

# Green manure, *Trichoderma asperellum* and homeopathy in cultivating the biquinho pepper<sup>1</sup>

## Adubação verde, *Trichoderma asperellum* e homeopatia no cultivo da pimenta biquinho

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**ABSTRACT** - The aim of this work was to study the effects of green manure, *Trichoderma asperellum* and homeopathy on the agronomic performance of the biquinho pepper (*Capsicum chinense* Jacq.). The design was of randomised blocks with four replications, in subdivided plots, with homeopathic remedies applied in the plots: 1) *Arnica montana* 6CH; 2) *Pulsatilla nigricans* 6CH; and 3) no homeopathic remedies; and seven treatments applied in the sub-plots: 1, 2 and 3) *Crotalaria juncea* 'IAC-KR-1' (sunn hemp P50 D25, P50 D50, and P0 D50); 4) *Canavalia ensiformis* (common jack-bean P0 D25); 5) *Cajanus cajan* 'IAPAR 43 Aratã' (pigeon-pea 00 D25); 6) *Trichoderma asperellum*; and 7) control (with no green manure or *T. asperellum*). The green manure was sown at a density of 25 kg ha<sup>-1</sup> (D25) and 50 kg ha<sup>-1</sup> (D50) when transplanting the biquinho pepper (P0) and 50 days prior to transplanting (P50). The stem height and diameter, relative chlorophyll index, normalised difference vegetation index (NDVI), and fruit production were evaluated in the biquinho pepper. The intercrop with sunn hemp, sown 50 days before transplanting at a density of 50 kg ha<sup>-1</sup>, increased the height of the pepper plant by 8%, added 0.47 kg ha<sup>-1</sup> dry biomass to the system, and showed similar productivity to the control treatment. The pepper plants treated with *Pulsatilla nigricans* 6CH were taller and had a larger stem diameter, with an increase of 11% and 6% respectively. Homeopathy had no influence on productivity in the pepper. *T. asperellum* brought no benefits to the biquinho pepper.

**Key words:** *Capsicum chinense* Jacq. Fabaceae. Agricultural microbiology. *Pulsatilla nigricans*.

**RESUMO** - Objetivou-se com este trabalho estudar os efeitos da adubação verde, *Trichoderma asperellum* e da homeopatia no desempenho agrônômico da pimenta biquinho (*Capsicum chinense* Jacq.). O delineamento foi em blocos casualizados com quatro repetições, em parcelas subdivididas, sendo na parcela aplicação dos medicamentos homeopáticos: 1) *Arnica montana* 6CH; 2) *Pulsatilla nigricans* 6CH; 3) e sem medicamento homeopático; e na sub-parcela 7 tratamentos: 1, 2 e 3) *Crotalaria juncea* 'IAC-KR-1' (crotalária-juncea P50 D25; P50 D50; e P0 D50), 4) *Canavalia ensiformis* cultivar comum (feijão-de-porco P0 D25), 5) *Cajanus cajan* 'IAPAR 43 Aratã' (guandu-anão P0 D25), 6) *Trichoderma asperellum*; e 7) controle (sem adubo verde e sem *T. asperellum*). A densidade de sementeira dos adubos verdes foi 25 kg ha<sup>-1</sup> (D25) ou 50 kg ha<sup>-1</sup> (D50), juntamente com o transplante da pimenta biquinho (P0) ou 50 dias antes do transplante (P50). Avaliaram-se a altura e diâmetro do caule das plantas de pimenta biquinho, o índice relativo de clorofila, o índice de vegetação por diferença normalizada (NDVI) e a produção de frutos. O consórcio com crotalária-juncea, semeada 50 dias antes do transplante na densidade de 50 kg ha<sup>-1</sup>, aumentou em 8% a altura da pimenteira, adicionou 0,47 kg ha<sup>-1</sup> de fitomassa seca ao sistema, e apresentou produtividade semelhante ao tratamento controle. As pimenteiros tratadas com *Pulsatilla nigricans* 6CH ficaram mais altas e apresentaram maior diâmetro de caule, com incremento de 11% e 6%, respectivamente. A homeopatia não influenciou na produtividade da pimenta. *T. asperellum* não trouxe benefícios à pimenta biquinho.

**Palavras-chave:** *Capsicum chinense* Jacq.. Fabaceae. Microbiologia agrícola. *Pulsatilla nigricans*.

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## INTRODUCTION

Cultivation and consumption of the biquinho pepper (*Capsicum chinense* Jacq.) has grown significantly in Brazil due to the crispness of the fruit, the sweet aroma and lack of pungency (HEINRICH *et al.*, 2015). It is grown all over the country, and produced almost exclusively by small and medium producers or family farmers, who can sell the fruit either fresh or processed (such as jams, canned or dehydrated), adding greater value to the product.

The introduction of techniques that favour biological processes and provide greater productivity per unit area is important for ecological and economic sustainability. As such, green manure is a conservationist practice in which plants are cultivated and then kept under cover or incorporated into the soil, contributing to its protection, water retention, temperature reduction, improvement of the physical, chemical and biological characteristics, and the control of spontaneous plants (GUARESCHI; PEREIRA; PERIN, 2012; PERIN *et al.*, 2010; TEODORO *et al.*, 2011). Fungi of genus *Trichoderma* can also benefit the development of crops of economic interest, acting as growth promoters, and contributing to nutrient availability and the solubilisation of phosphates (CHAGAS *et al.*, 2017; FRANCE *et al.*, 2017). In addition, *Trichoderma* spp. has the potential for inducing resistance in the plant and acting as a biological control agent (SANTOS *et al.*, 2012).

The application of homeopathic science to agriculture is also a highly viable technology in the productive system, and has been studied as an aid to plant health and development (STANGARLIN, 2020). It can be used to balance an agricultural system based on homeopathic remedies that pose no risks to the environment (MÜLLER; MEINERZ; CASAGRANDE, 2009), in addition to being a simple and accessible technology for small-scale producers. Homeopathic remedies act by stimulating plant defences to attack by pests and pathogens (MARTINEZ *et al.*, 2014), and contribute to an increase in biomass and crop production (SILVA *et al.*, 2012). The homeopathic remedy *Arnica montana* is indicated for application in organisms showing hypersensitive behaviour to traumatic conditions, while the remedy *Pulsatilla nigricans* is more related to environmental factors such as light, temperature, climate change, long periods of rain and excess water, and sudden changes in temperature (MAUTE, 2015).

Therefore, the aim of this work was to study agroecological techniques, such as green manure, inoculation with *Trichoderma*, and the application of homeopathic remedies, on agronomic performance and quality in the biquinho pepper.

## MATERIAL AND METHODS

The experiment was conducted from January to September 2018, in Pirassununga, São Paulo, in an area located at 21°59' S and 47°26' W.

The experimental design was of randomised blocks with four replications, in subdivided plots. The plots comprised treatments with homeopathic remedies: 1) *Arnica montana* 6CH; 2) *Pulsatilla nigricans* 6CH; and 3) no homeopathic remedy (NHR), while the subplots had seven treatments: 1, 2 and 3) *Crotalaria juncea* 'IAC-KR-1' (sunn hemp P50 D25; P50 D50; and P0 D50); 4) *Canavalia ensiformis* (common jack-bean P0 D25); 5) *Cajanus cajan* 'IAPAR 43 Aratã' (pigeon-pea 00 D25); 6) *Trichoderma asperellum*; and 7) control (with no green manure or *T. asperellum*). The green manure was sown at a density of 25 kg ha<sup>-1</sup> (D25) and 50 kg ha<sup>-1</sup> (D50) when transplanting the biquinho pepper (P0) and 50 days prior to transplanting (P50).

The soil was classified as a Eutrophic Red Latosol with a clayey texture (EMBRAPA, 2013). Chemical analysis of the 0-20 cm layer gave the following results: pH in water 5.85; P = 105.24 mg dm<sup>-3</sup>; S = 4.35 mg dm<sup>-3</sup>; K = 2.79 mmol<sub>c</sub> dm<sup>-3</sup>; Ca = 46.44 mmol<sub>c</sub> dm<sup>-3</sup>; Mg = 10 mmol<sub>c</sub> dm<sup>-3</sup>; H+Al = 24.23 mmol<sub>c</sub> dm<sup>-3</sup>; SB = 59.22 mmol<sub>c</sub> dm<sup>-3</sup>; CEC = 83.61 mmol<sub>c</sub> dm<sup>-3</sup>; V = 71% and OM = 29.26 g kg<sup>-1</sup>.

The beds were prepared with the aid of a tractor and bedder with a width of 1.2 m. Each block comprised three beds (plots), with each sub-plot 5 m in length, spaced 1 m apart. The green manure was sown in two rows (one on each side of the beds), and the pepper plants were transplanted to the middle, with five plants per sub-plot, spaced 1 m apart.

The species of pepper used was *Capsicum chinense* 'BRS Moema' from Embrapa, with the seedlings produced by the 'IBS Mudas' nursery in Piracicaba, São Paulo, in a substrate of coconut fibre. After 38 days of development, the seedlings were transferred to a 50-cell tray containing an organic substrate. At 45 DAS, *T. asperellum* was inoculated into the substrate of those plants that corresponded to the treatment, at a concentration of 1 x 10<sup>7</sup> conidia mL<sup>-1</sup>. The spores were obtained by multiplication, aseptically transferring 5 mm disks of potato dextrose-agar (PDA) culture medium containing *T. asperellum* to petri dishes with BDA culture medium, sterilised by autoclaving. The dishes were sealed and kept in a BOD incubator at 27 °C under a photoperiod of 12 hours for 15 days. The seedlings were kept in a greenhouse until transplanted in the field, and were irrigated daily.

The holes for the pepper plants in each treatment were 30 cm deep, to which 40 g of Yoorin Master® and

200 g of organic compost were added and incorporated into the soil. Thermophosphate, in addition to phosphorus (16%  $P_2O_5$ ), also contains 18% calcium (Ca), 7% magnesium (Mg), 0.10% boron (B), 0.05% copper (Cu), 0.30% manganese (Mn), 10% silicon (Si) and 0.55% zinc (Zn).

The sunn hemp treatments (P50, D25 and P50, D50) were sown on 10 January 2018 and cut at 55 DAS (days after sowing) with the aid of pruning shears, around 60 cm from the ground. The biomass was arranged on the soil surface around the pepper plants, which were transplanted the same week. The sunn hemp (P0 D50), jack bean (P0 D25) and pigeon pea (P0 D25) treatments were sown during the first week of March, at the same time as transplanting the pepper plants.

After transplanting the pepper plants, the remaining fertilisation was carried out by the addition of 250 mL plant<sup>-1</sup> earthworm humus distributed over the surface of the soil within the canopy projection at 33 DAT (days after transplanting); the application of Agrucon® mineral fertiliser as a source of micronutrients by backpack sprayer onto the leaves at a concentration of 2 g L<sup>-1</sup> at 40 and 173 DAT; and the addition of potassium using wood ash, distributing 15 g plant<sup>-1</sup> at 57 DAT.

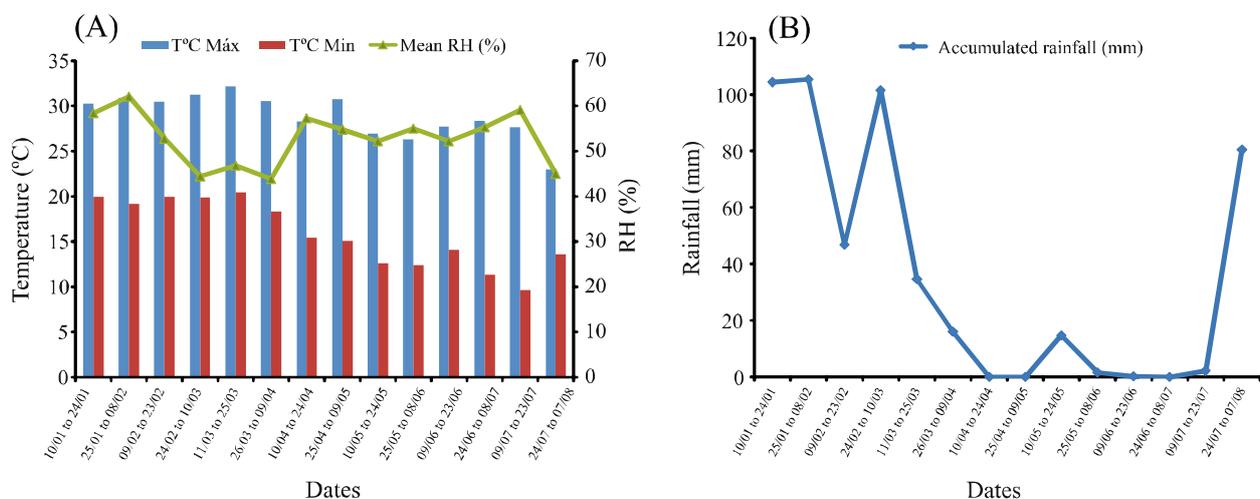
The maximum and minimum temperatures during the experimental period are shown in Figure 1a. The end of May and early June saw the lowest temperatures. The accumulated rainfall is shown in Figure 1b. There was a large amount of rain until the end of March, which then decreased and almost stopped by July. During this period the crop was irrigated.

Irrigation was based on a system of two lines of integrated and non-compensating drip tubes per bed, with a flow of 2.3 L h<sup>-1</sup> and emitters spaced every 0.70 m. Irrigation management included estimating the crop evapotranspiration (ETc) using a class A pan installed at a weather station near the area of cultivation of the biquinho pepper. To calculate the ETc, the values were corrected by the crop coefficient (Kc) at the different stages, as proposed by the Food and Agriculture Organisation of the United Nations (2008). The irrigation frequency was every two days.

Spontaneous vegetation was controlled by manual weeding. The green manure, sunn hemp P50 D25, P50 D50, P0 D50; jack-bean P0 D25 and pigeon-pea 00 D25 were managed at flowering, at 91, 91, 59, 48 and 76 DAS respectively, corresponding to 41, 41, 64, 53 and 79 DAT the pepper plants respectively. The green manure was cut close to the ground with the aid of scissors, the biomass being weighed and then redistributed around the pepper plants. When managing the green manure, two plants from each treatment were collected, weighed on an analytical balance, placed in a drying oven with forced air ventilation at 65 °C to constant weight, and then weighed to determine the dry matter.

The homeopathic remedies were purchased from a homeopathic pharmacy, dynamised to 5CH (centesimal Hahnemannian) in 30% hydroalcoholic solution. *Arnica montana* and *Pulsatilla nigricans* were dynamised to 6CH in distilled water on the days of application. The value of 6CH was chosen due to the positive results in other studies using this dynamisation (FRANCE *et al.*, 2017; PULIDO *et al.*, 2017; STANGARLIN, 2020).

**Figure 1** - Maximum and minimum temperatures and relative humidity (a), and accumulated rainfall (b) from January to August 2018. Data obtained from the Agrarian weather station (FZEA-USP), 2018



The 30% hydroalcoholic solution was diluted to 1% in deionised water, succussed and used as the control (NHR). The dynamisation procedure was carried out following the instructions of the Brazilian Homeopathic Pharmacopoeia (FARMACOPEIA, 2011). The trial was conducted using a double-blind system, with the treatments identified by numbers and unknown to the experimenter. The treatments were diluted to 0.5 mL L<sup>-1</sup> in water and applied every two weeks by manual sprayer over the entire length of the beds close to the root system of the pepper plants, as per Pulido *et al.* (2017), between 08:00 and 09:00 up to 161 DAT, to give a total of 10 applications.

At 65 DAT, the *T. asperellum* was reinoculated into the subplots corresponding to this treatment, this time in the field. The spores were applied to the soil, close to the root system of the plants, and due to the field conditions, a higher concentration, of 1.0 x 10<sup>8</sup> conidia mL<sup>-1</sup>, was used (FRANCE *et al.*, 2017).

The biometric data of the pepper plants were evaluated every two weeks starting at 19 DAT, using the three central plants of each sub-plot. The height was measured from the soil surface to the apex of the plant with a tape measure, and the diameter 3 cm from the ground, using a digital calliper. A reading was also taken of the leaf chlorophyll index using a Falker® ChlorofiLOG CFL 1030 electronic meter, on the first leaf of the plant counting from the apex of the branch. A GreenSeeker® sensor was used to determine the NDVI (Normalised Difference Vegetation Index), which is an indirect measure of plant vigour.

For the harvest, three working pepper plants were chosen per sub-plot, with the mature (red) fruit harvested manually every 10 to 15 days, depending on maturity. The first harvest took place at 67 DAT and the last at 208 DAT, totalling 13 harvests.

At 100 DAT, soil samples were taken from each sub-plot and sent to the Soil Analysis Laboratory, FZEA-USP, for chemical analysis.

The values for the variables under analysis (plant height, stem diameter, RCI and NDVI) were submitted to analysis of variance using the SISVAR statistical software (FERREIRA, 2011); when significant differences were detected between treatments, the mean values were compared by the Scott-Knott test at 5% probability. Regression analysis was carried out whenever there was an effect from the time factor.

## RESULT AND DISCUSSION

There was no interaction between the treatments (green manure and *T. asperellum*) and the homeopathic remedies over time (evaluation period), for any of the variables under analysis. There was an interaction between the treatments (green manure and *T. asperellum*) and the homeopathic remedies for the variables height, diameter, normalised difference vegetation index (NDVI) and relative chlorophyll index (RCI). There was also an interaction between the treatments (green manure and *T. asperellum*) and time for height, diameter and NDVI.

The sunn hemp treatments P50 D50 and P50 D25, sown 50 days before transplanting the biquinho pepper, stood out with the highest production of fresh (SFM) and dry matter (SDM) (Table 1).

In relation to SFM (fresh biomass), the jack bean treatment P0 D25 produced more than the crotalaria-juncea P0 D50 and pigeon-pea 00 D25. However, for SDM the three treatments did not differ (Table 1). Photoperiod and temperature are probably the factors that influenced the superiority of the two treatments sown in January. As crotalaria, jack bean and pigeon pea are sensitive to

**Table 1** - Shoot fresh matter (SFM) and shoot dry matter (SDM) in green manure grown intercropped with biquinho pepper, managed at flowering and used as cover

Treatment	Period	Density	SFM		SDM	
			----- kg m <sup>-2</sup> -----			
Sunn hemp	P50	D25	1.69 a		0.43 a	
Sunn hemp	P50	D50	1.83 a		0.47 a	
Sunn hemp	P0	D50	0.81 c		0.28 b	
Jack bean	P0	D25	1.33 b		0.30 b	
Pigeon pea	P0	D25	0.94 c		0.35 b	
CV(%)			16.14		18.61	

Mean values followed by different letters in a column differ by Scott-Knott test ( $p < 0.05$ ). P50: sown 50 days before transplanting the biquinho pepper; P0: sown immediately after transplanting the biquinho pepper; D25: sowing density of 25 kg ha<sup>-1</sup>; D50: sowing density of 50 kg ha<sup>-1</sup>

the photoperiod, the three treatments sown later were hampered, and produced a smaller quantity of biomass.

Leal *et al.* (2012), also found similar sensitivity when sowing and managing *crotalaria juncea* at different times, obtaining the least biomass production in late plantings, which took place at the end of the summer. When exposed to short days, flowering in *crotalaria* is induced, interrupting vegetative development (DUKE, 1983). The ideal mean temperatures for development in pigeon pea are between 20 and 30 °C. From March onwards, temperatures below this range were recorded.

From analysis of the biometric characteristics of the pepper plants, stem height and diameter, evaluated every two weeks, were influenced by the interaction between the treatments (green manure or *T. asperellum*) and the homeopathic remedies (Table 2).

Pepper plants without the application of homeopathic remedies showed greater height when intercropped with sunn hemp P50 D50, as did the plants that received *Arnica montana*, when intercropped with *crotalaria* P50 D50. For pepper plants treated with *Pulsatilla nigricans*, the effect of intercropping with sunn hemp P50 D50 and jack-bean P0 D25, and with no intercropping (control) was the same, and superior to the other plants. In pepper plants inoculated with *T. asperellum*, the application of *Arnica montana* afforded greater height, in contrast to França *et al.* (2017), who found no interaction between homeopathic remedies (Phosphorus 6CH and *Carbo vegetabilis* 6CH) and *Trichoderma* isolates when evaluating phosphate solubilisation and growth promotion in the cherry tomato.

For stem diameter, the presented trend does not follow that seen for height. Pepper plants that did not receive green manure and were not inoculated with *T. asperellum* achieved thicker stems, both with and without the application of the homeopathic remedies. In the case of the plants treated with *Arnica montana*, the intercrop with sunn hemp P50 D50 also afforded a larger stem diameter (Table 2).

Where there was no effect from the green manure (control), the pepper plants treated with *Pulsatilla nigricans* were taller and had a larger stem diameter, with an increase of 11% and 6% in relation to the No Homeopathic Remedy (NHR) treatment respectively. *Pulsatilla* may have acted on the plants by helping to overcome or mitigate climate change and full-sun conditions during development.

Positive results related to homeopathy were also found by Pulido *et al.* (2014), who noted the efficiency of *Arnica montana* 6CH and Sulphur 6CH in increasing dry weight, height, stem diameter and plant productivity in the cabbage. Silva *et al.* (2012), found that the application of *Pulsatilla nigricans* favoured the growth of soybean shoots at dynamisations of 6, 12, 18, 24 and 30CH. Pulido *et al.* (2017), obtained an increase in stem diameter, root length, and shoot and root dry matter in broccoli plants treated with *Silicea terra* 30CH, an increase in the fresh and dry matter of the inflorescences of plants treated with Sulphur 6CH, and an increase in plant height with the application of *Silicea terra* 6CH, *Carbo vegetabilis* 30CH and Sulphur 30CH.

The mean values for height in pepper plants intercropped with green manure or *T. asperellum*

**Table 2** - Plant height and stem diameter in the biquinho pepper evaluated every two weeks until 161 days after transplanting, submitted to the application of homeopathic remedies (6CH) and grown intercropped with green manure or *Trichoderma asperellum*

Treatment	NHR	<i>Arnica montana</i>	<i>Pulsatilla nigricans</i>	NHR	<i>Arnica montana</i>	<i>Pulsatilla nigricans</i>
	----- Height (cm plant <sup>-1</sup> ) -----			----- Diameter (mm plant <sup>-1</sup> ) -----		
SH P50 D25	32.45 Db	34.11 Ba	33.73 Ba	9.34 Db	10.03 Ca	9.86 Ca
SH P50 D50	37.02 Aa	37.62 Aa	36.73 Aa	11.04 Bb	11.87 Aa	10.88 Bb
SH P0 D50	31.52 Db	32.37 Cb	34.13 Ba	8.87 Eb	8.79 Eb	9.66 Ca
JB P0 D25	32.67 Da	30.11 Db	32.49 Ca	9.56 Da	8.45 Ec	8.98 Db
PP P0 D25	35.53 Bb	34.95 Bb	36.79 Aa	10.30 Cb	9.35 Dc	10.92 Ba
<i>T. asperellum</i>	33.41 Cb	34.41 Ba	32.58 Cb	11.31 Ba	10.93 Ba	10.72 Ba
Control	33.61 Cb	32.21 Cc	37.35 Aa	11.81 Ab	11.40 Ab	12.54 Aa
CV(%)	13.87			17.65		

Mean values followed by different uppercase letters in a column and lowercase on a row differ by Scott-Knott test ( $p < 0.05$ ). NHR: No homeopathic remedy; SH P50 D25, sunn hemp sown 50 days before transplanting (DAT) the biquinho pepper, at a density of 25 kg ha<sup>-1</sup>; SH P50 D50, sunn hemp sown 50 DAT at a density of 50 kg ha<sup>-1</sup>; SH P0 D50, sunn hemp sown immediately after transplanting the biquinho pepper, at a density of 50 kg ha<sup>-1</sup>; JB P0 D25, jack bean sown immediately after transplanting; PP P0 D25, pigeon pea sown immediately after transplanting

showed a positive linear response as a function of time (Figure 2) up to 161 days. There was a significant difference between treatments, especially for greater height in plants intercropped with sunn hemp P50 D50, with an increase of 8.30% compared to the control, and smaller heights with sunn hemp P0 D50 and jack-bean P0 D25.

Although the jack bean was sown at the same time as transplanting the biquinho pepper, its development is faster than that of the crop of economic interest; its broad leaves intercept the solar radiation, causing shading. There may also have been competition from sunn hemp P0 D50, due to its rapid growth.

In addition to the competition, the amount of biomass produced by the green manure and the period of availability to the plants may have had an effect. Use of the nutrients depends on the synchrony between the decomposition of the biomass and the demand of the crop (AMBROSANO *et al.*, 2014).

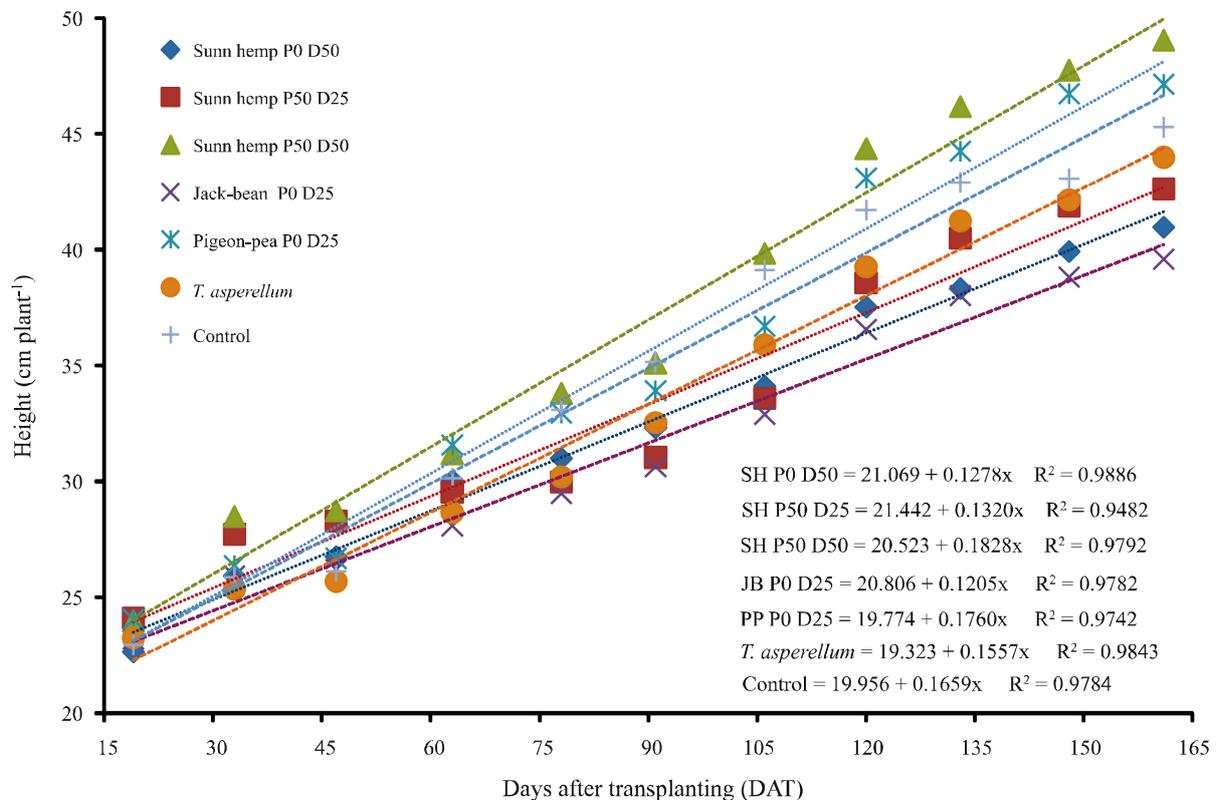
Although the pigeon pea also produced one of the smallest amounts of biomass among the treatments, it was the last to be managed, 82 days after transplanting the

pepper plants. At that time, the pepper plants were already spending energy on flowering and fruit production, considered the beginning of the harvest. In Figure 2, a peak in plant growth can be seen after management of the pigeon pea, which suggests that release of its nutrients coincided with the physiological demand of the pepper plants. Another characteristic of pigeon pea is the higher C/N ratio compared to the other legumes, resulting in slower mineralisation of the biomass, allowing phosphorus to be more-intensely absorbed by the pepper plants, as it remains available for a longer period (CARVALHO; AMABILE, 2006).

There was also a significant difference as a function of time in the mean values for stem diameter in pepper plants intercropped with green manure or *T. asperellum* (Figure 3), which were greater in the control and in the intercrop with sunn hemp P50 D50. As with height, pepper plants intercropped with P0 D25 and sunn hemp P0 D50 have the smallest measurements for stem diameter.

In pepper plants where there was no application of the homeopathic remedies, the highest values for NDVI

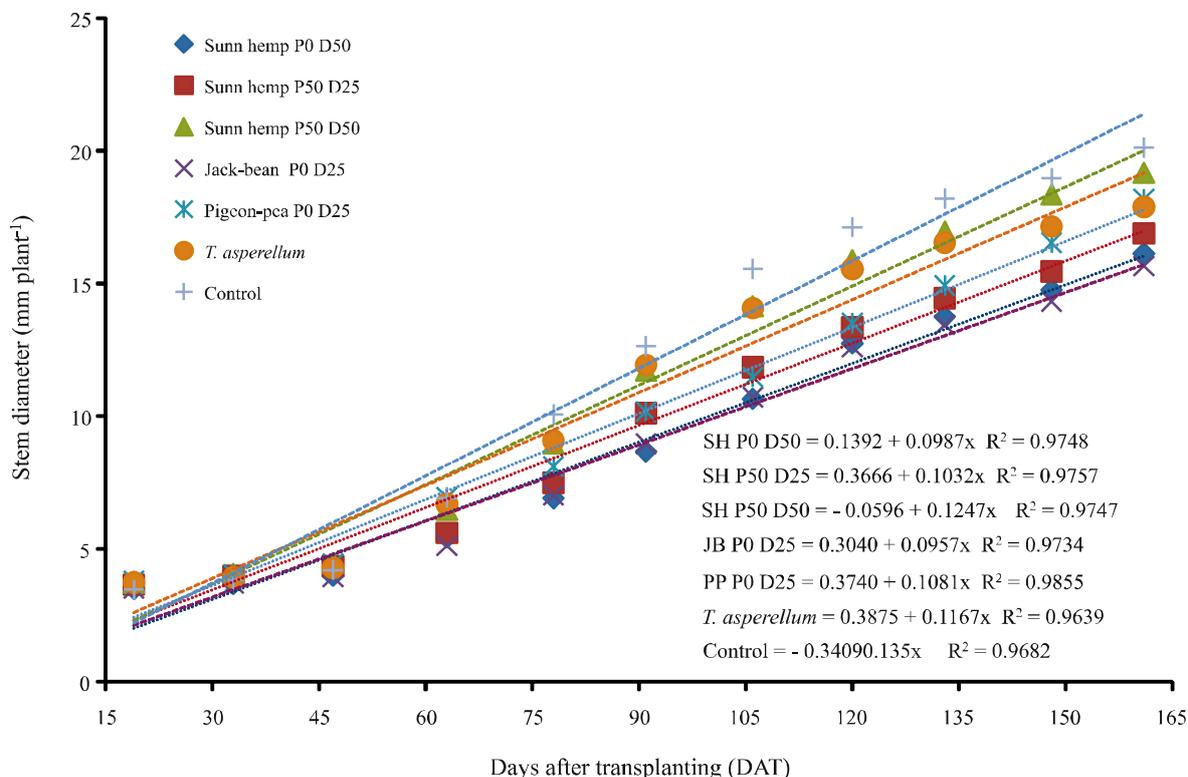
**Figure 2** - Height in the biquinho pepper as a function of time, intercropped with green remedies or *Trichoderma asperellum* and evaluated every two weeks up to 161 DAT, linear regression with trend curve



were found when intercropped with crotalaria-juncea P50 D50 or pigeon-pea P0 D25, and with the application of *T. asperellum* (Table 3). The NDVI increases for increases in green intensity and vegetation cover (LIRA *et al.*,

2009). This is because the vegetation tends to reflect two wavelengths differently for each physiological condition of the plant, and can be considered an indirect measure of vigour.

**Figure 3** - Stem diameter as a function of time, intercropped with green remedies or *Trichoderma asperellum*, and evaluated every two weeks up to 161 DAT, linear regression with trend curve



**Table 3** - Normalised difference vegetation index (NDVI), relative chlorophyll index (RCI) and mean value of the evaluations for 133 days after transplanting, in the biquinho pepper submitted to the application of homeopathic remedies (6CH) and grown intercropped with green manure or *Trichoderma asperellum*

Treatment	NDVI			RCI		
	NRH	<i>Arnica montana</i>	<i>Pulsatilla nigricans</i>	NRH	<i>Arnica montana</i>	<i>Pulsatilla nigricans</i>
SH P50 D25	0.61 Bb	0.64 Ba	0.61 Cb	51.11 Aa	50.33 Ba	51.22 Aa
SH P50 D50	0.66 Aa	0.66 Aa	0.63 Bb	50.99 Aa	50.90 Ba	50.31 Aa
SH P0 D50	0.53 Cc	0.59 Db	0.62 Ca	48.24 Bb	50.59 Ba	51.08 Aa
JB P0 D25	0.60 Ba	0.52 Ec	0.58 Db	50.66 Aa	48.85 Ca	49.98 Aa
PPP0 D25	0.65 Aa	0.61 Cb	0.64 Ba	51.75 Aa	52.35 Aa	51.68 Aa
<i>T. asperellum</i>	0.65 Aa	0.64 Ba	0.60 Cb	50.23 Aa	51.95 Aa	50.90 Aa
Control	0.62 Bb	0.61 Cb	0.67 Aa	51.24 Aa	50.98 Ba	51.62 Aa
CV(%)	11.86			6.93		

Mean values followed by different uppercase letters in a column and lowercase on a row differ by Scott-Knott test ( $p < 0.05$ ). NHR: No homeopathic remedy; SH P50 D25, sunn hemp sown 50 days before transplanting (DAT) the biquinho pepper, at a density of 25 kg ha<sup>-1</sup>; SH P50 D50, sunn hemp sown 50 DAT at a density of 50 kg ha<sup>-1</sup>; SH P0 D50, sunn hemp sown immediately after transplanting the biquinho pepper, at a density of 50 kg ha<sup>-1</sup>; JB P0 D25, jack bean sown immediately after transplanting; PP P0 D25, pigeon pea sown immediately after transplanting

The pepper plants treated with *Arnica* showed a higher NDVI when intercropped with sunn hemp P50 D50, showing that this remedies enhanced the effects of the green manure. Whereas, the pepper plants treated with *Pulsatilla* developed better in the absence of green manure and *T. asperellum*, showing greater height, larger stem diameter and a higher NDVI.

There was also a difference between treatments in relation to the relative chlorophyll index (RCI) in the pepper plants (Table 3). Plants treated with *Arnica*, and those treated with *Pulsatilla* showed a higher RCI than those that received no homeopathic treatment when intercropped with sunn hemp P0 D50. In this treatment, the homeopathic remedies probably helped the pepper plants with the effects of competition. When treated with *Arnica*, the pepper plants intercropped with jack bean showed a low RCI. The lowest values for height, stem diameter and NDVI as a function of time were also seen with above two types of green manure.

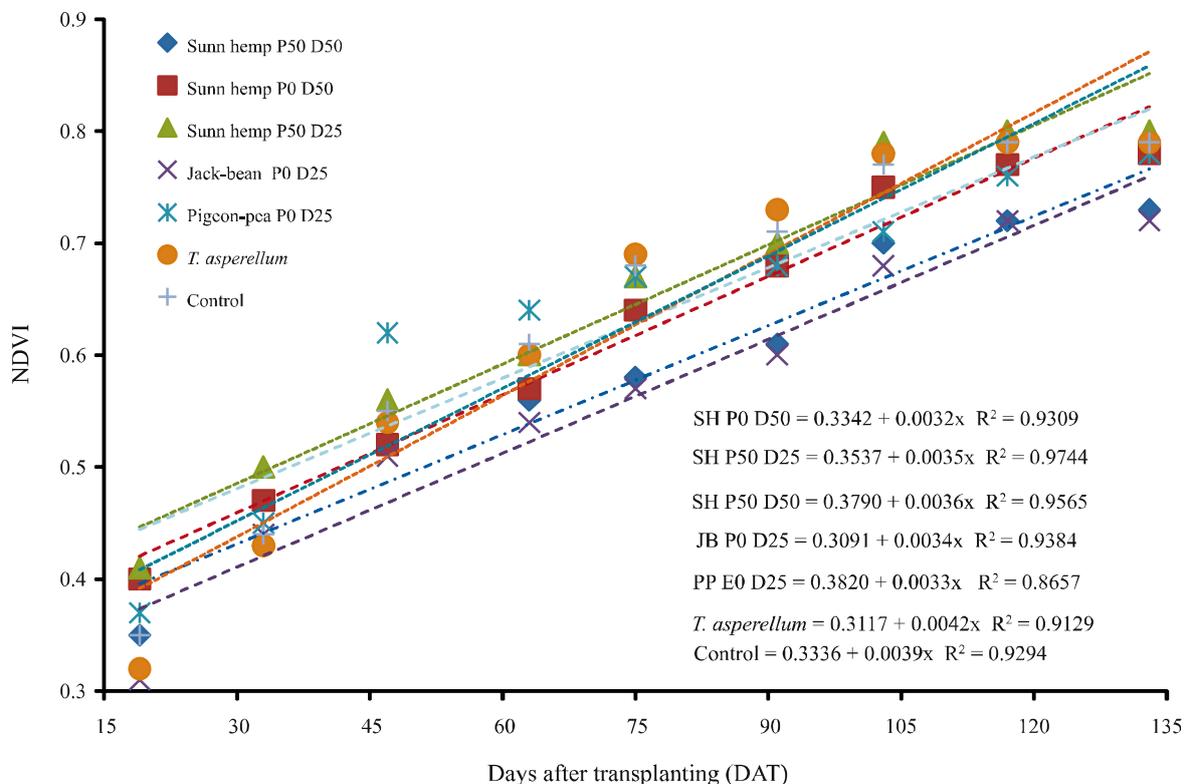
In the absence of green manure and *T. asperellum* there was no significant difference between the plants which did not receive the homeopathic remedies of *Arnica* and *Pulsatilla*. Gonçalves *et al.* (2015), also found a similar value for RCI between treatments when using

Sulphur at 6, 12 and 30CH in cultivating the onion. The RCI generally correlates well with the nitrogen content of the leaves (MINOTTI; HALSETH; SIECZKA, 1994), and can be an indication of a deficiency of this nutrient in the plant (WOOD; REEVES; HIMELRICK, 1993), since chloroplast enzymes are made up of 50% to 70% of the total N in the leaves.

For NDVI as a function of time, an increase in mean values was found during the period under analysis, where pepper plants under the sunn hemp P50 D50 and P50 D25 treatments, pigeon-pea P0 D25 and *T. asperellum*, did not differ from the control at 133 DAT, and showed a mean value of 0.79 (a) (Figure 4). These results were superior to the jack-bean P0 D25 and sunn hemp P0 D50 treatments, which had a mean value of 0.73 (b).

There was no interaction between the treatments (green manure and *T. asperellum*) and homeopathic remedies for the production components (Table 4). Pepper plants intercropped with sunn hemp P50 D50 or inoculated with *T. asperellum*, and the control, showed the greatest total number of fruit and the greatest total weight (TNF and TWF), with the greatest number and weight of commercial fruit (NCF and WCF). For percentage dry matter (PDM), only the fruit of pepper plants intercropped

**Figure 4** - Normalised difference vegetation index (NDVI) for the green manure and *Trichoderma asperellum*, as a function of time



**Table 4** - Number of fruit (TNF), number of commercial fruit (NCF), total weight of fruit (TWF), weight of commercial fruit (WCF) and percentage dry matter (PDM), in the biquinho pepper, School of Animal Science and Food Engineering (FZEA / USP), Pirassununga, São Paulo, 2018

Treatment	TNF	NCF	TWF	WCF	PDM
	----- fruit plant <sup>-1</sup> -----	----- g plant <sup>-1</sup> -----	----- g plant <sup>-1</sup> -----	----- g plant <sup>-1</sup> -----	--- % ---
SH P50 D25	849.60 b	787.8 b	427.25 b	338.05 b	14.58 a
SH P50 D50	1563.33 a	1481.5 a	687.19 a	659.55 a	14.73 a
SH P0 D50	1099.60 b	1025.1 b	465.64 b	438.98 b	13.97 b
JB P0 D25	701.20 b	662.8 b	318.92 b	284.09 b	15.05 a
PP P0 D25	939.22 b	872.11 b	368.55 b	345.96 b	14.74 a
<i>T. asperellum</i>	1273.33 a	1205.5 a	531.74 a	510.43 a	15.24 a
Control	1711.20 a	1637.6 a	763.50 a	738.61 a	15.21 a
CV1 (%)	7.82	7.85	6.63	9.88	5.52
CV2 (%)	4.31	4.37	6.89	4.66	3.57

Mean values followed by different letters in a column differ by Scott-Knott test ( $p < 0.05$ ). SH P50 D25, sunn hemp sown 50 days before transplanting (DAT) the biquinho pepper, at a density of 25 kg ha<sup>-1</sup>; SH P50 D50, sunn hemp sown 50 DAT at a density of 50 kg ha<sup>-1</sup>; SH P0 D50, sunn hemp sown immediately after transplanting the biquinho pepper, at a density of 50 kg ha<sup>-1</sup>; JB P0 D25, jack bean sown immediately after transplanting; PP P0 D25, pigeon pea sown immediately after transplanting

with sunn hemp P0 D50 showed lower values than the other treatments. PDM is an important attribute for understanding the capacity of the fruit for accumulating nutrients. Fruit that produce a greater amount of dry matter per area will produce more paprika and consequently have a higher yield (SOUZA; MALUF, 2003).

The pepper plants inoculated with *T. asperellum* or intercropped with sunn hemp P50D50, and the controls stood out, with a production of 531.74, 687.19 and 763.5 g plant<sup>-1</sup> respectively. It is worth noting that this level was achieved after four months of production (from May to September), under unfavourable climate conditions, and using the minimum possible management (no pruning, budding or fruit thinning). As reported by Hermosa *et al.* (2012), fungi of genus *Trichoderma* spp. promote the growth of both roots and shoots, in addition to increasing productivity, fruit quality, seedling fresh matter and secondary-root growth. The metabolites produced by *Trichoderma* spp. favour cell elongation in vascular plants, and enable greater access to soil nutrients due to the increase in the root surface (CHAPPS JUNIOR *et al.*, 2014).

There was no difference in the number or weight of defective fruit, with a mean value for all treatments of 66.40 fruit plant<sup>-1</sup> and 22.23 g plant<sup>-1</sup> respectively.

## CONCLUSIONS

1. The intercrop of biquinho pepper with sunn hemp sown 50 days before transplanting the pepper at a

density of 50 kg ha<sup>-1</sup>, allowed for good development of the crop of economic interest, gave fruit production similar to the control and added 0.47 kg m<sup>-2</sup> of dry biomass;

2. The homeopathic remedies *Arnica montana* 6CH and *Pulsatilla nigricans* 6CH affected plant height, plant diameter, the normalised difference vegetation index (NDVI) and relative chlorophyll index (RCI) in the biquinho pepper, but did not affect productivity. In general, *Pulsatilla nigricans* gave the best results in the absence of green manure;
3. There were no benefits to production in the biquinho pepper from *Trichoderma asperellum* at the dose under study.

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