



# Assessment of undersown white clover (*Trifolium repens* L.) on organic leek (*Allium porrum* L.) performance (yield and nutrient uptake)

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## ABSTRACT

A one year experiment was conducted to evaluate the influence of undersowing in vegetable fields. The field experiment was established in 2011 at the Hessian State Frankenhäusen research farm of the University of Kassel. In this experiment, randomized block design (RBD) was applied. Undersown (US) white clover (*Trifolium repens* L.) was established either immediately after planting of organic leek (*Allium porrum* L.) or 48 days after transplanting of leek. As second factor, the comparison between mulched and non-mulched system was included. The yield was influenced by mulching of clover. Treatments with mulch showed higher yield (13.6 and 19 t ha<sup>-1</sup>) at the first and second harvests, respectively. Treatment with late undersown (LS) and with mulch produced higher yield (14.3 and 21.3 t ha<sup>-1</sup>) at the first and second harvests, respectively; and at both harvesting time. The experiment shows that treatment with LS and without mulch produced higher dry matter (DM) percentage at the second harvest. DM content was significantly lower at treatment with mulching at the second harvest. The nitrogen (N) uptake for treatment with late undersown (LS) and mulching was significantly higher than other treatments at the second harvest. There is no significant difference for potassium (K) uptake at the second harvest.

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## INTRODUCTION

Losses of biodiversity in monoculture regimes cause problems in cropping systems. During the next 50 years, global agricultural expansion threatens worldwide biodiversity on a huge scale (Hole et al., 2005). Vegetable production in open field, where several crops are harvested per year, is associated with intensive use of chemical fertilizers and pesticides compared with other types of plant production (Müller-Schärer, 1996). Intercropping is considered as a defined technique, which can intensify and diversify the cropping system in time and space attributes (Biabani, 2008; Francis, 1986).

Competition between crop species is one of the factors influencing yield and quality of crops in intercropping systems and crop density is an important parameter affecting competition between intercrop and weeds. Nevertheless, concerns about interference between the vegetable crop and the intercrop have prevented development of intercropping vegetable production systems (Müller-Schärer, 1996).

Leek, *Allium porrum* L. is one of the important vegetable crops in Europe. Leek fields are vulnerable to weed interference and nutrient leaching during its vegetation period, because of open canopy up to harvest. Intercropping in leek fields can be an environmental alternative to conventional production on bare soil, which demands herbicide use (Müller-Schärer, 1996). Intercropping specially for transplanted leeks is a

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non-chemical method, which has a significant effect on weeds, especially in early growing period (Melander and Rasmussen, 2001). In addition, researches show that leek in mono-crop system is more afflicted by pests compared to intercrop system (den Belder et al., 2000).

Organic vegetable production needs extensive planning in advance in order to provide enough soil fertility, nutrient availability and acceptable crop protection. Conventional farming with intensive application of nitrogen (N) fertilizers, cannot exclude significant health risks and environmental damages by increasing the risk of nitrate contamination of ground and surface waters (Buckland et al., 2013). Francis (2009) reported that providing 125 to 225 kg N ha<sup>-1</sup> by the cover crop over several years, which is depending on gathered biomass and mineralization of N and control or minimizing the losses of N to provide for main crop or storage in soil as organic matter, is an objective for a good organic farming practice.

White clover (*Trifolium repens* L.) is known to its high capacity of N fixation due to *Rhizobium leguminosarum*. High values of feeding quality for white clover, transmuted this plant as an interesting plant used as pasture in temperate areas, but more than that, the role of white clover as a cover crop for providing N in the soil (Murray et al., 2002) and also in gathering soluble nutrient is vitally important (Kroeck and Langer, 2011).

In this study, intercropping between leek (*A. porrum* L.) and white clover (*T. repens* L.) is the subject of investigation.

## MATERIALS AND METHODS

The experimental field is located at the Hessian State Estate Frankenhausen, the research farm of the University of Kassel (51° 27' 0" N, 9° 25' 0" E) with 249 m above sea level. According to 30 years average during 1961-1990 the average daily temperature was 8.5°C, the annual precipitation mean is 650 mm a<sup>-1</sup> (German Weather Service). The field soil type is Haplic Chernozem (according to FAO classification). Leek was cultivated without artificial irrigation.

The experiment was established on the 10<sup>th</sup> of July, 2011. Field study was done as a factorial in randomized block design (RBD) (Hoshmand, 2006). The first factor was the comparison between early (immediately after transplanting) and late sowing of the intercrop (48 days after transplanting), and the second factor was the comparison between mulching and non-mulching of the intercrop. The soil was ploughed at March and harrowed by circular harrow at April. Besides that, mechanical weeding was done by rotavator for several times before planting. The plot dimensions were 3 × 4 m (Baumann et al., 2001) while the whole field was 21 × 28 m. The first and second previous crops were grass clover and potato,

respectively. Leeks were transplanted with 10 cm distance from each other in the row (Baumann et al., 2001) and 75 cm distance between the rows. In order to ensure better soil condition for availabilities of water and nutrition during growing season, rotavator was applied two times, two days before transplanting on 10<sup>th</sup> of July. The leeks were bought as organically grown transplants. The organic white clover seeds were applied by 200 kg ha<sup>-1</sup> in two lines in both leek sides and well distributed by hand sowing. The leek was harvested at two dates, 93 and 146 days after transplanting (October 14 and December 6).

Parameters for assessment were fresh matter yield, nutrient content and uptake. Ten plants were harvested from inner rows of a plot at each harvesting date. The dry matter content was measured after a gradual heating at 60 and 105°C. Total N content was determined by Kjeldahl method (Bremner, 1960; Bradstreet, 1965) and P and K were analyzed by using spectrophotometer (Matt, 1970) and flame photometry (Hald, 1947), respectively.

## Statistical analyses

Statistical analyses were carried out by analysis of variance (ANOVA-GLM) by MINITAB 17. LSD test (P≤0.05) was applied for the comparison between the treatments.

## RESULTS

Yield and DM content were measured at both harvesting dates. The yield responded to undersowing system at both harvesting time, 93 and 146 days after transplanting. The mean yield productions were 13.4 and 19 (t ha<sup>-1</sup>) for treatments with mulching at the first and second harvests, respectively. Unlike mulching, date of sowing affected yield production just at the second harvest, 146 days after transplanting. The total were 18.3 (t ha<sup>-1</sup>) for treatments with LS at the second harvest (Table 1).

Differences occurred among treatments regarding the total yield production. For all treatments with each date of sowing, mulching gave a greater increase in yield than treatments without mulch. On the contrary, date of sowing influenced treatments without mulch. In the absence of mulch, LS produced higher yield at both harvesting date. Treatments with LS and with mulching generated the highest amount of yield, 14.3 and 21.3 t ha<sup>-1</sup> at the first and second harvests, 93 and 146 days after transplanting, respectively. Accordingly, delay in presence of US in long term and cutting the clovers in short term created interaction on yield production (t ha<sup>-1</sup>) of leek during growing season (Table 1). The results of leek DM content obtained in this investigation shows that

**Table 1.** Yield production (t ha<sup>-1</sup>) at 93 and 146 days after transplanting.

Treatment	93 days after transplanting		146 days after transplanting	
(A) Mulching				
-M	10.2	b	13.4	A
+M	13.6	a	19	B
(B) Date of sowing				
ES	11.1	n	14	O
LS	12.7	n	18.3	N
(C) A × B				
-M, ES	9.2	v	11.4	V
+M, ES	12.9	u	16.6	UV
-M, LS	11.1	uv	15.3	UV
+M, LS	14.3	u	21.3	U

Means that do not share a letter are significantly different ( $P \leq 0.05$ , LSD test); Individual evaluation per harvest date; -M, without mulching; +M, with mulching; ES, early sowing; LS, late sowing.

**Table 2.** Dry matter content (%) at 93 and 146 days after transplanting.

Treatment	93 days after transplanting		146 days after transplanting	
(A) Mulching				
-M	11.3	a	16.2	A
+M	10.7	a	14.9	B
(B) Date of sowing				
ES	10.8	n	15.4	N
LS	11.2	n	15.7	N
(C) A × B				
-M, ES	10.9	u	16	UV
+M, ES	10.7	u	14.9	V
-M, LS	11.7	u	16.5	U
+M, LS	10.7	u	14.8	V

Means that do not share a letter are significantly different ( $P \leq 0.05$ , LSD test); Individual evaluation per harvest date; -M, without mulching; +M, with mulching; ES, early sowing; LS, late sowing.

the effects of different treatments on DM content were not significant at the first harvesting date of experiment. However, US influenced DM significantly ( $P \leq 0.05$ ) at the second harvesting date. Differences occurred among the treatments with different mulching system. Treatments without mulch created higher DM content (16.2%), 146 days after transplanting. For treatments with any date of sowing, lack of mulch gave an increase in DM content in comparison with treatments with mulch (Table 2). As shown in Table 2, at the second harvest date, treatment with LS and without mulch created highest DM content (16.5%). Existence of mulch significantly reduced DM content to 14.8 and 14.9% in both treatments with LS and ES, respectively.

There were no statistically significant differences among treatments for different date of sowing at both harvesting date, 93 and 146 days after transplanting

(Table 2).

At the first harvest, mulching significantly affected N uptake (mean 29 kg ha<sup>-1</sup>) in leek. There was a clear difference among treatments in N uptake. Leeks from treatments with mulch showed higher N uptake (29 kg ha<sup>-1</sup>) each for ES and LS regimes. No significant effects on N uptake occurred between treatments with different date of sowing at both harvesting date (Table 3). The results in Table 3 indicate that treatment with mulch and LS obtained highest N uptake (51 kg ha<sup>-1</sup>) at the second harvesting date, 146 days after transplanting.

At the first harvest, differences occurred among the treatments regarding the P uptake. For treatments with any date of sowing, mulching gave an increase in P uptake than treatments without mulch (Table 3).

Table 3 illustrates that K uptake (13 and 24 kg ha<sup>-1</sup> at the first and second harvests, respectively) increased

**Table 3.** Nitrogen, Phosphorus and Potassium uptake ( $\text{kg ha}^{-1}$ ) at 93 and 146 days after transplanting.

Treatment	93 days after transplanting						146 days after transplanting					
	N		P		K		N		P		K	
(A) Mulching												
-M	22	b	2	b	8	b	39	A	4.8	A	19	B
+M	29	a	3.2	a	13	a	49	A	4.7	A	24	A
(B) Date of sowing												
ES	26	n	2.5	n	13	n	40	N	4.6	N	21	N
LS	28	n	2.7	n	12	n	50	N	5	N	23	N
(C) A × B												
-M, ES	21	v	1.8	v	9	uv	32	V	3.8	U	18	V
+M, ES	29	u	3.3	u	13	u	48	UV	5.3	U	24	UV
-M, LS	25	uv	2.2	uv	8	v	46	UV	5.9	U	23	UV
+M, LS	30	u	3.2	u	13	u	51	U	4.0	U	25	U

Means that do not share a letter are significantly different ( $P \leq 0.05$ , LSD test); Individual evaluation per harvest date; -M, without mulching; +M, with mulching; ES, early sowing; LS, late sowing.

significantly at both harvesting time over those in leeks treated with mulch. The highest K uptake ( $25 \text{ kg ha}^{-1}$ ) was obtained by treatment with mulch and LS at the second harvesting date, 146 days after transplanting.

## DISCUSSION

The presence of more than one plant in the same area creates competition for environmental resources (Uchino et al., 2009). In the leek field, main crop and clover as US competed with each other for resources such as space and nutrient. Applying living mulch such as clover not only could supply N for main crop, but can increase ecological and biological interactions between plants and soil and help control weeds. The results obtained indicate that yield production in leek field with US regimes was influenced by date of sowing and also by applying mulch for treatments (Table 1). Based on the data, the date of sowing affected the yield production during the time and differed significantly in 146 days after transplanting (LSD,  $P \leq 0.05$ ). It was observed that competition has effect on yield production at 93 days after transplanting, and the differences increased throughout the growing season. Uchino et al. (2009) reported higher grain yield production in treatment with LS for soybean undersown with winter rye, which were US sowed 21 days after the main crop. Table 1 illustrates that, LS with mulch produced higher yield ( $14.3$  and  $21.3 \text{ t ha}^{-1}$  at the first and second harvests, respectively) during growing season. These results are relevant to that of Uchino et al. (2009) about the effect of date of sowing on yield production in maize and soybean intercropping, which was higher in treatments with LS of rye and hairy vetch, when the main crop was established.

This experiment illustrated that interference affected the DM at the second harvest. Treatment with LS and without mulch generated highest DM content (16.5%) at the second harvest while, the differences at the second harvest was not significant. Nassiri and Elgersma (1998) reported that perennial ryegrass and white clover created similar DM at the beginning of season in an intercrop regime with frequent and infrequent cutting treatment but, over the season, DM tend to be significantly higher in white clovers with infrequent cutting regime. Based on the presented data, ES originate decreased in DM during season. Other studies show that competition with other plants will cause decrease in DM content during growing season (Ivany, 1986; Nassiri and Elgersma, 1998).

The results in Table 3 illustrate that N uptake was significantly ( $P \leq 0.05$ ) higher in treatment with mulching application. These data display that mulching, increases the ability of leek to absorb more N especially at the beginning of growing period. Based on data from Table 3, decrease in competition by cutting clovers and applying them as mulch, affected N uptake during growing season. Increase in N fixation by cover crop, create sufficient N at the time of growing season and avoid loss of N to leaching with the use of large amounts of organic matters (Clark et al., 1999). The results in Table 3 show that N uptake did not differ markedly by different treatments at the second harvest in comparison with the first harvest but, treatment with LS and with mulch showed highest N uptake at the second harvest. Booi et al. (1996) also reported less dependency of leek to N for DM support. In line with the results, treatments which had fewer competitors could uptake more N.

From the results obtained, mulching increased K uptake at both harvesting date and this may be as a result of higher temperatures around leek as well as less

competition between leek and clover for absorption of radiation in these plots. Similar facts were reported by Gardner et al. (1985).

## Conclusion

This study illustrates that less competition have effect on total yield production in leek field. Treatment with LS and with mulch produced higher yield ( $21.3 \text{ t ha}^{-1}$ ). Increase in competition and interference between main crop and cover crop increased DM content during growing season. At the second harvest, 146 days after transplanting, treatment with LS and without mulch, produced higher DM content in comparison with other treatments. Mulch affected N uptake for leek as a main crop. It is observed that reducing competition between leek and clover by cutting cover crop especially at the beginning of growing season can affect N uptake in leek. Previous researches reported that N uptake in intercropping system is greater but, it is difficult to identify whether the higher yield was the cause of or due to greater N uptake (Baumann et al., 2001). We have found that applying mulch, increased K uptake at both harvesting dates.

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