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Mulching effects on the yield and quality of garlic as second crop in rice fields

M.B. Mahdieh Najafabadi[a], Gh. Peyvast[a], M. Hassanpour Asil[a], J.A. Olfati[a,*], M. Rabiee[b]

[a]*Affiliated to Horticultural Department, University of Guilan, Rasht, Iran. I.R.*
[b]*Affiliated to National Rice Research Institute, Rasht, Iran. I.R.*
*Corresponding author. E-mail: jamalaliolfati@gmail.com

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Abstract

Plastic mulch increased minimum temperature of soil, accelerated plant height, early growth, early yield, and bring satisfactory weed control without any application of herbicides. This experiment was laid out on three-factorial Randomized Complete Block Design with three replications during 2008-2010 at the National Rice Research Institute, Rasht, Iran using three kinds of mulches (Transparent and black PE and rice straw). Results showed that garlic total yield, bulb ash percent, TSS, vitamin C and flavonoids content were affected by mulching. Although mulching could improved some quality indices in garlic but no effect on forcing was observed. Due to two years experiment and interaction between year and mulches the usage of rice straw in rainy and cool season and plastic mulch in low rain fall and warm season recommended increasing garlic quality as second crop in rice field.

Keywords: Garlic; Mulch; Early yield; Forcing; Second crop.

Introduction

Guilan province with a sub-tropical climate along the Caspian coast has a humid temperate climate with plenty of annual rainfall. Rice is the only crop grown exclusively under irrigation. The long-grain rice of Iran grows primarily in the wet Caspian lowlands in the northern provinces of Guilan and Mazandaran, where heavy rainfall facilitates paddy cultivation. After harvesting rice farm land remains unused. Several vegetable as second crops in rice field can provide productivity and bring farm profits to the farmers. But because of interfering between the main and second crops, all kind of vegetables are not suitable for this purpose.

Garlic is primarily grown for its cloves used mostly as a food flavoring condiment. But many producers in northern Iran cultivated this crop for its leaves to prepare different local dishes (Olfati et al., 2010). Therefore many farmers cultivated garlic in rice farm after harvesting without any limitation for next rice transplanting. The only problem can be caused by harvesting of whole plant in next spring. Thus, any guidelines of garlic forcing such as the using different mulches is necessary.

Many producers use plastic mulch in horticulture due to several benefits such as beneficial microbial activity in the soil, increasing soil temperature, evaporation reduction, increasing root development, promoting faster crop development and observing earlier harvest. The main negative consequence of its usage is disposal of waste and the associated environmental impact (Lamont, 1993).

Plastic mulch gave satisfactory weed control without any application of herbicides (Mahajan et al., 2007). Black and white polythene mulch or organic mulch are a reasonable expense and conserve soil moisture (Mukherjee et al., 2004). Polythene mulch also increases soil temperature and moisture especially in early spring. These synthetic mulches reduce weed problems and certain insect pests and also stimulate higher crop yields by more efficient utilization of soil nutrients (Rhu et al., 1990; Kashi, et al., 2004). Mulching with plant residues and synthetic materials is a well-established technique for increasing the profitability of many horticultural crops (Duranti and Cuocolo, 1989; Gimenez et al., 2002). Such effects are mainly contributed to the capacity of mulch to conserve soil moisture (Vavrina and Roka, 2000). Kwon et al. (2011) investigate the effects of mulching by transparent polyethylene and net polyethylene on the growth of garlic. Plant height and leaf number of garlic were highest at transparent polyethylene treatment and this treatment also promoted the number of cloves.

Garlic is sensitive to moisture stress and high temperature and found about 60% reduction in yield when it was associated with water stress (Miko et al., 2000). Walters (2008) compared garlic produced on bare soil during the winter and wheat (*Triticum aestivum*) straw mulch in the spring to black plastic. Black plastic provided greater winter protection for garlic (95% survival rate) compared with bare soil (85% survival rate). Greater marketable weights and bulb diameters resulted when garlic was grown in black plastic compared with the bare soil/wheat straw mulch treatment. Islam et al. (2007) reported that the effect of black polyethylene and water hyacinth mulch were almost similar on the growth and yield of garlic. They proposed that the water hyacinth and black polyethylene mulch were suitable for increasing garlic production. Karaye and Yakubu (2006) indicated that the number of leaves/plant, weed growth and cured bulb yield responded significantly to mulching and they based on their results for optimum bulb yield in garlic proposed the using of 9 t/ha mulch. The use of water-hyacinth root, rice straw and dried grass as mulches was evaluated for their effects on the growth and yield of late planted garlic in Baten et al. experiments (Baten et al., 1995). Plants treated with any kind of mulches under study significantly increased plant height, number of leaves per plant, length of leaf, length of pseudo stem, number of roots per plant, bulb and neck diameter over the control (Baten et al., 1995). These mulches significantly influenced both on chlorophyll-a and chlorophyll-b contents. Bulb length, bulb diameter, clove length, clove diameter, clove number per bulb, 100 clove weight and yield were also significantly higher in plants treated with mulches. All mulches provided weed control as well.

The objective of this study was to determine the effects of different organic and inorganic mulches on growth, yield, and quality of garlic when used as a second crop in rice field.

Materials and Methods

The experiment was conducted at the National Rice Research Institute, Rasht, Iran, during 2008-2010 Table 1 refer to rainfall and temperature during experiment months in this region. It was laid out on three-factorial Randomized Complete Block Design with three replications. Three mulches (Transparent and black PE and rice straw) excluding a control treatment were either used for whole season. A local variety of garlic was used 600 Kg/ha in this experiment (Suthar, 2009). All cultural practices were adopted as recommended for this region. The cloves were planted on November 5, 2008 and 2009, with a distance of 0.45×0.10 m between rows and plants and harvested on 20 May 2009 and 2010 before rice cultivation (Muro et al., 2000). The observations recorded during these studies were, temperature at 10 centimeter soil depth, bulb and neck diameter and their ratio (Forcing characteristics); bulb weight and yield were also recorded.

Table 1. Temperatures and rainfall at garlic planting site.

Month	Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May.	
	2008	2009	2008	2009	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Rainfall (mm)	178.9	170.0	238.4	94.7	149.0	47.9	66.2	127.5	27.3	89.8	133.0	74.4	44.9	140.0
Temperature (°C) Max.	17.4	18	14.1	15.0	9.6	14.3	12.8	10.2	15.9	13.7	16.8	16.2	22.2	21.0
Temperature (°C) Min.	10.5	10.7	5.9	5.9	2.2	7.3	4.9	3.5	5.8	7.7	6.0	8.3	12.8	14.0

Dry matter was determined by drying at 75±5 ^{o}C until samples reached constant weight (AOAC, 1984). Total soluble solid contents (TSS) were determined by squeezing the tissue and placing one drop of juice from each sample into a refractometer (Atago HSR-500, Tokyo, Japan).

Ascorbic acid was determined according to the 2,6-dichlorophenolindophenol dye method (Ranganna, 1997). Fresh samples (10 g) were extracted by grinding in a mortar and pestle and 3% metaphosphoric acid (v/v) as a protective agent. The extract was made up to a volume of 100 mL and centrifuged at 3,000 g for 15 min at room temperature. Ten-mL were titrated against 2,6-dichlorophenolindophenol dye which had been standardized against standard ascorbic acid. Results were expressed as mg/100 g on a fresh weight (FW) basis.

Methanol extracts of sample (1 g sample in 10 cc methanol) were used for determination of total phenolics. Total phenolic content was evaluated by colorimetric analyses using Folin-Ciocaltaue's phenol reagent (Singleton and Rossi, 1965). The total phenolics content was expressed as mg galic acid equivalent/100 g of sample.

The free radical-scavenging activity against DPPH radical was evaluated with the methods of Leonge and Shui (2002) and Miliouskas et al. (2004) with minor modification. In the presence of an antioxidant, the purple color intensity of DPPH solution decays and the change of absorbance are followed spectrophotometrically at 517 nm.

Acetone solvent was used to determine the percentage of lipid in garlic samples. Protein were determined in samples of 0.5 g dry weight by the Kjeldhal method using concentrated H_2SO_4, K_2SO_4, and $CuSO_4$ to digest the sample. Measurement of total flavonoids was performed according to method Bozin et al. (2008).

Data were subjected to analysis of variance in SAS (SAS, Inc., Cary, NC). If interactions were significant they were used to explain the data. If interactions were not significant means were separated with tukey test.

Results and Discussion

All kind of mulching by this experiment had affected total yield, bulb ash percent, TSS, vitamin C and flavonoids content (Table 2). Black and transparent polyethylene putted in different classes when separated with Tukey test. Black polyethylene mulch reduce yield while other treatments didn't have any significant differences. Black polyethylene effect on soil temperature (Table 3) and the differences can be related to this characteristic (Lamont, 1993). All type of mulches that used in this research increase bulb ash percent, TSS and Vit. C in garlic samples while mulching reduce flavonoids content (Table 4).

Table 2. ANOVA table of affects of year and mulches on garlic measured characteristics.

S.O.V.	d.f.	Total yield ($t{\cdot}ha^{-1}$)	Corm yield ($t{\cdot}ha^{-1}$)	Corm mean weight (g)	Harvesting index (Corm yield/ Total yield)	Corm dry matter (%)	Leaf dry matter (%)
Year	1	59.54**	96.80**	3180.90**	1537.28**	110.90**	2.17^{ns}
R (year)	4	7.19	9.01	35.66	22.75	2.98	0.89
Mulch	3	27.10*	27.06*	146.79^{ns}	47.13^{ns}	7.48^{ns}	4.46^{ns}
Year×mulch	3	8.05^{ns}	17.14*	131.08^{ns}	110.14*	38.60*	2.30^{ns}
Error	12	5.69	18.28	54.44	21.23	8.07	2.35
C.V. (%)		14.71	16.75	15.32	10.33	10.31	15.93

^{ns}, **, *: non significant and significant at P≤0.01 and P≤0.05 respectively.

Table 2. Continue.

S.O.V.	d.f.	Corm ash (%)	Leaf ash (%)	TSS (^{o}Brix)	Protein (g/100 g FW)	Lipid (%)	Antioxidant (% DPPH reduction)
Year	1	1.13**	8.52*	0.43^{ns}	1.48^{ns}	0.03^{ns}	5.10*
R (year)	4	0.04	2.13	12.98	0.33	0.08	0.59
Mulch	3	0.71**	3.64^{ns}	41.85**	0.47^{ns}	0.16*	1.01^{ns}
Year×mulch	3	0.36*	9.86**	0.40^{ns}	0.90^{ns}	0.26**	4.97**
Error	12	0.10	1.53	3.94	0.66	0.03	0.70
C.V. (%)		8.70	16.67	9.50	14.30	16.64	14.05

^{ns}, **, *: non significant and significant at P≤0.01 and P≤0.05 respectively.

Table 2. Continue.

S.O.V.	d.f.	Vit. C (mg/100 g FW)	Total phenol (mg/100g FW)	Flaveonoids (mg/100g FW)	Corm neck diameter to corm diameter ratio
Year	1	0.06^{ns}	1.06^{ns}	2.33**	3.39**
R (year)	4	0.07	0.34	0.02	0.18
Mulch	3	0.28**	0.20^{ns}	0.92**	0.23^{ns}
Year×mulch	3	0.001^{ns}	0.19^{ns}	0.04^{ns}	0.22^{ns}
Error	12	0.04	0.26	0.12	0.08
C.V. (%)		8.99	15.36	15.85	10.50

^{ns}, **, *: non significant and significant at P≤0.01 and P≤0.05 respectively.

Table 3. Temperatures under different mulches.

Month	Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May.	
	2008	2009	2008	2009	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Control	15.0	15.5	9.5	8.5	5	9	7.5	6.5	10	10	11.5	12	15.5	17
Rice straw	15.0	15.5	10.0	9.7	7	10.0	8	7.5	11	10	12	12.5	15.8	17
Black PE	15.0	15.5	11.0	10.3	7	11	8	7.5	12.5	10.5	12.5	13.5	18.0	18.5
Transparent PE	15.0	15.0	11.5	10.8	8	11.4	8.7	8.1	12.8	10.7	12.8	13.6	18.0	18.5

Table 4. Effects of mulches on total yield, corm ash, TSS, Vitamin C and flavonoids in garlic.

Mulches	Total yield ($t{\cdot}ha^{-1}$)	Corm ash (%)	TSS (^{o}Brix)	Vit. C (mg/100g FW)	Flaveonoids (mg/100g FW)
Control	15.26^{ab}	3.33^{b}	17.5^{b}	1.93^{b}	19.80^{a}
Rice husk	17.42^{ab}	3.48^{ab}	20.12^{ab}	2.21^{ab}	7.10^{b}
Transparent polyethylene	18.46^{a}	3.77^{ab}	22.98^{a}	2.44^{a}	15.24^{ab}
Black polyethylene	13.73^{b}	4.12^{a}	23.00^{a}	2.32^{ab}	7.26^{ab}

Values in a column followed by the same letter are not significantly different.

Interaction between year and mulches on corm yield showed that the highest corm yield was obtained in transparent polyethylene mulch in first year but the highest corm yield in second year was obtained in rice husk mulch (Table 5). These results are similar to results obtained by Kwon et al. (2011). Surprisingly, in second year transparent polyethylene reduce yield in comparison to control. Considering the data on interactions between year and mulch on harvesting index showed the similar results. Walters (2008) in the same report stated that the black mulch is better than the transparent polyethylene.

Table 5. Influence of different mulches and year interaction on some measured characteristics.

Year	Mulch	Corm yield ($t{\cdot}ha^{-1}$)	Harvesting index (Total yield/ Corm yield) (%)	Corm dry matter (%)	Corm ash (%)
1	Control	8.62±0.57	51.22±2.38	29.03±4.20	3.23±0.47
1	Rice husk	9.70±1.76	51.29±3.04	33.38±1.24	3.40±0.35
1	Transparent polyethylene	11.70±1.92	54.79±2.87	28.79±0.26	3.67±0.21
1	Black polyethylene	7.50±2.10	53.17±3.75	27.65±4.99	3.53±0.06
2	Control	5.47±0.87	40.56±9.73	23.01±1.90	3.43±0.38
2	Rice husk	7.12±0.43	44.51±1.31	22.66±1.43	3.57±0.15
2	Transparent polyethylene	4.81±0.95	31.10±2.17	28.48±1.47	3.87±0.31
2	Black polyethylene	4.05±0.54	30.27±5.87	27.49±1.53	4.70±0.20

Table 5. Continue.

Year	Mulch	Leaf ash (%)	Lipid (%)	Antioxidant (%DPPH reduction)
1	Control	5.93±1.86	1.00±0.69	25.64±2.94
1	Rice husk	6.43±1.76	1.15±0.56	43.74±23.47
1	Transparent polyethylene	9.13±1.40	1.31±0.95	27.20±1.17
1	Black polyethylene	5.83±1.26	4.21±1.43	28.03±2.47
2	Control	8.47±0.23	1.98±0.32	38.43±10.35
2	Rice husk	9.87±0.95	2.10±0.29	23.75±11.31
2	Transparent polyethylene	6.73±0.90	0.50±0.28	55.97±2.29
2	Black polyethylene	7.03±1.26	1.32±0.90	53.55±5.71

Interaction between year and mulches on corm dry matter showed that the highest corm dry matter was obtained from organic mulch (rice straw) and inorganic mulch (black and transparent polyethylene) in first and second year respectively. Inorganic mulches also was resulted the highest corm ash percent in both years. Leaf ash percent showed that the highest leaf ash was obtained in transparent polyethylene mulch in first year but the highest leaf ash in second year was obtained in rice straw mulch. Lipid percent showed that the highest amount was obtained in black and transparent polyethylene mulch in first year but the highest lipid in second year was obtained in rice straw. Inorganic mulches reduce lipid percent in comparison to control. The highest antioxidant capacity was obtained in rice straw mulch in first year whereas in second year in both plastic mulch. Organic mulches reduce antioxidant capacity in comparison to the control. Data related to interaction between year and mulches on other traits don’t show any significant differences.

As mention above, the results of two cultivated years were different. Garlic is a sensitive plant to water and high temperature stress (Miko et al., 2000). In first year the higher rainfall (658.8 mm) in comparison to second year (574.3 mm) and lower mean temperature (10.7 ^{o}C) compaired to second year (11.4 ^{o}C) lead to better results with inorganic mulch while in second year rice straw without high temperature negative effect lead to better results.

The values of soil temperatures with mulching are much higher than those of soil without mulching (Table 3). This may be owing to mulching prevents cooling of the soil surface due to evaporation. Sunlight passes through the transparent plastic and heats the soil. A layer of water on the underside of the plastic retains the radiant heat at night through what is known as a greenhouse effect. Black plastic mulch absorbs most of the sunlight energy and becomes greatly warmed, but little energy passes through to warm the soil (Hopen, 1964; Maged, 2006) so transparent polyethylene mulch increased soil temperature more than black polyethylene.

Although mulching improve some quality indices in garlic but different mulch had no effect on plant forcing so one of the problems ahead for the cultivation of garlic as a second crop in rice filed to be maintained that must be resolved in future researches so due to above results and discussion we recommended the use of rice husk mulch in rainy and cool years while in low rain fall and warm years we recommended the use of inorganic mulch to increase garlic quality.

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