Univ. of Min. Intl. Mult. Disc. Res. Jour. Vol. 3, Issue 1, Dec. 2018
http://www.umindanao.edu.ph/journal

Smothering potential of different crops for sustainable weed control in Pummelo Orchard

[1]Larry V. Aceres*, [2]Emmanuel T. Libuangan and [3]Rhegyn R. dela Torre
[1,2,3]University of Southeastern Philippines, Tagum-Mabini Campus, Philippines
Email: larry.aceres@usep.edu.ph

Date received: September 6, 2018
Date accepted: November 19, 2018
Date published: December 20, 2018

ABSTRACT

Weeds were considered the silent killer in the crop field and/or orchard due to its unobserved effect to crop production. Weeds harbor pests and diseases and also pollinators and natural enemies. Ecological farming makes use of the non-chemical method for weed control due to the ill-effects of continuous herbicide use which decreases diversity and promotes soil erosion. Hence, the use of smother or cover crops was evaluated as to their potential of preventing and/or reducing weed growth in pummelo orchard.

This study was conducted at the Pummelo Orchard of the University of Southeastern Philippines, Mabini, Compostela Valley Province with the following smother crops treatment such as pintoi peanut (*Arachis pintoi*), peanut (*Arachis hypogaea*), sweet potato (*Ipomoea batatas*), squash (*Cucurbita maxima*) and bottle gourd (*Lagenaria siceraria*) arranged in Randomized Complete Block Design with 3 replications in 8 m x 15 m dimension per plot. Data were gathered using the 1 x 1 m quadrat per plot for weed populations at 45, 75 and 105 days after planting.
The population of beneficial arthropods were monitored using various sampling techniques such as yellow pan trap, pitfall trap, and sweep net. Data were analyzed using the Analysis of Variance (ANOVA) and comparison of means was done following the DMRT analysis.

Results revealed that the pintoi peanut, peanut and sweet potato were the best smother crops in suppressing weeds since they produced the lowest weed density and fresh weed weight across sampling dates. Moreover, pintoi peanut and sweet potato provided prolonged weed suppression in the pummelo orchard. Furthermore, higher population of beneficial arthropods were recorded particularly in reproductive stage of the various smother crops than in without smother crops. On the other hand, squash and bottle gourd gave the highest net income based on the partial budget analysis though not an effective smother crop.

Keywords: *Smother crops, Beneficial Arthropods, Pummelo Orchard, Weeds, Sustainable Weed Management.*

INTRODUCTION

Nowadays, weed control relies heavily on synthetic herbicides but this dependence to such input must be reduced if not avoided from using due to its destructive action brought in the agricultural ecosystem. Finding an alternative that is sustainable and at the same time provides biodiversity to the orchard is very crucial for an effective weed management program. One of these approaches of sustainable weed control is the use of live cover or smothers crops.

Smother crops are those plants that are established in the orchard for the purpose of weed suppression, provide additional income to the growers, prevent soil erosion and also provide biodiversity in the orchard. Moreover, cover crops are important, as it serves as habitat and refuge for beneficial insects to sustain pollinators and predators (Kuepper, 2010).

Smother plants are specialized cover crops that offer an alternative method to control weeds and have the potential of reducing soil erosion and improving soil quality (Buhler, 1999). Hartwig and Ammon (2002) proved that cover crops provide unlimited benefits to crop production, to mention: enhance soil productivity by limiting nutrient loss in surface run-off and preventing leaching of nitrate to ground; reduction in surface water pollution; added organic matter to the soil; improved soil structure and tilth; soil erosion control; fixing of atmospheric nitrogen particularly with leguminous plants; and providing weed control. Teasdale *et al.* (2007) compared the efficacy of live cover crops versus cover crop residue and found out that the former has a greater suppressive effect on the life cycle of weeds than the latter. They further stressed that live cover crops can compete well in emerging and growing weeds than the cover crop residue. In a trial conducted using living mulch versus traditional weed control in a cornfield in Switzerland, treatment with living mulch has higher earthworms, collembolans, and microbial soil biomass than in traditional treatment (cultivation + herbicide application). Similarly, common smut, European corn borer, and aphids are significantly low and with abundant natural enemies such as ground beetle, rove beetle, green lacewing, spiders and ants are observed in a corn field with living mulch than in without living mulches (Hartwig and Ammon 2002). In pear orchard, sown grown cover crop favored higher beneficial arthropods population over phytophagous pest in pear canopy showing promising management of pear pests (Rieux *et al.*, 1999). Also, Paredes *et al.* (2013) revealed that ground cover and adjacent vegetation significantly influence the abundance of natural enemies such as spiders and parasitoids in olive ecosystem. Greater beneficial arthropods communities in lemon orchard with ground covers over bare soil applied with herbicides was recorded with significantly high numbers of parasitoid wasps, coccinellids and lacewing under resident vegetation treatment and sowed selected species of ground cover (Silva *et al*., 2010). Moreover, the ground cover treatments serve as refuge for spider population during late winter and early spring resulting to greater population while more spiders were recorded in bare soil during summer.

One of the smother crops to be studied from this study is the pintoi peanut, *Arachis pintoi*. This leguminous cover crop has been used as a ground cover in citrus orchards in Florida and Costa Rica (Kiss, 1997) and Brazil (Severino and Christoffoleti, 2004). Since the cover crop is a legume, it improves nitrogen availability through nitrogen fixation, reduces or prevents soil erosion and prevents pests and diseases (Coleman, 1995) and also attracts beneficial arthropods.

Sweet potato, on the other hand, has the potential to be used as smother crops due to its fast-growing characteristic with early formation of the closed canopy that could potentially suppress weeds

(Woolfe 1992). Noriel (Personal communication, 2011) revealed that sweet potato can effectively control perennial weeds like cogongrass (*Imperata cylindrica*) based on her study at the Visayas State University, Leyte, Philippines.

Bottle gourd (*Lagenaria siceraria* (Mol.) Standley) has been included from this study due to its characteristic rounded leaves of about 10-40 centimeters wide, soft-hairy on both sides and five-angled and lobed (Stuart, 2017). The possession of wider leaves could produce more canopy and enable to cover the ground efficiently, thus has the potential to prevent weed growth. Similarly, squash (*Cucurbita maxima* Duchesne) like bottle gourd has more expanded leaves that could potentially shade-out weeds in the orchard. It has a course, prostrate or climbing, annual, herbaceous vine, reaching a length of 4 meters or more. The leaves of the crop are hispid, rounded, 15 to 30 centimeters in diameter, heart-shaped at the base, shallowly five-lobed, with finely toothed margins, and often mottled on the upper surface (Stuart, 2017).

Peanut (*Arachis hypogaea*) is a leguminous favorite snack and a potential source of nutrients and antioxidants for Filipinos. At the latter stage of its growth, peanut can shade and sheltered soil surface that could hamper weed germination. Likewise, cultivation of peanut or groundnut in narrow rows can lead to maintenance of a complete crop cover over the soil which inhibits weed seed germination and reduces the need to carry out weeding (Konlan, 2013).

There have been limited literatures and studies conducted in the Philippines as to the potential of these crops in suppressing weed population in an established pummelo orchard. Hence, this study was conducted to test the efficacy of these smother crops on weed suppression and to determine their potential of attracting beneficial arthropods in the pummelo orchard of the USeP, Mabini, Compostela Valley Province; and to calculate the profitability of planting smother crops in the pummelo orchard using the partial budget analysis.

MATERIALS AND METHODS

Duration and location of the study

The field experiment was conducted at the pummelo Orchard of the University of Southeastern Philippines, Mabini, Compostela Valley Province (Longitude, 125.853240^{o}, and Latitude, 7.273382^{o}) from May 2014 to December 2014. The 15-year old "Magallanes" pummelo trees planted at a distance of 8m x 8m with non-overlapping of canopies between trees in a one-hectare area (Figure 1). Spaces in between trees are infested with weeds.

Figure1. Pummelo trees at USeP spaced at 8m x 8m infested with weeds.

Experimental design and treatments

The various treatments were arranged in a Randomized Complete Block Design (RCBD) replicated three times in the study area. The treatments were as follows: T1 – No smother crop but with a monthly application of glyphosate; T2 – Squash; T3 – Peanut; T4 - Pintoi Peanut; T5 - Sweet potato; and T6 - Bottle gourd.

Maintenance of pummelo trees

Pummelo trees were maintained by applying the recommended rates of fertilizer, watering, weeding, and pruning. Weeding was only performed during the establishment stage of the smother crops done by manual weeding; afterward, no more weeding was done. Watering was done when there is no rain or when the soil is dry above 30 cm deep. Fertilization using different inorganic fertilizers was applied following the soil analysis recommendation. Regular pruning was done to infected and unproductive branches.

Planting and Maintenance of smother crops

The various economically important crops as indicated in the treatments were tested as to their smothering potential to regulate weed growth in pummelo orchard. They were planted at the experimental plot measuring 8 m x 15 m in accordance with the standard cultural techniques in raising these crops in the field. The smother crops were maintained by applying the recommended rate of fertilizers, watering, and weeding. Minimum tillage was applied; the area was cleared through hand weeding. Weeding was done two weeks after planting and up to one month after planting; afterward, no other weeding was done to test the ability of these crops to suppress weeds. For the treatment 1 (no smother crop treatment but with glyphosate application), the herbicide glyphosate was applied 15 days after the smother crops treatments were planted and monthly thereafter till termination. For pintoi peanut treatment, this was already planted ahead since this leguminous crop takes time to be established in the orchard. Watering of the smother crops was done using hand sprinkler when there is no rain to keep proper soil moisture. All smother crops received inorganic and organic fertilizers based on soil analysis recommendation. Harvesting of smother crops was based on their days of maturity and was done during cooler hours.

Sampling procedure for weeds

Weed sampling (Figure 2) was done by using quadrat (1m x 1m); this was placed at the center of each plot for the purpose of counting, weighing and identifying and recording weed species present within the sampling unit. Only one quadrat was used per treatment per replication throughout the duration of the study.

Beneficial arthropod populations count

Populations of beneficial arthropods were determined during the vegetative and reproductive stages of the smother crops and were done a week after the trapping materials were installed in each plot (Figure 3). One pitfall trap and one yellow pan trap was installed per plot to monitor the population of ground-dwelling arthropods and parasitic insects, particularly from orders Hymenoptera and Diptera. Moreover, sweep net was used to sample flying insects. However, care must be the prime consideration as the net must not touch the top growth of plants as it may mechanically injure the smother plant. Five strokes at 180^0 angle were employed per plot. Actual numbers of beneficial arthropods were recorded.

Figure 2. Weed collection at various smother crops: (A) Pintoi peanut; (B) Squash); (C) No smother crop but with monthly application of glyphosate; (D) Sweet Potato; (E) Peanut; (F) Bottle Gourd

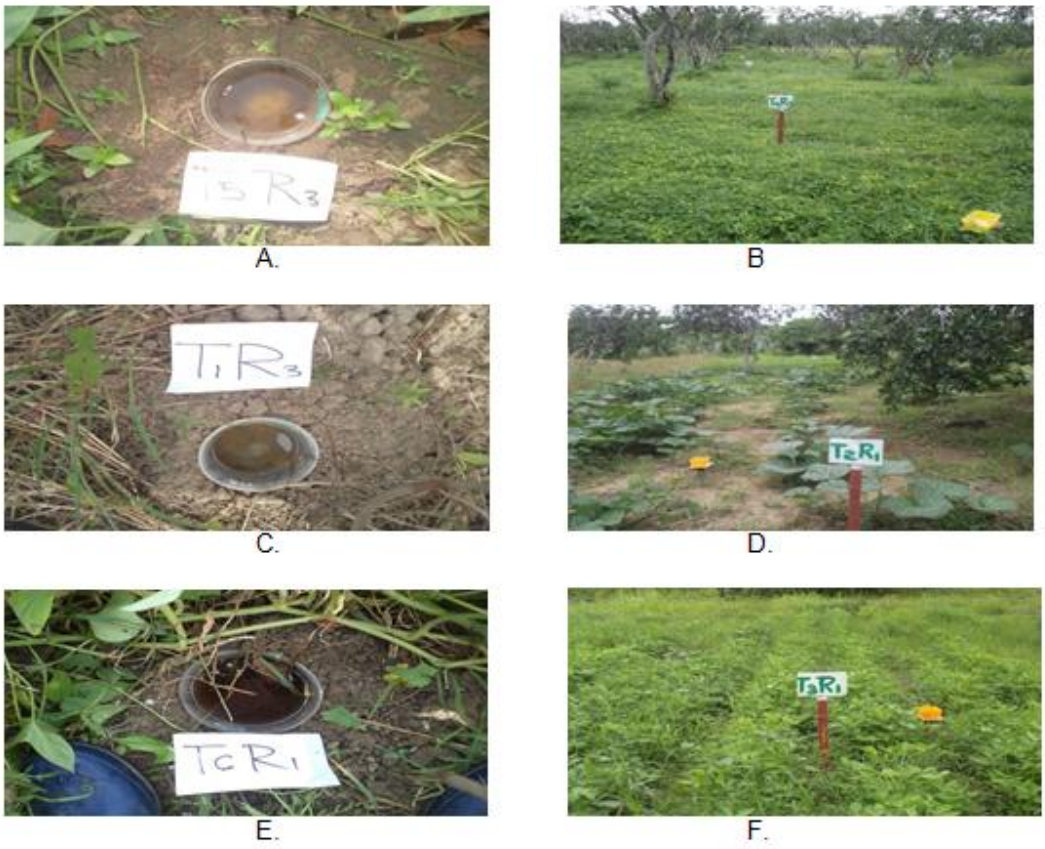

Figure 3. Pitfall traps (A, C, & E) and yellow pan trap (B, D, & F) installed per treatment to monitor beneficial arthropod populations

Statistical analysis

The data were statistically analyzed through Analysis of Variance (ANOVA) following the Randomized Complete Block Design (RCBD) and the differences among treatments were computed using Duncan's Multiple Range Test (DMRT).

Weed Population Count

Weeds within the quadrat of the various smother crops were counted and recorded and classified into grasses, sedges, and broadleaves.

Weed Weight (g)

Weeds were weighed according to its morphology such as grasses, sedges and broadleaf using digital weighing balance.

Population of beneficial arthropods

This was gathered during the vegetative and reproductive stages of the various smother crops based on the sampling techniques presented above. The beneficial arthropods were classified up to a family level only in the Crop Protection Laboratory of USeP Mabini, COMVAL Province, Philippines.

Economic analysis

This refers to the economic value of the smother crops in the pummelo orchard. This was computed using the partial budget analysis.

RESULTS AND DISCUSSION

Population of grasses

The population of grasses at 45 Days after Planting (DAP) of the smother crop revealed that the pintoi peanut and sweet potato obtained the lowest grass population count across treatments (Table 1). This is because the former treatment was already established in the pummelo orchard while the latter is fast in producing a thick canopy that inhibits weed growth. Kartika *et al.* (2007) stated that pintoi peanut (*Arachis pintoi*) serve as living mulch that has the ability to improve vegetative and generative growth from the main crop and to suppress weed germination. Woolfe (1992) supported that the smothering potential of sweet potato was derived from its fast-growing characteristic with early formation of the closed canopy that could suppress weeds. Assessment at 75 DAP, all smother crops obtained low weed density compared to no smother crop check but with monthly glyphosate application. It is because all smother crops were already produced canopy rendering them more competitive than the weeds. In fact, sweet potato got zero grass population due to its spreading vines that able to cover soil surface rapidly. At 105 DAP, among smother crops evaluated, peanut, sweet potato, and pintoi peanut significantly suppressed weed growth more effectively than bottle gourd and squash. The reason could be that the two cucurbits, squash and bottle gourd do not have sufficient closed vines that serve as a cover to the soil surface. However, its wide leaf index is essential in preventing weed growth and further development. It was also observed that the leaves that shade out the weeds were already senescing at this period of data collection.

Table1. Average grass populations in three collection periods as affected by different smother crops on pummelo orchard of USeP – Mabini Campus

	COLLECTION DATES		
TREATMENTS	45DAP**	75DAP**	105DAP**
T_1 – no smother crop	99.67^{c}	76.00^{b}	55.33^{c}
T_2 – Squash	45.67^{bc}	8.67^{a}	11.67^{b}
T_3 – Peanut	45.00^{bc}	0.67^{a}	0.33^{a}
T_4 – Pintoi peanut	3.00^{a}	0.33^{a}	0.00^{a}
T_5 – Sweet potato	10.02^{ab}	0.00^{a}	0.33^{a}
T_6 – Bottle Gourd	38.33^{b}	2.67^{a}	16.67^{b}
C.V = %	35.43	44.00	39.32

**means in a column having the same letter superscript are not significantly different at 1% level of significance using DMRT.

Populations of sedge

The means of sedge populations is presented in Table 2. Based on the analysis of variance, no significant difference was noted among treatments at 45, 75 and 105 DAP. It signified that smother crops did not show a significant effect on the density of sedge populations in the experimental area.

Table2. Average sedge populations in three collection periods as affected by different smother crops on pummelo orchard of USeP – Mabini Campus

	COLLECTION DATES		
TREATMENTS	45DAP^{NS}	75DAP^{NS}	105DAP^{NS}
T_1 – no smother crop	2.33	16.67	3.33
T_2 – Squash	18.00	5.33	4.67
T_3 – Peanut	8.00	0.00	1.67
T_4 – Pintoi peanut	16.00	1.67	4.67
T_5 – Sweet potato	22.00	1.33	0.33
T_6 – Upo Bottle Gourd	50.33	1.67	2.00
C.V = %	55.69	71.95	72.36

NS = Not Significant

Population of Broadleaved Weeds

Means of broadleaved populations as affected by different smother crops at 45, 75 and 105 DAP is shown in Table 3. Assessments at 45 DAP, analysis of variance revealed no significant difference among treatment means. The result implies that smother crops at this stage have no significant effect in preventing broadleaved weeds germination. This is because the canopy of the smother crops was not yet closed enough to cover the soil surface. Thus, Isaac *et al.* (2013) stated that the ability of the crops to suppress weeds differ in their competitiveness with weeds based on their emergence, leaf area expansion, light interception, canopy architecture, leaf-angle, shape, and competitiveness. In addition, the suppression of weeds may be through both competition and allelopathy. At 75 DAP and 105 DAP, significant differences among treatments were observed. Analysis of variance implied that smother crops at late vegetative and at reproductive stage had a highly significant influenced on the density of broadleaved weeds. Among the various smother crops evaluated, pintoi peanut consistently gave the lowest weeds density collected followed by peanut and sweet potato, respectively. Considering the ability of pintoi peanut in hindering weeds germination since this was already established in the area. Peanut and sweet potato also have a great potential in preventing weed germination. As observed, the canopy of peanut sheltered soil surface that hampers weed germination. Likewise, cultivation of peanut in narrow rows can lead to maintenance of a complete crop cover over the soil which inhibits weed seed germination and reduces the need to carry out weeding as stated by Konlan (2013).

Table 3. Average broadleaved weed populations in three collection periods as affected by different smother crops on pummelo orchard of USeP – Mabini Campus

TREATMENTS	COLLECTION DATES 45DAP[NS]	75DAP**	105DAP**
T_1 – no smother crop	81.00	210.33[b]	108.67[c]
T_2 – Squash	29.00	40.00[a]	22.33[b]
T_3 – Peanut	26.33	7.67[a]	3.33[a]
T_4 – Pintoi peanut	5.33	4.67[a]	0.67[a]
T_5 – Sweet potato	31.33	19.00[a]	4.67[a]
T_6 – Bottle Gourd	37.67	22.67[a]	30.33[b]
C.V = %	54.97	41.00	22.59

**means in a column having the same letter superscript are not significantly different at 1% level of significance using DMRT.

Fresh weight of grasses

Table 4 shows the mean fresh weight of grasses collected at 45, 75 and 105 DAP, as affected by different smother crops on pummelo orchard. Weights of grass weeds at 45 DAP revealed no significant difference among treatment means. Weed weights at 75 and 105 DAP, analysis of variance revealed significant effect to the weight of grasses as influenced by smother crops. Smother crops such as pintoi peanut, peanut, and sweet potato, respectively gave consistent effect on the weight of grass weeds. The reason for this could be that they were well established in the area and their spreading vines and/or canopies were closed enough that hinder weeds germination and further growth. Smother crops using green manure species, when well established in an area, provide additional weed control to the cropping system and are effective and valuable tools in integrated weed management (Severino and Christoffolite, 2004).

Table 4. Average fresh weight of grasses in three collection periods as affected by different smother crops on pummelo orchard of USeP – Mabini Campus

TREATMENTS	COLLECTION DATES 45DAP[NS]	75DAP**	105DAP**
T_1 – no smother crop	193.33	74.33[b]	125.33[b]
T_2 – Squash	93.33	7.00[a]	14.00[a]
T_3 – Peanut	183.33	0.67[a]	0.33[a]
T_4 – Pintoi peanut	1.67	0.33[a]	0.00[a]
T_5 – Sweet Potato	14.67	0.00[a]	0.33[a]
T_6 – Bottle Gourd	64.00	1.33[a.]	20.67[a]
C.V = %	57.55	51.58	52.87

**means in a column having the same letter superscript are not significantly different at 1% level of significance using DMRT.
NS= not significant

Fresh weight of sedges

The fresh weight of sedges as affected by different smother crops is presented in Table 5. Analysis of variance revealed no significant difference in the weight of sedges at 45, 75 and 105 DAP. Their corresponding weights were correlated to the weeds' population and may also affect the response of smother crops to avoid weed seeds germination and further growth. It was observed that sedges were least collected species in the experimental area.

Table 5. Average weight of sedge populations in three collection periods as affected by different smother crops on pummelo orchard of USeP – Mabini Campus

TREATMENTS	COLLECTION DATES 45 DAP^{NS}	75 DAP^{NS}	105 DAP^{NS}
T_1 – no smother crop	0.67	4.00	2.00
T_2 – Squash	10.0	1.00	1.67
T_3 – Peanut	3.67	0.33	0.67
T_4 – Pintoi peanut	15.0	0.67	0.33
T_5 – Sweet potato	11.0	0.33	0.33
T_6 – Bottle Gourd	44.0	1.00	1.33
C.V = %	63.89	58.16	58.56

NS = not significant

Fresh weight of broadleaved weeds

The fresh weight of broadleaved weeds as affected by various smother crops on pummelo orchard at 45, 75 and 105 DAP is shown in Table 6. Results showed no significant effects on the weight of broadleaves at 30 DAP but revealed significant differences at 75 and 105 DAP. At 45 DAP, the weight of broadleaved should response with the population of weeds collected. Numerically, various treatments except the pintoi peanut gained the highest weeds collected. This happened because smother crops at this stage were not totally established. Results at 75 and 105 DAP, it was noticed that the various smother crops obtained the lowest weight while the no smother crop treatment with monthly glyphosate application got the highest weed weight. At two collection periods, among the various crops evaluated, the pintoi peanut, peanut, and sweet potato, respectively got the lowest weed weight data. The consistency of the three treatments to counter weed germination and growth could be attributed to their rapid spreading and the production of the thick canopy that cover soil surface. In addition, sweet potato and pintoi peanut would have long-term effect since it would serve as perennial crops. Schonbeck (2011) revealed that cover crops can develop rapidly and form a dense canopy that keeps sunlight from newly emerged weeds and to outcompete from necessary nutrients and water. Cover crops can also provide organic mulch or act as living mulch to further weed suppression. Moreover, sweet potato got the lowest fresh weight among treatments. The main reason for this is that sweet potato has a fast vegetative growth and closed canopy that quickly covered the field. Moreover, Woolfe (1992) reported that sweet potato is fast growing vines that suppress weeds. At 105 DAP, weeds collected from the treatments squash and bottle gourd obtained the heaviest weed weight. This is because of the increased number of weeds collected. The smothering ability of the two cucurbits reduced at 105 DAP due to the fact that their leaves already senescing, hence more weeds emerged.

Table 6. Average weight of broadleaved weeds in three collection periods as affected by different smother crops on pummelo orchard of USeP – Mabini Campus

TREATMENTS	COLLECTION DATES 45DAP[NS]	75DAP**	105DAP**
T_1 – no smother crop	86.00	112.0[b]	112.67[c]
T_2 – Squash	16.33	18.00[a]	26.67[ab]
T_3 – Peanut	46.67	9.00[a]	2.33[a]
T_4 – Pintoi peanut	9.33	6.33[a]	10.67[ab]
T_5 – Sweet potato	31.67	5.61[a]	2.67[a]
T_6 – Bottle Gourd	34.67	11.33[a]	49.00[bc]
C.V = %	59.92	37.50	48.78

**means in a column having the same letter superscript are not significantly different at 1% level of significance using DMRT
NS= not significant

Beneficial Arthropod Populations Count on smother crops at vegetative stage

Table 7 shows the total beneficial arthropods collected on pummelo orchard in association with various smother crops. Analysis of variance revealed no significant difference among treatments at the vegetative stage but significant difference among smother crops on beneficial arthropods count at reproductive stage was recorded. Result shows that smother crops at vegetative stage would not affect the abundance or presence or absence of beneficial arthropods in the study area. The reason for this could be the absence of their prey or flower nectars as the main source of food for their survival or maybe the smother crops at this stage could not provide good habitat or refuge for their presence. On the other hand, smother crops at their reproductive stage in the pummelo orchard would help to increase the presence of beneficial arthropods.

The most dominant beneficial arthropods collected among smother crops were from the Family of Formicidae, Lycosidae, Coccinellidae, Carabidae, Braconidae, Tachinidae, Apidae and Ichneumonidae. The greater number of beneficial arthropods was observed particularly in the pintoi peanut and sweet potato cover crops. According to Mohler (2000), planting smother crops will lead to increase the numbers of beneficial insects; it provides the beneficial insects with an important resource, such as pollen, nectar, alternate prey, shelter, or overwintering sites. Moreover, Hartwig and Ammon, (2002) revealed that greater population of beneficial arthropods such as ground beetle, rove beetle, green lacewing, spiders and ants were far more in with cover crop treatments than in without cover crop treatment.

Table 7. Arthropods population at vegetative and reproductive stages of the different smother crops in pummelo orchard USeP – Mabini Campus

	VEGETATIVE[ns]	REPRODUCTIVE*
T_1 – No smother crop	6.67	4.67[b]
T_2 – Squash	20.33	15.33[a]
T_3 – Peanut	18.67	11.33[ab]
T_4 - Pintoi peanut	11.33	17.67[a]
T_5 - Sweet Potato	23.33	17.00[a]
T_6 - Bottle Gourd	16.33	9.00[ab]
C.V =	41.37%	37.21%

*means in a column having the same letter superscript are not significantly different at 5% level of significance using DMRT
NS = not significant

Partial Budget Analysis

Table 8 shows the partial budget analysis of using different smother crops as a weed management strategy in pummelo orchard. Results show that smother crops give an additional income aside from its weed suppressing ability. Among the smother crops evaluated bottle gourd got the highest net income of PHP 6565.00, then followed by squash with a net income of P6175.00. Sweet potato got the third highest net income of P3995. Importantly, sweet potato has had the greatest potential as smother crops as evidence of its suppressive ability to control weeds such as itch grass, goosegrass and cogon grass (Noriel, 2011, Personal Communication). As a matter of fact, the smother crop (sweet potato) still provides weed suppression even after 1 year of its establishment at the pummelo orchard of USeP, Mabini, COMVAL Province, Philippines. Moreover, the smothering potential of *Arachis pintoi* is so evident from this study on the capacity of the crop from preventing weed growth in pummelo orchard. The use of pintoi peanut has more ecological importance such as nitrogen fixation, soil erosion prevention, attraction of beneficial arthropods among others (Kartika *et al*,2007).

Table 8. Partial budget analysis of the various smother crops in pummelo orchard of USeP, Mabini, Compostela Valley Province, Philippines

Changes in cultural management from weeding to smothering in the Pummelo orchard					
From weeding (FW) to smothering (S)	**SQUASH**	**PEANUT**	**A. PEANUT**	**SWEET POTATO**	**BOTTLE GOURD**
Added Revenue					
Income from smother	**7280.00**	3450.00	-	2250.00	**7640.00**
Reduced cost					
Labor on weeding	1000.00	1500.00	**3500.00***	**3500.00***	1000.00
Added cost					
Planting materials	450.00	420.00	100.00	100.00	420.00
Land Preparation and weeding	1000.00	1000.00	1000.00	1000.00	1000.00
Fertilizer of smother crops	230.00	230.00	230.00	230.00	230.00
Fertilizer application	125.00	125.00	125.00	125.00	125.00
Harvesting	300.00	300.00	-	300.00	300.00
Total added cost	2105.00	2075.00	1455.00	1755.00	2075.00
Change in net income	6175.00	2875.00	2045.00	3995.00	6565.00

* prevent weed germination/growth for 7 months

CONCLUSION AND RECOMMENDATION

The results of the study concluded that the mean population of grasses and broadleaved weeds and their corresponding fresh weights were significantly affected by the various smother crops while sedges population was not affected with the various smother crops. Among the various smother crops evaluated, pintoi peanut, sweet potato and peanut proved to suppressed grass and broad-leaved weed populations and fresh weed weight in pummelo orchards across sampling dates. The study revealed that planting smother crops does not only provide good weed management but also offers additional income to farmers. Furthermore, smother crops when well established in the area would serve as a source of food and a good habitat for beneficial arthropods particularly during the reproductive stage of the crop. Among smother crops evaluated, the squash and bottle gourd gained the highest net income value following the result of the partial budget analysis. However, in terms of their performance as to their weed suppressing capacity, the attraction of beneficial arthropods and the nutrition and additional income it provides to farmers, the sweet potato and pintoi peanut as smother crops are highly recommended.

ACKNOWLEDGMENT

The authors would like to thank the USeP for providing fund and to the former students for data gathering and establishment of the smother crops in the pummelo orchard.

REFERENCES

Buhler, D. D. (1999). Spring-seeded smother plants for weed control in corn and soybeans. USDA/ARS National Soil Tilth Laboratory Ames, Iowa, 8(6).

Coleman, R.G. (1995). Perennial peanuts - potential looms larger in citrus. Citrus Industry, V.45, p.43-44. In Severino, F. J. and P.J. Christoffolite (2004). Weed suppression by smother crops and selective herbicides. *Science Agricola, 61*(1).

Hartwig, N. L. and H. U. Ammon. (2002). Cover crops and living mulches. Weed Science, 50: 688-699.

Isaac, W.P, P. Bridgemohan, and W.G. Ganpat. (2013). Integrated Weed Management Practices for Adoption in the Tropics. from http://www.intechopen.com/download/pdf

Kartika, J. G., M. R. Reyes, and A. D. Susila. (2007). Review of literatures on perennial peanut (*Arachis pintoi*) as potential cover crop in the Tropics. http://www.sanrem.cals.vt.edu/1123/ikaravesion.doc

Kiss, J. (1997). Viva. Revista Globo Rural, v.37, p.9-11. In Severino, F. J. and P.J. Christoffolite (2004). Weed suppression by smother crops and selective herbicides. *Science Agricola, 61*(1).

Konlan S. (2013). Yield Response of three groundnuts (*Arachis hypogaea L.*) Varieties intercropped with maize (*Zea mays*) in the guinea savanna zone of Ghana. From http://www.academicjournals.org/journal/JCO/article-full...pdf

Kuepper G. (2010). Rotations, Cover Crops & Green Fallow on the Cannon Horticulture Project. Kerr Center for Sustainable Agriculture from www.kerrcenter.com/publications/summer-cover-crops.pdf

Mohler C.L. (2000). Crop Rotation on Organic Farms. In: A Planning Manual www.sare.org/content/download/.../Crop_Rotation_on_Organic_ Farms.pdf.

Noriel, L. M. (2011). Personal Communication. Visayas, State University, Visca, Baybay City, Leyte.

Paredes, D., L. Cayuela, M. Campos. (2013). Synergestic effects of ground cover and adjacent vegetation on natural enemies of olive insect pests. *Agriculture, Ecosystem and Environment, 173*(1), 72-80.

Rieux, R., S. Simon and H. Defrace. (1999). Role of hedgerows and ground cover on arthropod populations in pear orchard. *Agriculture, Ecosystems and Environment, 73* (2), 119-127.

Schonbeck M. (2011). Principles of Sustainable Weed Management in Organic Cropping Systems. 3rd Edition.

Severino, F. J. and P. J. Christoffolite (2004). Weed Suppression by Smother Crops and selective herbicides. *Science Agricola, 61*(1). http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-90162004000100004

Silva, E. B., J. C. Franco, T. Vasconcelos and M. Branco. (2010). Effect of ground cover vegetation on the abundance and diversity of beneficial arthropods in citrus orchards. *Bulletin of Entomological Research, 100* (4), 489-499.

Stuart, G. U. (2017). Philippine Alternative Medicine: Bottle gourd or Upo. Access from www.stuartxchange.org/Upo.html

Stuart, G. U. (2017). Philippine Alternative Medicine: Kalabasa. Access from http://www.stuartxchange.org/Kalabasa.html

Teasdale, J. R., Brandsaeter L. O., Calegari, L., F. Skora Neto. (2007). Cover crops and weed management. CABI International. 16 p.

Woolfe, J. A. (1992). Sweet Potato: An untapped food resource. Cambridge University Press, Cambridge. 643 pp. In Nedunchezhiyan, M., G. Byju and S. Jata. Sweet Potato Agronomy. Fruit Vegetable and Cereal Science and Biotechnology. http://www.globalsciencebooks.info/JournalsSup/images/Sample/FVCSB_6(SI1)1-10o.pdf