Revista Agro@mbiente On-line, v. 9, n. 1, p. 1-7, janeiro-março, 2015
Centro de Ciências Agrárias - Universidade Federal de Roraima, Boa Vista, RR
www.agroambiente.ufrr.br
DOI: 10.5327/Z1982-8470201500012073

Artigo Original

ISSN 1982-8470

Soil covering in organic cultivation of onion cultivars

Cobertura de solo em cultivo orgânico de cultivares de cebola

Leonardo Barreto Tavella[1]*, Regina Lúcia Felix Ferreira[2], Sebastião Elviro de Araújo Neto[3], Antônio Jussie da Silva Solino [4] Eliana Mara Napoli Corrêa de Paula da Silva[5], Maísa Pinto Bravin[6]

Abstract: The soil preparation in horticulture, including organic, is characterized by intense soil tillage, which increases energy costs and unbalanced the environment. The organic system in onion cultivation has shown satisfactory results, however the soil covering use tends to improve the cultivation environment and may result in higher yields. The objective of this work was to evaluate the performance of onion cultivars in organic cultivation under different soil coverages. The experiment was conducted in the period of April to October of 2009, under protected cropping, in the experimental area of the horticulture sector of the Universidade Federal do Acre (UFAC), in Rio Branco, Acre, Brazil. A randomized block design was adopted, in a split-plot arrangement, the plots being comprised of soil coverings: coffee bean husks, grass straw (Brachiaria decumbens); dessicated bamboo leaves (Bambusa spp.) and uncovered soil (control treatment), and the subplots comprised of three onion cultivars (IPA 10, IPA 11 and IPA 12), with four repetitions. The variables analyzed were total bulb yield (t ha^{-1}), marketable bulb yield (t ha^{-1}), fresh mass of the bulb (g $bulb^{-1}$), classification of the bulbs and loss of mass as a function of storage time. There was no interaction effect between the soil coverings and the cultivars. Cultivars IPA 10 and IPA 11 showed greater agronomic performance of the studied variables. The soil coverings did not affect the yield and average mass of the bulbs under organic cultivation. The three cultivars presented more than approximately 70% of the bulbs in class 2 and a maximum of 5% of unmarketable bulbs. The loss of mass after 49 days of storage was 10% independent of the cultivar or soil covering.

Key words: *Allium cepa*. Organic agriculture. Sustainability.

Resumo: O preparo do solo na olericultura, incluindo a orgânica, caracteriza-se por intenso revolvimento do solo, o que aumenta os gastos com energia e desequilibra o ambiente. O cultivo de cebola em sistema orgânico tem mostrado resultados satisfatórios, todavia o uso de cobertura do solo tende a melhorar o ambiente de cultivo, podendo resultar em maior produtividade. O objetivo deste trabalho foi avaliar o desempenho de cultivares de cebola em cultivo orgânico sob diferentes coberturas do solo. O experimento foi conduzido no período de abril a outubro de 2009, em cultivo protegido, na área experimental do setor de olericultura da Universidade Federal do Acre (UFAC), em Rio Branco, Acre, Brasil. Adotou-se delineamento experimental em blocos casualizados, com arranjo em parcelas subdivididas, sendo as parcelas constituídas pelas coberturas de solo: casca de café, palha de gramínea (Brachiaria decumbens); folha de bambu dessecada (Bambusa spp.) e solo descoberto (tratamento controle), e as subparcelas constituídas pelas três cultivares de cebola (IPA 10, IPA 11 e IPA 12), com quatro repetições. As variáveis analisadas foram produtividade total de bulbos (t ha^{-1}), produtividade comercial dos bulbos (t ha^{-1}), massa fresca do bulbo (g $bulbo^{-1}$), classificação dos bulbos e perda de massa em função do tempo de armazenamento. Não houve efeito da interação entre as coberturas do solo e as cultivares. As cultivares IPA 10 e IPA 11 apresentaram maior desempenho agronômico para as variáveis estudadas. As coberturas do solo não afetaram o rendimento e a massa média dos bulbos sob cultivo orgânico. As três cultivares apresentaram mais de 70% dos bulbos na classe 2 e até 5% de bulbos não comerciais. A perda de massa após 49 dias de armazenamento foi de 10% independentementeda cultivar e da cobertura do solo.

Palavras-chave: Agricultura orgânica. *Allium cepa*. Sustentabilidade.

*Corresponding author
Send to publication in 07/07/2014 and approved in 10/12/2014.
[1]Adjunct Professor, Universidade Federal do Acre, Campus Floresta, Cruzeiro do Sul, AC, Brazil, leo_tavella@hotmail.com
[2]Adjunct Professor, Universidade Federal do Acre, Campus Universitário, Rio Branco, AC, Brazil reginalff@yahoo.com.br;
[3]Associated Professor, Universidade Federal do Acre, Campus Universitário, Rio Branco, AC, Brazil, selviro2000@yahoo.com.br
[4]PhD Student, Post-graduated Program in Agronomy, Universidade Estadual de Maringá, Maringá, PR, Brazil, jussiesolino@hotmail.com
[5]Agricultural Engineer, Secretaria de Assistência Técnica e Produção Familiar, Rio Branco, AC, Brazil, eliananapoli@hotmail.com
[6]PhD Student, Post-graduated Program in Agronomy, Universidade Federal do Acre, Rio Branco, AC, Brazil, maisabravin@gmail.com.

INTRODUCTION

The onion (*Allium cepa* L.), among the various cultivated species of the genus Allium, has greater prominence on volume of world production and is the second most valuable vegetable crop in the world, second only to tomatoes (ABDELMAGEED; GRUDA, 2009). In Brazil, the culture ranks third in economic importance, with 17.88 t ha^{-1} average productivity (NUNES *et al.*, 2014; SOUZA; RESENDE, 2002).

This crop requires high technological levels to achieve the greatest fiscal and economic productivity, including ecological technology that cause less entropy, especially in new areas, where agroeconomic streamlining is still possible, to meet the environmental requirements and the food quality demands for the consumer (VILELA *et al.*, 2005).

The cultivation of onion is gaining popularity in producing regions, however few studies with this organic production system have been conducted (VIDIGAL *et al.*, 2010). According Resende *et al.* (2010) organic cultivation make it possible to achieve superior productivity than that of conventional agriculture using chemical fertilizer, especially when one uses adapted cultivars. It is required to adjust the technologies, mainly with the application of organic waste that provides the necessary nutrients for the growth of the plants, as well as the physical protection of the soil.

Despite the beneficial effect of mulch soil covering in the reduction of weed infestation (SILVA *et al*., 2009), in the reduction of soil temperature (OLIVEIRA *et al.,* 2005), in nutrient availability (OLIVEIRA *et al*., 2008), in the increase of the microbial biomass of the soil (WANG *et al*., 2008; LEE, 2010) and in improved water economy (OLIVEIRA *et al*., 2005; MOTA *et al*., 2010), the effect of the use of soil coverings on crop production depends on three other factors: the physical, chemical and biological traits of the material (SEDIYAMA *et al*., 2011) that can increase the productivity of vegetables (LEE, 2010). Thus, it is advisable that the use of mulch soil covering must be regionally adapted, and that, in addition to being technically possible, must be economically viable.

In the cultivation of chives (condiment), Araújo Neto *et al*. (2010) observed that productivity was 43% higher in soil covered in weed mulch than in uncovered soil. Sediyama *et al*. (2011) founded an increase of 20% in the productivity of beets in soil covered with coffee bean husks. It is demonstrated in both cases that the use of mulch had a beneficial effect on the production of vegetables.

Given the difficulty of producing onion in the state of Acre, due to a lack of technical information about the onion crop cultivation system, absence of onion cultivars adapted to the region and level of applied technology, this study aimed to evaluating the performance of onion cultivars in organic cultivation under different soil coverings in protected environment.

MATERIAL AND METHODS

The experiment was conducted in the horticulture sector of the Universidade Federal do Acre (UFAC), in Rio Branco, Acre, Brazil (9°25' to 10°30' S latitude, 67°00' to 67°50' W longitude and altitude of 150 m), km 05, BR-364, in the period of April to October 2009.

The climate of the region is characterized by an average annual temperature varying from 18 ºC in the coldest month to 24,5 ºC in the warmest month; the average yearly precipitation is 1,915 mm, mostly concentrated in the rainy season which lasts from December to May, and the relative humidity of the air is 85% (ACRE, 2010). The soil, classified as *Argissolo Vermelho-Amarelo plíntico* (Ultisol Plinthic), presents the following chemical attributes at a depth of 0-20 cm: pH=5.6; Ca^{2+}=1.6 $cmol_c dm^{-3}$; Mg^{2+}=1.2 $cmol_c dm^{-3}$; K^+=54 mg dm^{-3}; Al^{3+}=1$cmol_c dm^{-3}$; H^++Al^{3+}=1.89 $cmol_c dm^{-3}$; SB=2.93 $cmol_c dm^{-3}$; CTC a pH 7=4.83 $cmol_c dm^{-3}$; Organic Carbon=10.71 g kg^{-1}; $P_{(Mehlich-1)}$= 6 mg dm^{-3}; V= 58%.

The experimental design was a randomized complete block design (RCBD), in a split-plot arrangement, with the main plots consisting of the soil covering: coffee bean husks, grass straw (*Brachiaria decumbens*), dessicated bamboo leaves (*Bambusa spp*) and uncovered soil (control treatment), and the subplots consisting of three cultivars of onion (Franciscana IPA 10, Vale Ouro IPA 11 and Brisa IPA 12), with four repetitions. A split-split plot design was used for the variable loss of mass, including storage time (7, 14, 21, 28, 35, 42 e 49 days after harvest) as a sub-subplot, rated lamp 20 for repetition.

The experimental plot measured 1.2 x 1.8 m, the plant spacing was 0.2 m between rows and 0.15 m between plants, and are used as 20 onion plants per plot.

For the production of seedlings, they were used up 128 cells with three seeds for onion per cell, subsequently conducting thinning at 11 days after the sowing and transplanting to the final beds at 40 days after sowing.

The composition of the substrate used in the trays followed equal measures of organic soil, organic compost and rice husks (incinerated), adding 10% charcoal (pulverized), 1.0 kg m^{-3} of limestone and 1.5 kg m^{-3} of natural thermophosphate.

Two days before transplanting the seedlings to the protected environment, bed survey was done manually at a height of 0.20 m, using a manual hoe. Fertilization of the beds was made with compost prepared from alternating layers of desiccated brachiaria, hardened bovine manure and poultry manure, naturally decomposed and possessing the following composition: N=1.13%; P=1.33%; K_2O=0.18%;

Ca=3.36%; Mg=0.20%; S=0.10%; pH=6.55; M.O.=11.97%; Ash=88.61%; Density (g ml)= 0.87; C/N ratio= 6.11.

After transplanting, the onion plants were arranged in six lines per bed with 0.20 m between lines and 0.15 m between plants.

The planting fertilization consisted of 30 t ha^{-1} of base organic compost, and at 25 days after transplanting the biofertilizer "Super Magro" was applied, followed by two more applications throughout the crop cycle in 15 day intervals in 2,315 L ha^{-1} doses.

The irrigation system was a micro-sprinkler type, with an application rate of 6 mm day^{-1}, during the entire crop cycle, except in the last week of the cycle, the irrigation was suspension to facilitate the curing process.

Pest and disease control took place as necessitated by infestations, and, in accordance with the needs of the crop, it was doing two applications of lime sulfur and two applications of Bordeaux mixture alternately. To control invasive plants hand weeding were carried in the plots.

The harvest was carried out 114 days after sowing, when the plants showed advanced signs of senescence, such as yellowing and drying of the leaves, and more than 70% of the plants were "snapped". The curing was carried out in the sun for 3 days in the case of vegetation and 10 days in the shade inside a ventilated shed.

The variables analyzed were: the average fresh mass of the bulb (g bulb^{-1}), determined by dividing the marketable mass of bulbs after curing by the number of marketable bulbs harvested in each plot; total yield with harvest and weighing all of the bulbs useful area of the plots; the marketable yield with harvesting and weighing all of the bulbs useful area of the plots, after the removal of the external leaves that showed yellow coloration or some type of injury. Subsequently, the total and marketable yield of the useful area of the plots was estimated to t ha^{-1}.

The marketable bulb classification according to transversal diameter (mm) of the most compact part was done in accordance with the Ministry of Agriculture, Livestock and Food Supply (MAPA, 1995), expressed as a percentage (%).

The loss of mass (%) started after the end of curing, being evaluated for a period of approximately 50 days, spaced once every 7 days; that is to say, weekly loss of mass was used as the marketable yield initial weight, soon after curing, in order to determine the decrease as a function of curing time. First week: ((P0-P1)/P0)*100); second week: (((P1-P2)/P1)*100), in which P0 is the initial weight and P1 is the final weight.

The results obtained in this experiment were subjected to the Grubbs Test to identify outliers, the Shapiro and Wilk test to verify the normality of the variances, and to the Bartlett Test to verify the homogeneity of the variances. An analysis of variance was used in order to test significance ($p \leq 0.05$) of treatment effects, and Tukey's test ($p \leq 0.05$) was used to compare the means for the qualitative factor and regression analysis for the quantitative factor (loss of mass).

RESULTS AND DISCUSSION

In a general sense, covering soil with straw did not promote an effect in the agronomic performance of the cultivars evaluated when compared with uncovered soil in all variables (Table 1). The beneficial effect provided by the soil covering, such as reduction in weed infestation (SILVA *et al*., 2009), reduction of soil temperature (OLIVEIRA *et al*., 2005), greater nutrient availability (OLIVEIRA *et al*., 2008), greater microbial biomass (WANG *et al.,* 2008) and greater water economy (OLIVEIRA *et al*., 2005; MOTA *et al.*, 2010), which promote greater yield in other crops like chives (ARAÚJO NETO *et al*., 2010) and beets (SEDIYAMA *et al*., 2011), did not translate into better performance for onion. The use of a protected environment, the residual effect of the succession of organic management in the area and the efficient control of irrigation may have neutralized the effect of the soil coverings.

Although no significant differences were observed between the coverages, as well as its interaction with the other factors evaluated, it is needed to consider that in cultivation with uncovered soil, combined with own structure of the onion plant (thin and erect leaves), there is an increase in demand for water (irrigation) and greater need for control of weeds (labor) in the entire cycle, and these factors may result in increased cost of production.

The soils coverages provided a total yield average of 15.32 t ha^{-1}, where it has remained slightly below the crop average, can possibly be explained by the interval and dose of biofertilizer applied in cover.

Tabela 1 - Summary of the analysis of variance for total yield, marketable yield and fresh mass of bulbs of onion. Experimental campus of Universidade Federal do Acre, Rio Branco, Acre, Brazil, 2009

Source of variation	DF	Total yield		Marketable yield		Fresh mass of bulbs	
		MS	F	MS	F	MS	F
Soil coverings (A)	3	11537913.2	0.81 ^{ns}	11443717.4	1.17 ^{ns}	310.01	1.44 ^{ns}
Cultivars (B)	2	31872394.7	10.60**	31666507.9	10.60**	337.44	13.24**
A x B	6	1289881.9	0.43 ^{ns}	1279273.6	0.43 ^{ns}	31.46	1.23 ^{ns}

^{ns}: not significant; **significant at 1%; *significant at 5%; MS: medium square ; F: F calculated; DF: degree of freedom.

Resende *et al*. (2010) obtained a yield varying between 10.15 t ha^{-1} (cv. Red Creole) and 33.58 t ha^{-1}(Bahia F1) in an organic system, however with a high quantity of fertilizer (75 t ha^{-1} of tanned hardened bovine manure and 5.6 t ha^{-1} of Yoorin®, plus 240 L of "Super Magro" in 3 cover applications). According to Swift e Woomer (1993), the organic fertilizers are of great importance, especially in soils in tropical climates, where organic material decomposes quickly, rapidly reducing the content of these materials.

Mendonça *et al*. (2003), to study mulch coverings in the production of white onion for canning, in the cultivation conditions of the Brazil Central, identified a marked difference between the cultivars, with cv. Beta Cristal being more productive than cv. Diamante, regardless of the soil covering.

The total yield varied between cultivars independent of soil cover, where the cultivar IPA 11 (Vale Ouro) had the best performance, however this did not differ significantly from IPA 10 (Franciscana) and this was similar to cv. IPA 12 (Brisa) (Table 2).

Costa *et al.* (2008), researching the performance of cultivars of onion in an organic system, in contrast to this study, have observed that the cultivar IPA 12 was more productive than the cultivars IPA 11 and IPA 10. This differing behavior is explained by Paula *et al*. (2008) as they assert that generally the cultivars are evaluated in regions with different edapho-meteorological characteristics, so that a mostly productive performance does not carry over into other regions, especially when one changes the planting season, as was the case in this work. The capacity of the cultivars to endure environmental variation could contribute significantly to the evaluation and future recommendation of these cultivars.

The soil coverings did not statistically influence the marketable yield of bulbs of onion cultivars. The cultivar IPA 11 (Vale Ouro) showed the best results and did not differ from cv. IPA 10 (Franciscana), which was similar to cv. IPA 12 (Brisa) (Table 2). In general, the results of marketable yield of bulbs are close to the national average and have a low number of rejected bulbs, demonstrating promising potential for organic cultivation in the conditions of Rio Branco.

Considering the marketable yield aspect, Duarte *et al.* (2003) also obtained the best results with the cultivars IPA 11 (Vale Ouro) and IPA 10 (Franciscana), showing a great adaptation and cultivation viability of these materials in the conditions of Piauí's semi-arid. Costa *et al.* (2008) assert that in an organic system there is significant variation among onion cultivars, with marketable yield ranging between 7.45 t ha^{-1} and 38.32 t ha^{-1}, especially with the cultivars Brisa IPA 12 (38.32 t ha^{-1}) and São Paulo (35.86 t ha^{-1}), and the cultivars Conquista (7.45 t ha^{-1}) and Crioula Alto Vale (7.81 t ha^{-1}) present themselves as the least productive.

The soil coverings had no effect on the fresh mass of the bulbs. The difference in the average fresh mass of the bulbs became evident among the cultivars, with an average of 49.13 g bulb^{-1} for cv. IPA 11 did not differ from IPA 10, with an average of 46.73 g bulb^{-1}, which did not differ statistically from IPA 12, with an average of 42.05 g bulb^{-1}, less than cv. IPA 12 (Table 1). According to Souza and Resende (2002), the more elevated temperatures, especially in the initial phase of the plant, promote accelerated early bulb formation and more rapid maturation (smaller bulbs) that decrease yield. According to the same authors, bulb formation will only be good if the temperature is favorable to the cultivar planted.

The mass of bulbs below those observed in the other studies with onions can be explained by EPAGRI (2000), observing that, when the onion is cultivated in agroecological systems, the spacing should be greater than those conventionally used, as the lower population density provides greater ventilation in the crop canopy, less shadowing and less competition for nutrients, water and light, rendering them stronger, more resistant to leaf diseases, ergo increasing the growth of the bulbs. However, Resende *et al.* (2003) report that in the practice of consumer preference it is for smaller bulbs, those that are used in their entirety at one time when consumed raw and last longer as a result of the lower moisture content.

In regards to the commercial classification of the bulbs (Figure 1), the 3 cultivars IPA 10, 11 and 12 fall completely within the consumer market in terms of bulb transversal diameter, as more than 70% of the bulbs of the 3 cultivars presented a diameter between 35 and 50 mm (class 2), this size being the minimum for commercial classification (MAPA, 1995).

Tabela 2 - Total yield, marketable yield and fresh mass of bulbs as function onion cultivars. Experimental campus of Universidade Federal do Acre, Rio Branco, Acre, Brazil, 2009

Cultivars	Total yield	Marketable yield	Fresh mass of bulbs
	---------------- (kg ha^{-1}) ---------------		(g bulb^{-1})
IPA 11	16.38 a	16.20 a	49.13 a
IPA 10	15.57 ab	15.49 ab	46.73 ab
IPA 12	14.02 b	13.30 b	42.05 b
CV	12.28%	15%	12.28%

*Averages followed by the same letter in columns do not differ statistically among themselves by the Tukey Test at 5% probability.

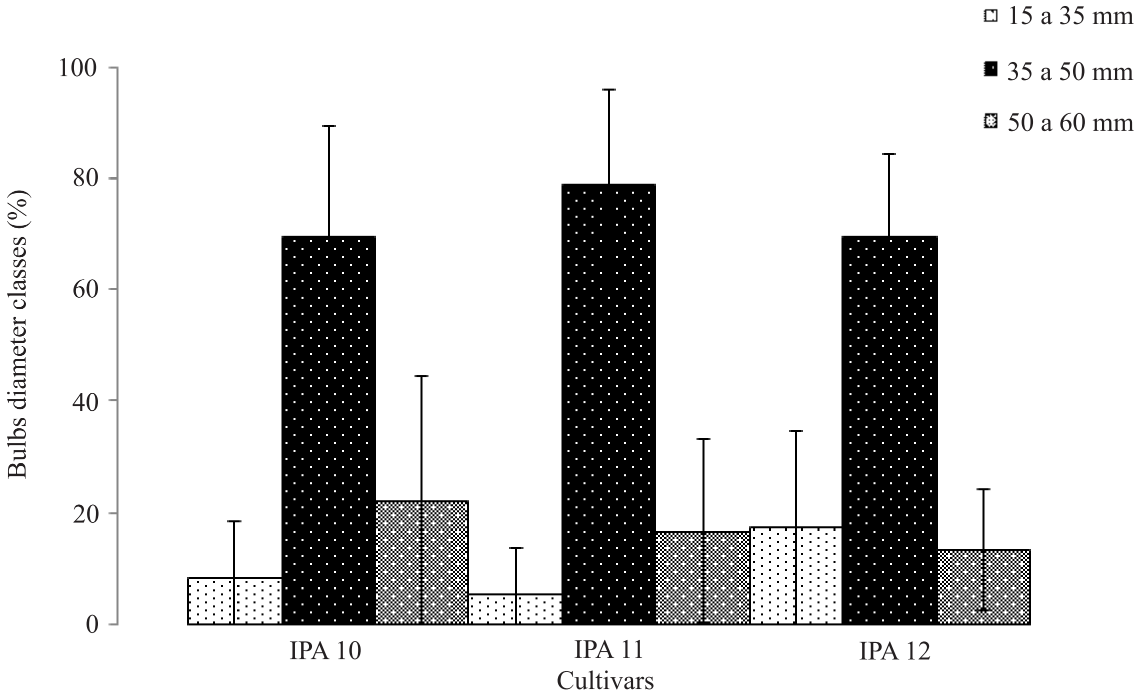

Figure 1 - Classification of the bulbs of the cultivars according to transversal diameter. Experimental campus of Universidade Federal do Acre, Rio Branco, Acre, Brazil, 2009.

There was no difference in the yield by class among the cultivars, however cultivar IPA 10 (Fanciscana) had 20% of its bulbs classified as class 3 (bulbs 50 to 60 mm), followed by cultivar IPA 11 (Vale Ouro) with a yield of 10% of bulbs in class three. This class with larger bulbs achieves higher prices in the market (VIDIGAL *et al*., 2010).

Cultivar IPA 12 (Brisa) presented the largest percentage of rejected bulbs (5%). The frequency distribution of the diameter classes of the bulbs in response to each cultivar is shown to be practically similar (Figure 1). The bulbs called "cigars or toothpicks" are sold at half of the market price, and thus 20% of one truckload may be complete with these bulbs, according to Souza and Resende (2002). This fact is clearly observed in the street markets of the region.

As for bulb transversal diameter, all of the cultivars are acceptable, without exception. "Reddish yellow" bulbs are preferred by the consumer (IPA 11 - Vale Ouro and IPA 12 - Brisa), but there is a specific consumer market, governed by a series of factors and liked to buying power and regional culture. In Belo Horizonte and Rio Janeiro, for example, there is a slight tendency to buy onions with a purple or purplish coloration (IPA 10 - Franciscana). The national consumer with the increase in buying power, having had contact with imported produce, is in an accelerated process of change regarding the demand for quality, discarding irregular produce on the basis of color, shape and size. (SOUZA; RESENDE, 2002).

The loss of the bulbs mass was not influenced by soil coverings and did not show significant difference among the cultivars, being affected only by storage time. Around 10% of the mass of the bulbs was lost in 49 days, a daily loss rate of 0,164% was observed (Figure 2).

The loss of mass observed during the first days of storage probably resulted from the greater loss of water in the external films (curing) and from the injuries sustained during the process of cleaning the bulbs and cutting the shoots (toilet). Resende and Costa (2006) observed similar behavior for the onion cultivar Texas Grano, being influenced only by storage time. Moreover, the mass loss of the bulbs during storage varies among the cultivars

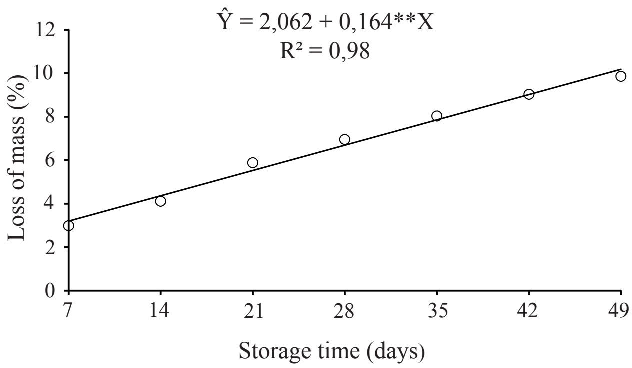

Figure 2 - Loss of mass of the bulbs (%) as a function of storage time (days); **significant 1% probability. Experimental campus of Universidade Federal do Acre, Rio Branco, Acre, Brazil, 2009.

onion and these are less marked when adopts the organic cultivation system (RESENDE *et al*., 2010).

The physiological rot may be related to the curing process that has as an end goal the loss of excess water, drying the external films (husks) and reducing the intensity of rot (SOUZA; RESENDE, 2002). The same authors report that this activityrenders the bulbs more resistant to damage and the entrance of microorganisms, increasing the storage time. In Brazil, it is estimated that losses can reach approximately 40 to 50% of the yield.

In general, the weight loss has a larger influence of time of the bulbs remain stored, and significant losses begin to be observed after 40 days of storage (RESENDE *et al*., 2008), while after 3 months storage Menezes Junior and Vieira Neto (2012) obtained 54% of mass loss.

CONCLUSIONS

The soil coverings did not affect the yield and average mass of the bulbs.

The cultivars IPA 11 and IPA 10 were the best in yield and average bulb mass.

Cultivars of onion and soil coverings do not influence the mass loss of the bulbs until 49 days of storage.

ACKNOWLEDGEMENTS

The granting of onion seeds, courtesy of the researcher at Embrapa Semi-Árido, Geraldo Milenez de Resende.

CIENTIFIC LITERATURE CITED

ABDELMAGEED, A.H.A.; GRUDA, N. Influence of grafting on growth, development and some physiological parameters of tomatoes under controlled heat stress conditions. **European Journal of Horticultural Science**, v. 74, p. 16-20, 2009.

ACRE. Governo do Estado do Acre. **Zoneamento Ecológico-Econômico do Acre Fase II (**Escala 1:250.000): 2. ed. Rio Branco: SEMA, 2010. 356 p.

ARAÚJO NETO, S. E.; GALVÃO, R.O.; FERREIRA, R. L. F.; PARMEJIANI, R. S.; NEGREIROS, J. R. S. Plantio direto de cebolinha sobre cobertura vegetal com efeito residual da aplicação de composto orgânico. **Ciência Rural**, v. 40, n. 5, p. 120-1209, 2010.

COSTA, N. D.; ARAUJO J. F.; SANTOS C. A. F.; RESENDE, G. M.; LIMA, M. A. C. Desempenho de cultivares de cebola em cultivo orgânico e tipos de solo no Vale do São Francisco. **Horticultura Brasileira**, v. 26, n. 4, p. 476-480, 2008.

DUARTE, R. L. R.; VELOSO, M. E. C.; MELO, F. B.; SOBRINHO, C. D.; RIBEIRO, V. Q.; SILVA, P. H. S. Produtividade de cultivares de cebola no Semi-árido piauiense. **Horticultura Brasileira**, v. 21, n. 1, p. 34-36, 2003.

EPAGRI. **Sistema de produção para cebola.** 3. ed. Santa Catarina: Florianópolis, 2000. 91 p.

LEE, J. Effect of application methods of organic fertilizer on growth, soil chemical properties and microbial densities in organic bulb onion production. **Scientia Horticulturae**, v. 124, n. 3, p. 299-305, 2010.

MENDONÇA, J. L.; ARAGÃO, F. A. S.; OLIVEIRA, V. R. Produção de cebola branca para conserva em solo com cobertura morta, nas condições de cultivo do Distrito Federal. **Horticultura Brasileira**, v. 21, n. 2, p. 325-326, 2003.

MENEZES JÚNIOR, F. O. G.; VIEIRA NETO, J. Produção da cebola em função da densidade de plantas. **Horticultura Brasileira**, v. 30, n. 4, p. 733-739, 2012.

MINISTÉRIO DA AGRICULTURA PECUÁRIA E ABASTECIMENTO (MAPA). **Classificação e padronização dos bulbos de cebola**. Portaria n. 529 de agosto 1995.

MOTA, J. C. A.; LIBARDI, P. L.; BRITO, A. S.; ASSIS JÚNIOR, R. N.; AMARO FILHO, J. Armazenagem de água e produtividade de meloeiro irrigado por gotejamento, com a superfície do solo coberta e desnuda. **Revista Brasileira de Ciência do Solo**, v. 34, n. 5, p. 1721-1731, 2010.

NUNES, R. L. C.; OLIVEIRA, A. B.; DUTRA, A. S. Agronomic performance of onion hybrids in Baraúna, in the semi-arid region of Brazil. **Revista Ciência Agronômica**, v. 45, n. 3, p. 606-611, jul-set, 2014.

OLIVEIRA, F. F.; GUERRA, J. G. M.; ALMEIDA, D. L.; RIBEIRO, R. L. D.; ESPINDOLA, J. A. A.; RICCI, M. S. F.; CEDDIA, M. B. Avaliação de coberturas mortas em cultura de alface sob manejo orgânico. **Horticultura Brasileira**, v. 26, n. 2, p. 216-220, 2008.

OLIVEIRA, M. L.; RUIZ, H. A.; COSTA, L. M.; SCHAEFER, C. E. G. R. Flutuações de temperatura e umidade do solo em resposta à cobertura vegetal. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v. 9, n. 4, p. 535-539, 2005.

PAULA, J. T.; FARIA, M. V.; GOUVEIA, A. M. S.; BAIER, J. E.; GALVÃO, A. G.; MACHADO, M. M.; RESENDE, J. T. V.; NASCIMENTO, I. R.; MENEZES, C. B. Adaptabilidade de cultivares de cebola em Guarapuava-PR. In: CONGRESSO BRASILEIRO DE OLERICULTURA, 48, 2008. **Resumos...** Maringá: SUB (CD-ROM). 2008.

RESENDE, G. M.; CHAGAS, S. J. R.; PEREIRA, L. V. Características produtivas de cultivares de cebola no Sul de Minas Gerais. **Horticultura Brasileira**, v. 21, n. 4, p. 722-725, 2003.

RESENDE, G. M.; COSTA, N. D. Produtividade e massa fresca de bulbos de cebola sob densidades de plantio no Vale do São Francisco. **Horticultura Brasileira**, v. 24, n. 2, p. 228-232, 2006.

RESENDE, G. M.; COSTA, N. D.; PINTO, J. M. Produtividade e qualidade pós-colheita de cebola adubada com doses crescentes de nitrogênio e potássio. **Horticultura Brasileira**, v. 26, n. 3, p. 388-392, 2008.

RESENDE, J. T. D.; MARCHESE, A.; CAMARGO, L. K. P.; MARODIN, J. C.; CAMARGO, C. K.; MORALES, R. G. F. Produtividade e qualidade pós-colheita de cultivares de cebola em sistemas de cultivo orgânico e convencional. **Bragantia**, v. 69, n. 2, p. 305-311, 2010.

SEDIYAMA, M. A. N.; SANTOS, M. R.; VIDIGAL, S. M.; SALGADO, L. T. Produtividade e exportação de nutrientes em beterraba cultivada com cobertura morta e adubação orgânica. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v. 15, n. 9, p. 883-889, 2011.

SILVA, A. C.; HIRATA, E. K.; MONQUERO, P. A. Produção de palha e supressão de plantas daninhas por plantas de cobertura, no plantio direto do tomateiro. **Pesquisa Agropecuária Brasileira**, v. 44, n. 1, p. 22-28, 2009.

SOUZA, R. J.; RESENDE, G. M. **Cultura da cebola**. Lavras: UFLA, 2002. 115 p. (Textos Acadêmicos - Olericultura, 21).

SWIFT, M. J.; WOOMER, P. Organic matter and the sustainability of agricultural systems: definitions and measurement. In: MULUNGOY, K.; MERCKX, R. (eds.). **Soil organic matter dynamics and sustainability of tropical agriculture**. Leuven: Wilei-Sayceco., 1993.p. 3-18.

VIDIGAL, S. M. Produtividade de cebola em cultivo orgânico utilizando composto à base de dejetos de suínos. **Horticultura Brasileira**, v. 28, n. 2, p. 168-173, 2010.

VILELA, N. J. Desafios e oportunidades para o agronegócio da cebola no Brasil. **Horticultura Brasileira**, v. 23, n. 4, p. 1029-1033, 2005.

WANG, Q.; BAI, Y.; GAO, H.; HE, J.; CHEN, H.; CHESNEY, R. C.; KUHN, N. J.; LI, H. Soil chemical properties and microbial biomass after 16 years of no-tillage farming on the Loess Plateau, China. **Geoderma**, v. 144, n. 4-5, p. 502-508, 2008.