{-2}	g m^{-2}
Weedy	NA	0	0	0	0	39	1254
Hand-weeded	Biweekly	94	92	2	1	9	119
Oxyfluorfen	PRE	92	85	40	10	10	506
Oxadiazon	PRE	83	70	28	1	17	840
Oxyfluorfen	POST	73	67	28	1	9	844
Oxyfluorfen. plus fluazifop-P	POST	80	70	20	2	15	943
Contrasts							
Weedy vs. others		NA	NA	NA	NA	**	**
Hand-weeded vs. others		**	**	**	NS	NS	**
PRE vs. POST		**	**	**	**	NS	**
Oxadiazon PRE vs. oxyfluorfen PRE		**	**	**	**	*	**
oxyfluorfen POST vs. oxyfluorfen plus fluazifop-P		**	NS	*	NS	NS	NS

- WAT= Weeks after postemergence treatment
- NA= Not applicable
- *and ** indicate significant contrasts at P ≤0.05 and ≤0.01, respectively. NS= Not significant contrast.

Table 2: Weed control, garlic visible injury, weed numbers and weed weight in the 1997/98 season
Tabelle 2: Unkrautbekämpfung, sichtbare Beeinträchtigung des Knoblauchs, Unkrautdichte und -gewicht in der Vegetationsperiode 1997/98

Treatment	Time of Application	Weed control 2 WAT	Weed control 6 WAT	Visual Injury 2 WAT	Visual Injury 6 WAT	Weed No.	Weed fresh weight
		%			%	Weed m^{-2}	g m^{-2}
Weedy	NA	0	0	0	0	37	1473
Hand-weeded	Biweekly	94	93	2	1	7	525
Oxyfluorfen	PRE	94	87	47	20	11	600
Oxadiazon	PRE	94	87	25	10	9	600
Oxyfluorfen	POST	91	83	25	10	8	849
Oxyfluorfen plus fluazifop-P	POST	96	88	17	12	9	938
Contrasts							
Weedy vs. others		NA	NA	NA	NA	**	**
Hand- weeded vs. others		NS	*	**	NS	NS	**
PRE vs. POST		NS	*	**	NS	NS	**
Oxadiazon PRE vs. oxyfluorfen PRE		NS	NS	**	NS	NS	**
oxyfluorfen POST vs. oxyfluorfen plus fluazifop-P		NS	NS	NS	NS	NS	NS

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Table 3: Garlic dry yield and number for the 1996/97 and 1997/98 seasons
Tabelle 3: Knoblauchertrag (Trockengewicht und Knollenzahl) in den Vegetationsperioden 1996/97 und 1997/98

Treatment	Time of Application	Garlic dry weight		Garlic bulb number	
		g m^{-2}		Bulbs m^{-2}	
		1996/97	1997/98	1996/97	1997/98
Weedy	NA	49	77	3.0	1.0
Hand-weeded	Biweekly	862	356	12.7	4.0
Oxyfluorfen	PRE	529	328	10.0	3.0
Oxadiazon	PRE	304	295	6.0	3.0
Oxyfluorfen	POST	302	308	7.3	3.0
Oxyfluorfen plus fluazifop-P	POST	360	424	7.6	4.7
Contrasts					
Weedy vs. others		**	**	**	**
Hand-weeded vs. others		**	NS	**	NS
PRE vs. POST		NS	NS	NS	NS
Oxadiazon PRE vs. oxyfluorfen PRE		*	NS	*	NS
Oxyfluorfen POST vs. oxyfluorfen plus fluazifop-P		NS	NS	*	NS

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occasional hand-hoeing. By this approach, herbicide related injuries and the extensive use of manpower in weeding would be minimized. These results are applicable to areas having growing conditions similar to those prevailing in this study and certainly are not transferable to conditions of central Europe.

References

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Contrasts							
Weedy vs. others		NA	NA	NA	NA	**	**
Hand- weeded vs. others		NS	*	**	NS	NS	**
PRE vs. POST		NS	*	**	NS	NS	**
Oxadiazon PRE vs. oxyfluorfen PRE		NS	NS	**	NS	NS	**
oxyfluorfen POST vs. oxyfluorfen plus fluazifop-P		NS	NS	NS	NS	NS	NS

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Weedy vs. others		**	**	**	**
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PRE vs. POST		NS	NS	NS	NS
Oxadiazon PRE vs. oxyfluorfen PRE		*	NS	*	NS
Oxyfluorfen POST vs. oxyfluorfen plus fluazifop-P		NS	NS	*	NS

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