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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet

Asian Network for Scientific Information

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 9 (12): 2323-2327, 2006
ISSN 1028-8880

Utilization of Rye and Hairy Vetch Cover Crops for Weed Control in Transplanted Tomato

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Abstract: In a field experiment, the effects of rye (*Secale cereale* L.), hairy vetch (*Vicia villosa* Roth) and a mixture of rye and hairy vetch and method of killing them investigated on weeds control and tomato yield. Cover crops planted in fall of 2000 and 2001 in Varamin. Ten days before transplanting tomato cover crops controlled with glyphosate, mowing and harvesting. Rye had more biomass than mixture and vetch and the vetch had the least biomass. Cover crops was completely killed by glyphosate but regrew following mowing and harvesting. Cover crops treatments could not suppressed grass weeds. Mowing and glyphosate treatments of cover crops, reduced weeds density and biomass more than harvest treatment. Maximum tomato yield was in the mowing rye and mixture, such it increased yield more than 2 times compared to control. But in the hairy vetch the maximum tomato yield was in glyphosate treatment, which was 3 times compared to control. Generally, the results of this research showed that use of winter cover crops with suitable management is a good weed management system in tomato fields which increases efficacy of input and bring us closer to sustainable agriculture.

Key words: Cover crops, rye, hairy vetch, tomato, weeds, weed control

INTRODUCTION

Application of cover crops in vegetable crops production have potential as management tools (Putnam, 1986). One popular management system included hairy vetch and rye, which planted in the fall, allowed to overwinter and produce a high biomass the following spring. These cover crops are easily killed by herbicides or mower or rolling in the spring to leave a uniform mulch on the soil surface (Anonymous 1999; Masiunas *et al*., 1995). Mixture of hairy vetch and rye can provide higher mulch biomass and improved weed control (Teasdale and Abdul-Baki, 1998).

Researches have shown that cover crops are able to prevent weed establishment in early season (Creamer, 1994), aid in preserving soil humidity (Gould, 1992), increase soil in cultivated land and may play a role in the reduction of some soil pests (Adem *et al*., 1996). It has been shown that production and possibly fruit quality may be affected by cover crops (Teasdale and Abdul-Baki, 1993). Many species of cover crops are known to release considerable amounts of allelochemicals that reduced weed emergence (Barnes and Putnam, 1983).

Many studies have been conducted on cover crops application in weed control of tomato. Wyenandt *et al*. (1996) showed that application of rye and vetch mixture mulch increased tomato yield about 2 times compared to common and conventional cultivation. Masiunas *et al*. (1995) reported that tomato yield in plots that rye desiccated by glyphosate were equal or even better than conventional till plots. Abdul-Baki *et al*. (1996) showed that in 2 of 3 years, hairy vetch, crimson clover and a mixture of vetch plus rye produced higher tomato yields and heavier fruits than the plastic mulch. Abdul-Baki and Teasdale (1993) reported that hairy vetch mulch produced the highest tomato yield than subterranean clover, paper mulch and black plastic. Creamer *et al*. (1996) showed that cover crops mixture treatments included hairy vetch, crimson clover, rye and barley, provided the same level of weed control as the conventional treatments. Mwaja *et al*. (1996) reported that in 2 of 3 years, tomato yield in the rye and hairy vetch that killed by glyphosate+mowing, or mowing+disking were similar to the conventional system.

The cultural approach of using cover crop to suppress the weeds has gained acceptance by producers of vegetables (Adem *et al*., 1996; Teasdale and Abdul-Baki, 1993). However, no effort has so far been made to this in Iran. Therefore, this research was supported by the International Foundation for Science, Stockholm, Sweden and Organization of Islamic Conference Standing Committee on Scientific and Technological Cooperation (COMSTECH), Islamabad, Pakistan, through a grant to gain more information in Iran on the efficacy of two winter annual cover crops and mixture of them and study on cover crops management systems in tomato production.

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MATERIALS AND METHODS

This study was conducted in the growing season of the years 2000-2001 and 2001-2002 in the Varamin Research Station. Soil texture was silty loam with a pH, EC and SP of 7.8, 3.4 and 37, respectively. During the fall deep plough and disc furrowing were applied to prepare the soil. Simultaneously and according to the soil tests, fertilizers were applied.

The experiment was performed as a split-plot factorial design in a randomized complete block form with 3 replications. The cover crops were regarded as the main factor in 3 levels (rye, hairy vetch and a mixture of rye and vetch). The three factors of mulch management (glyphosate, mowed and harvest) and numbers of weedings (two hand-weedings and weedy control) were taken as secondary factors in subplots. A control treatment (fall deep plough) was included in a side of experiment to compare the means of experiment with it (Table 1).

In October 160 kg ha^{-1} winter rye, 45 kg ha^{-1} hairy vetch and 80 and 22 kg ha^{-1} rye and hairy vetch respectively (as a mixture) were seeded. In the late March, 10 days before transplanting of tomatoes, the cover crops were desiccated by 1) applying glyphosate at 6 L ha^{-1} and followed by mowing after 7 days, 2) mowing cover crops and leaving the residues on plots and 3) harvesting cover crops and removing the residues out of plots (similar grazing). When transplanting tomatoes had 4-5 leaves, were placed in 25 cm apart on one side of furrows. The plot size was 24 m^2 and had 4 furrows.

From planting to harvest time, biomass of the cover crops collected several times from a 0.25 m^2 quadrate, oven dried at 70°C and weighed. In March, the passage of light through the canopy of cover crops was measured by photometer. Density and biomass of weeds were taken at 80, 90, 100 and 110 Days After Transplanting (DAT) from a 0.25 m^2 quadrate. Weeds were dried and weighed. Harvest of the ripe tomatoes was from the two mid-lines of each plot, with removal of marginal effect.

Plots were established at the same site each year after deep ploughing and disking. Standard cultural practices for insect and disease control were followed. Irrigation was done when was necessary.

Analysis of variance and all statistical calculations were done by MASTAT-C software. Comparison of the means of experiment with control were done with T-test at the level of 5% probability.

RESULTS AND DISCUSSION

Biomass of cover crops: The maximum biomass of cover crops was achieved five months after planting (Fig. 1). Rye monoculture showed the highest level of biomass. It yielded 7.13 t ha^{-1} in March 2001 and 5.9 t ha^{-1} in the year 2002. In both years, the lowest biomass belonged to vetch monoculture. There was no significant difference between rye monoculture and its mixture with vetch. The biomass of mixed crops during the March of the first and second year reached to 5.28 and 4.01 t ha^{-1}, respectively. Ranells and Wagger (1996) showed that mixture of rye and hairy vetch produced higher biomass than their monoculture. Teasdale and Abdul-Baki (1998) and Vaughan and Evanylo (1998) reported that rye monoculture biomass and it's mixture with vetch is considerably higher than vetch monoculture. Samedani *et al.* (2002) show that rye had more biomass than vetch.

Percentage of light passage through the canopy of cover crops: The average light passage through the canopy of cover crops in 2 years in control, rye, vetch and rye+vetch was 1467, 21, 105, 18 μ moles m^{-2} sec^{-1}, respectively. Rye and rye and vetch mixture had the largest shading capacity compared to control (98.5 and 98.7%, respectively). Transmissible light under vetch canopy was

Table 1: Treatment included in the study

Supplemental weeding	Method of cover crops kill	Cover crops	Tillage
No	-	-	Fall
Two time	-	-	Fall
No	Glyphosate	Rye	Fall
Two time	Glyphosate	Rye	Fall
No	Mowed	Vetch	Fall
Two time	Mowed	Vetch	Fall
No	Harvest	Rye+Vetch	Fall
Two time	Harvest	Rye+Vetch	Fall

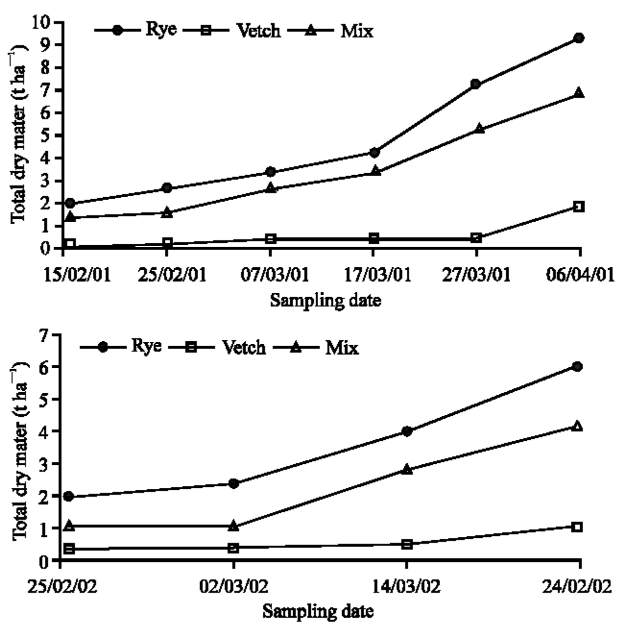

Fig. 1: Cover crops biomass fluctuations during growth period in 2001(up) and 2002 (down)

92.8% less than control. Reduction of transmissible light under canopies of cover crops is an effective parameter in preventing germination of some weed seeds, in particular photoblastic and small seeds. On the other hand, red light increment under the canopy could stimulate dormancy and prevent germination of weed seeds (Teasdale, 1996).

Biomass of grass weeds: The predominant weed species in 2001 were purple nutsedge (*Cyperus rotundus* L.), barnyardgrass (*Echinochioa crus-galli* L.), johnsongrass (*Sorghum halepense* L.), common purslane (*Portulaca oleracea* L.) and redroot pigweed (*Amaranthus retroflexuse* L.), but in 2002 all of these weeds except common purslane were predominant weeds. Cover crops treatments could not reduced biomass of grass weeds (data not presented). Burgos and Talbert (1996) showed that none of the cover crop treatments (wheat, vetch and mixture of wheat and vetch) could reduce sweet corn biomass. Also according to reports, many of grass weeds were not controlled completely by rye in a no tillage system (Martin *et al*., 1990; Clopez and Almendros, 1995).

Density and biomass of common purslane and redroot pigweed: Eighty DAT percent control of purslane density in the mowed treatment of rye, vetch and their mixture in comparison to control was 91, 82 and 64%, respectively (Table 2). All glyphosate treatments 80 DAT, compared to control, reduced common purslane density by more than 90%. Control and harvest treatments showed no significant difference in all sampling.

Mowed rye, vetch and their mixture, 80 DAT, reduced common purslane biomass compared to control by 98, 79 and 100%, respectively (Table 2). Glyphosate treatments, 80 DAT reduced common purslane biomass over 99%, compared to control. In harvest treatments, slower growth and development of common purslane was only observed in the 80 and 90 DAT.

Only 80 DAT, mowed and glyphosate treatments of cover crops could reduce pigweed density up to 75-88%. It seems that redroot pigweed could tolerate conditions of the experiment and optimally germinated. Less sensitivity of redroot pigweed seed to light and inhibitors of cover crops may be considered as the reason.

In 2001, redroot pigweed biomass was reduced by mowed rye, vetch and its mixture compared to control, in all sampling. Thus, 80 DAT, redroot pigweed biomass reduction reached up to 97, 88 and 100%, respectively. Vetch glyphosate treatment reduced redroot pigweed biomass up to 91% compared to control, only in early stages of sampling (80 and 90 DAT), but glyphosate rye and its mixture with vetch controlled it compared to control in all sampling (80 DAT by 95 and 96%, respectively). Harvest treatment in all sampling, in rye and its mixture with cover crops, reduced redroot pigweed biomass compared to control up to 97 and 99%, respectively, possibly due to inhibitory effect of rye over redroot pigweed seeding. Harvest vetch treatment decreased redroot pigweed biomass by 98% compared to control only 80 DAT.

In 2002, glyphosate vetch 80 and 90 DAT and mowed vetch 90 and 100 DAT had more weed than control and other treatments did not show significant difference with control (Table 3). It seems that in the second year, cover crops increased redroot pigweed due to the residual effects of the last year and therefore there was no significant difference with the control, while almost all treatments reduced redroot pigweed in the first year. Increasing weeds in the second year in hairy vetch treatments, is due to the fact that vetch supplies nutrients such as nitrogen for redroot pigweed. Vetch harvest treatment did not increase redroot pigweed biomass. This is because there was no vetch to supply nutrients to the soil.

Table 2: Comparison of weeds density and biomass between control treatment (fall tillage with two weedings) and cover crops treatments (two weedings) in different sampling (applying t-test) in 2001

	Common purslane density (plant m^{-2})				Common purslane biomass (g m^{-2})				Redroot pigweed density (plant m^{-2})				Redroot pigweed biomass (g m^{-2})			
Treatments	S1	S2	S3	S4	S1	S2	S3	`S4	S1	S2	S3	S4	S1	S2	S3	S4
Control	3.66	4.00	10.66	2.33	24.68	68.94	37.32	19.92	2.66	1.33	1.00	1.00	26.93	63.53	68.46	84.52
Mowed																
Rye	0.33*	1.00*	2.00*	1.00ns	0.50*	2.18*	3.93*	0.49*	0.33*	0.33ns	0.33ns	0.66ns	0.05*	0.16*	3.52*	0.20*
Vet.	0.66*	0.66*	1.00*	2.00ns	5.33*	4.73*	2.09*	11.4ns	0.66*	0.33ns	0.66ns	1.3ns	3.45*	4.40*	16.12*	4.08*
Mix	1.33*	1.00*	0.33*	2.00ns	0.02*	0.44*	0.68*	6.08ns	0.66*	1.00ns	0.66ns	1.0ns	0.96*	1.65*	6.38*	6.15*
Glyphosate																
Rye	0.33*	0.33*	1.00*	1.33ns	0.03*	0.26*	9.3*	8.6ns	0.33*	0.33ns	0.66ns	1.0ns	1.32*	2.08*	6.53*	4.48*
Vet.	0.33*	1.33*	1.00*	0.66ns	0.02*	2.52*	11.01*	10.6ns	0.33*	1.00ns	1.66ns	1.0ns	0.12*	11.14*	47.7ns	42.2ns
Mix	0.33*	0.33*	0.66*	1.00ns	0.15*	1.61*	2.50*	8.10ns	0.33*	1.33ns	0.33ns	0.7ns	1.07*	7.90*	10.81*	2.15*
Harvest																
Rye	2.66ns	3.3ns	8.3ns	2.0ns	0.33*	5.98*	18.2ns	11.1ns	1.33ns	0.33ns	0.66ns	1.0ns	0.22*	0.55*	1.49*	1.02*
Vet.	2.3ns	4.3ns	9.6ns	2.3ns	0.21*	5.17*	32.4ns	16.1ns	1.33ns	1.66ns	1.00ns	0.7ns	0.50*	56.1ns	76.2ns	69.5ns
Mix	2.3ns	3.3ns	7.66ns	1.3ns	2.16*	19.88*	28.9ns	12.9ns	2.00ns	0.33ns	1.00ns	0.7ns	0.74*	1.05*	6.17*	3.53*

*: Significant at $p<0.05$, ns: No significant at $p>0.05$, S: Sampling

Table 3: Comparison of redroot pigweed biomass between control treatment (fall tillage with two weedings) and cover crops treatments (two weedings) in different sampling (applying t-test) in 2002

	Redroot pigweed biomass (g m^{-2})			
Treatment	S1	S2	S3	S4
Control	3.8	3.83	3.82	3.95
Mowed				
Rye	5.75ns	6.3ns	6.3ns	5.4ns
Vet.	5.37ns	21.37*	19.95*	5.01ns
Mix	4.26ns	3.95ns	6.3ns	5.37ns
Glyphosate				
Rye	7.94ns	3.89ns	5.01ns	5.37ns
Vet.	19.95*	26.9*	6.3ns	5.01ns
Mix	7.24ns	5.01ns	3.95ns	3.9ns
Harvest				
Rye	10.0ns	3.95ns	5.01ns	5.37ns
Vet.	5.37ns	5.37ns	5.84ns	4.29ns
Mix	6.76ns	3.89ns	5.01ns	5.4ns

*: Significant at $p<0.05$, ns: Non significant at $p>0.05$, S: Sampling

Table 4: Comparison of tomato yield between control (fall tillage with two weedings) and cover crops treatments (applying t-test) in 2001 and 2002

Treatments	Tomato yield (kg ha^{-1}) in 2001	Tomato yield (kg ha^{-1}) in 2002
Control	21020.83	67000.6
Mowed		
Rye	64874.99*	8000.5ns
Vet.	49062.50*	23000.4*
Mix	70583.33*	11000.7ns
Glyphosate		
Rye	49104.16*	14000.7ns
Vet.	68250.00*	15000.8ns
Mix	46166.66*	21000.4ns
Harvest		
Rye	33750.00*	11000.7ns
Vet.	51645.83*	18000.6ns
Mix	42437.50*	21000.4ns

*: Significant at $p<0.05$, ns: Non significant at $p>0.05$

The weed suppression by cover crops dependent on weed species. In this experiment cover crops could not controlled grass weeds and controlled common purslane better than redroot pigweed. Teasdale (1996) mentioned that plant residues acted selectively and inhibited certain weed species emergence, but Tobeh (1999) reported that if rye residue leaching was downwards, there would be 50% reduction in redroot pigweed seedling growth compared to no residues plots. But if rye residues were put over soil surface (without leaching), there was only 11% reduction in density.

Also weed suppression by cover crops dependent on cover crops species and length of decomposition. This study showed that vetch with small biomass production (170 g m^{-2}) and more rapid decomposition compared to rye could not have a considerable effect on weeds. Thus, it seems that to obtain optimum weed control from vetch, it should be mixed with rye. Teasdale and Mohler (1992) described that rye and vetch residues in a no-tillage system reduced weed emergence until biomass increased and also it was mentioned that at the same level of rye and vetch biomass, light transmission and weed density reduction rate were similar. Eric *et al.* (quoted from Tobeh, 1999) showed that rye residues (over 4 t ha^{-1}) inhibited weed emergence and growth for a 12 week period. In another study (Burgos and Talbert, 1996), vetch could not inhibit weed growth until 8 weeks.

We may generally conclude that if cover crops (rye, vetch, rye+vetch) remain as a mulch on the soil surface after they have been harvested, they can prevent the growth and development of some weeds. Although, they require supplemental management, such as cultivation, hand weeding or postemergence herbicides for commercially acceptable weed control.

Tomato yield: In 2001, maximum tomato yield was in mowed treatments of rye and their mixture with over 200% increase of yield compared to control (Table 4). There were 133 and 57% tomato yield increase in the rye glyphosate and harvest treatments respectively compared to control. Mixed cover crops in above mentioned treatments brought 2 times yield compared to control. In vetch, maximum yield was in glyphosate treatment which was 3.25 times of control and in mowed and harvest treatments, tomato yield increased by vetch 133 and 142%, respectively compared to control.

In 2002, only mowed vetch treatment had no significant difference with control. In the other treatments, tomato yield was significantly less than control. It seems that yield reduction in second year, was not due to tomato self-toxicity since it was not shown in control treatment. May be negative effects of cover crops on soil and then on tomato could be considered as the reason.

Acquired results from this study showed increment tomato yield in 2001. There are other observations that indicate main plant yield increment with winter cover crops planting. For example Yenish *et al.* (1996) reported corn yield increment after rye and vetch planting compared to control. Also, in a study (Vaughan and Evanylo, 1998) corn yield increment was attributed to soil humidity preservation by cover crops residues and availability of soil nitrogen which indicated that availability of nitrogen plays more important role to upgrade corn yield potential compared to soil humidity preservation by plant residues. Ranells and Wagger (1996), referred to nitrogen releasing from plant residues as the major reason for main crop yield increment after cover crops planting. Release of nitrogen from rye and vetch monocultures is 35 and 118 kg ha^{-1}, respectively, which can provide part of fertilizer requirement for second planting. Also, in another experiment (Galloway and Weston, 1996) vetch increased sweet corn up to 24%, compared to control. The reason was reported as soil nitrogen increment by vetch. Teasdale (1996) has suggested that in order to reach a sustainable yield, we must integrate a cover crops system with suitable postemergence herbicides. In this case dosage of herbicide would usually be lower than normal.

Generally, it seems that planting winter cover crops is very effective in increasing soil fertility level and second planting yield. It could be considered as a way to achieve sustainable agriculture, particularly in countries like Iran where soils are poor in organic matter and crop rotation should be considered in their farming practice.

ACKNOWLEDGMENTS

The authors wish to thank International Foundation for Science (IFS), Stockholm, Sweden and Organization of Islamic Conference Standing Committee on Scientific and Technological Cooperation (COMSTECH), Islamabad, Pakistan, for support (Grant agreement No. C/3018-1) of this study.

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