International Journal of Minor Fruits, Medicinal and Aromatic Plants. Vol. 5 (2) : 33- 38, December 2019

Growth and yield responses of papaya *(Carica Papaya L.)* intercropped with herbaceous weeds

Siriwardana AJMCM, Wathugala DL* and Kumarasinghe HKMS

Department of Crop Science, Faculty of Agriculture,
University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka

**Email: wgdlakmini@crop.ruh.ac.lk*

Received: 20.8.18 Revised: 21.10.18 Accepted: 25.10.18

ABSTRACT

Organic production of medicinally important crop is substantial to ensure food quality. Papaya is medicinally important fruit crop all over the world. A field experiment was conducted to test both growth and yield responses of papaya (Carica Papaya L.) cover cropped with different herbaceous weed species possess in allelopathic effect with the purpose of reduction of herbicide application and cost for weed management. Four herbaceous weeds namely Cleome viscosa, Andrographis paniculata, Ocimum sanctum and Celosia argentea were used with papaya var. Red Lady. Papaya was planted with 2.5x 2.5m spacing. Treatments included cultivation of four herbaceous weeds and hoe weeding (control) in between papaya rows. Mowing of cover crops was practiced at the blooming stage to ensure addition of maximum bio mass to the cultivation. A varity of data was collected throughout the trial, such as growth and yield parameters of papaya, weed survey and soil analysis. Results indicated that herbaceous weed cover did not significantly affected on vegetative growth and yield of papaya and exerted good control over weeds. However, Cleome viscose significantly reduced the number of flowers and fruits per plant. There was a long term effect of herbaceous weed cover on soil nutrient contents. Although further research is needed, it is possible to conclude that there is a possibility to use some weed species as a cover crop in papaya orchards to suppress other weed growth.

Key words: *Andrographis paniculata, Celosia argentea, Cleome viscosa, Cover crop, Herbaceous weeds, Ocimum sanctum*

INTRODUCTION

Papaya (*Carica papaya* L.) is one of the important fruit crop cultivated in Sri Lanka. It is short-lived perennial plant in the family Caricaceae. Papaya is a rich source of nutrient and use as remedy against a variety of diseases. Moreover, it contains vitamin A, C, E and minerals. Additionally, the different plant parts including leaf, ripped and unripe fruit, seed, root, bark and latex contain variety of chemicals. Papain is a digestive enzyme contains in milky juice present in papaya plant parts. Hence, it is used to treat trauma, allergies and patients with inflammatory disorders of intestine, liver and eye (Vij and Prashar, 2015; Ayoola and Adeyeye, 2010). Furthermore, leaf, seed and fruit juice have been used to treat cancers, dyspepsia, digestive disorders and chronic ulcers as well (Workneh *et al*., 2012).

However, weed management of papaya orchards in Sri Lanka become a major and costly operation due to labor scarcity and banding of herbicide glyphosate which is widely used for weed management in orchards. Nevertheless, indiscriminate use of potentially harmful agrochemicals may affect food quality and food safety, environmental pollution and health of famers (Linares *et al*., 2008). It has also increased resistance of weeds to the herbicides. Finally all these create agro ecologically unbalanced, high cost agricultural systems with irregular and reduced yield. Cover crops suppress weed by means of competition and inhibiting weed growth via allelopathy (allelochemicals) while providing multiple potential benefits to soil health and crop productivity.

Life span of papaya orchard is comparatively shorter than other perennials. Generally, it should be replaced after 2-3 years to obtain economic yield. In Sri Lanka, there are recommended cover crops for weed suppression in long term plantation crops such as tea, rubber, coconut. But for short term perennial fruit orchards, there are no

recommended cover crops for the purpose of weed suppression. Intercropping with short term crops like medicinal plants and vegetables is also a recommended method for weed management in orchards in the world. As an example the intercropping experiment conducted by Nandi and Ghosh (2016) in 8 year old Mosambi Sweet orange orchard with short term medicinal plants showed one year growing of medicinal plants namely *Menthaspicata* and *Bacopamonnieria* has no adverse effect on Mosambi, but results also indicated that *Aloevera* plant should not be grown in the orchard while growing of *Withania somnifera*and *Rouwolfia serpentine* need to be investigated further due to their high mortality rate. In spite of several benefits of intercropping, commercial orchard owners have little interest to follow this due to several issues such as higher capital investments, wider spacing, need specific attentions on managing both crops, lack of information on suitable crops, etc.

All the cover crops recommended in long term perennials are creepers. Frequent slashing and adding biomass to the soil is not practiced. Therefore, addition of biomass to the soil is not considerably higher in growing these recommended cover crops. Considering all these facts from this study we tested the effectiveness of growing some common weeds as a cover crop. These weeds can suppress the growth of other weeds due to higher competitive ability. Further they produce large amount of biomass within short period of time and resistant to various pests and diseases. Therefore, 4 weed species namely *Cleome viscose, Andrographis paniculata, Ocimum sanctum* and *Celosia argentea* were selected for the experiment.

Cleome viscosa, belongs to the family *Capparaceae*, commonly known as wild mustard. The plant is sticky herb which grows up to 30– 90 cm high and is branched. It is characterized by its yellow flowers with long slender pods with strong penetrating odour. Seeds look like mustard seeds. *C. viscosa* possess ethnobotanical, phytochemical and pharmacological importance. Hence it has been used as a remedy for various therapeutic purposes. Jana and Biswas (2011) reported that root exudates of *C.viscosa* showed inhibitory activity on rice, mustard and gram seeds germination and growth. Moreover, aqueous extracts of *C. viscosa* was significantly inhibited seed germination as well as growth and biomass production of *Sesamum indicum* L (Natarajan *et al*., 2014).

Andrographis paniculata (Acanthaceae) is commonly known as King of Bitter. Plant height ranging from 50- 100 cm, profusely branched and erect stem. This plant is used as a remedy for various diseases in most of Asian countries (Niranjan *et al*., 2010). Except medicinal properties *A. paniculata* possess allelopathic effect. Nagaraja and Deshmukh, (2009) investigated allelopathic effect of *A. paniculata* residue on growth and physiology of *P. hysterophorus*. Mandal *et al*. (2016) also reported aqueous leaf extracts of *A. paniculata* reduced seed germination and seedling growth of wheat (*Triticum aestivum* L.).

Ocimum sanctum L., (Lamiaceae) commonly known as Basil. The plant characterized by 0.5-1.5 m tall, much branched and leaves are rich in secondary metabolites (Singh and Singh, 2009, Purohit and Pandya, 2013). It is also rich in pharmacological properties thus used as a medicinal plant in India (Islam and Kato-Noguchi, 2014). Other than the medicinal properties of *O. sanctum* some researchers have investigated phytotoxic activity of *O. sanctum* on different weed species and common legume species (Singh and Singh, 2009; Islam and Kato-Noguchi, 2014; Purohit and Pandya, 2013).

Celosia argentea L. (Amaranthaceae) show erect growth to a height up to1.0 to 1.6 m. It has greater reproductive capacity, thus produces large number of seeds creating huge seed banks in the soil. Saritha and Sreeramulu, (2013) investigated allelopathic effect of *C. Argentea* for agricultural crops such as inhibitory effects on seed germination and seedling growth of *Sorghum bicolor*, *Phaseolous aureus*, *Arachis hypogaea*, *Dolichos lab lab* and *Vigna unguiculata*. Moreover, it has been reported presence of phytochemicals namely, hyaluronic acid, celosianin, betanin and isocelosianin affected on seed germination and plant growth of above crop plant.

Cleome viscose, Andrographis paniculata, Ocimum sanctum L. and *Celosia argentea* L. are commonly grown herbaceous plant in Sri Lankan

orchards. In this study mainly focused to assess the possibility of use of those herbaceous plants for papaya orchard floor management. Effects on soil nutrients, papaya plant growth, yield and weed control efficacy were investigated

MATERIALS AND METHODS

The study was conducted in Faculty of Agriculture, University of Ruhuna Sri Lanka (Low country wet zone) during 2016 to 2018. Before establishing papaya, selected weed species ie, *Cleome viscose* (T1), *Andrographis paniculata* (T2), *Ocimum sanctum* L. (T3) and *Celosia argentea* L. (T4) seedlings were established in the field. After having uniform dense weed population in each plot, seedlings of papaya variety "Red lady" were transplanted in March 2017 at a spacing of 2.5 x 2.5 m. Each plot contained 4 papaya plants and in between papaya plants, there was previously established weed species as cover crops. Hoe weeding (T5) was used as the control. Weeds were moved using a grass cutter at their blooming stage while keeping few plants for the seed production for next generation. Each treatment was repeated in three plots in a randomized block design. Plant height, and number of leaves per plant were measured at 50% flowering (50%FI) and first fruit ripening (1stFR) stages of papaya. Number of flowers per plant and number of fruits per plant were also recorded in weekly intervals. Total yield of papaya were also taken one year after planting. Number of weeds and number of weed species were also counted by using 20 cm x 20 cm quadrate at 6 month after planting. Composite soil samples were randomly collected from the top 20 cm depth of soil from each plot except manure circle of papaya plant before cover crop establishment and at 6 months (6 MAP) and 12 months (12 MAP) after planting. Soil samples were air dried, grounded and sieved in 2 mm mesh. Total nitrogen (N), available prosperous (P), extractable potassium (K) and total organic carbon (TOC) were analyzed at plant nutrient laboratory, Tea Research Institute, Walahanduwa, Sri Lanka.

The analysis of variance for all data was measured using the ANOVA procedure of the statistical analysis system (SAS). The mean values were separated by using Duncan's Multiple Range Test (DMRT) at the 0.05 probability level.

RESULTS AND DISCUSSION

Intercropping cover crops along with other cash crops can have some unique benefits, such as improving soil fertility, reduction of soil erosion, water evaporation, stimulate pollinators, increase soil organic matter content *etc*. Therefore integration with cover crops is an important agricultural practice in sustainable crop production systems. Some weeds can also be used as a cost effective cover crop in crop fields as there is no cost for seeds and establishment in the field. Those weeds can frequently and easily mow down using a grass cutter which reduces the cost for herbicide application. In this study, the suitability of four herbaceous weed species as a cover crop in papaya orchards was investigated as an organic weed control method.

It was observed that cover cropping of *Ocimum sanctum*, *Celosia argentea*, *Cleome viscose* and *Andrographis paniculata* did not significantly affect on plant height and number of leaves of papaya (Table 1) with respect to hoe weeding. However, papaya plants which intercropped with *Cleome viscose* showed significant (P = 0.05) reduction in number of number of fruits per plant (Table 1) at 50% fruiting stage (Table 1) and it continued up to 12 months after planting (Figure 1). All the plots intercropped with herbaceous weeds gave lower yield compare to the control plots. The reason for the lower yield might be the allelopathic effect and competition for growth resources between herbaceous weeds and papaya. However, all cover crops except *Cleome viscose*, did not significantly affect on average yield of papaya (kg/plant). The control (hoe weeding) showed maximum fruit yield (25.81 kg/plant) (Figure 1).

Significant difference was not observed in number of weeds and number of weed species among treatments (Table 1). Linares *et al*., (2008) reported cover cropping of Sun hemp (*Crotalaria juncea* L.), hairy indigo (*Indigo ferahirsuta* L.), cowpea (*Vigna unguiculata* L. Walp.) and alyceclover (*Alysicarpus vaginalis* L.) in organic citrus orchards provide better weed control by means of weed suppression and cover crops dry matter accumulation. Cheema and Khaliq, (2000) investigated that sorghum stalks soil incorporation

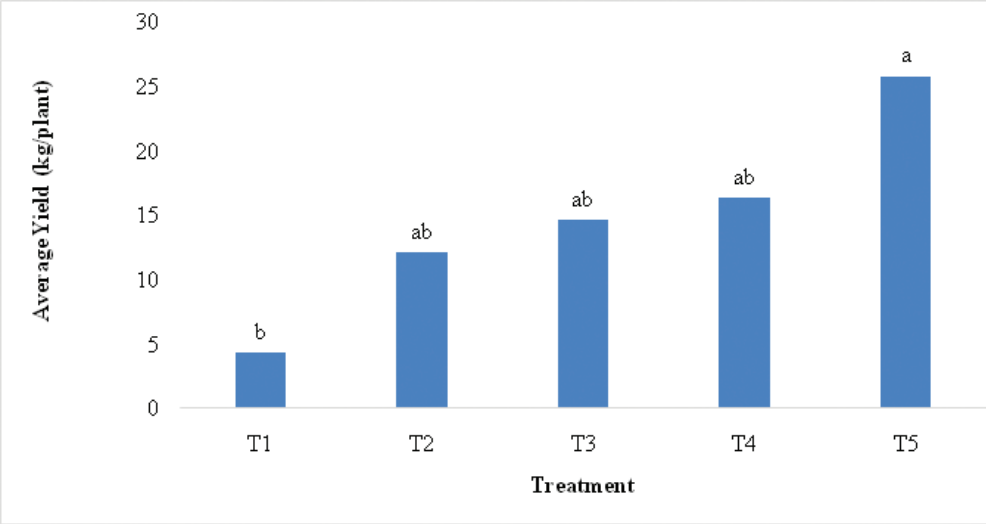

Figure 1: **Effect of herbaceous weed cover crop on average yield of papaya**. (Means with identical letters within the graph do not differ significantly based on the Duncan's Multiple Range test ($p < 0.05$), T1-*Cleome viscose*, T2-*Andrographis paniculata*, T3-*Ocimum sanctum* L., T4-*Celosia argentea* L. and T5- *hoe weedi*

Table 1. Effects of cultivation of different herbaceous weeds as a cover crop in papaya orchards on growth and yield of papaya and weed population of the field.

Treatment	Plant height (cm)		No. of leaves		No. of flowers	No. of fruits	No. of weeds/400 cm^2	No. of weed species/400 cm^2
	50% FI	1st FR	50% FI	1st FR				
C. viscosa	85.3 a	157.8 a	13.0 a	16.5 a	2.22 b	6.3 b	49.7 a	4.0 a
A.paniculata	106.3 a	187.0 a	14.5 a	19.1 a	4.02 ab	12.3 a	41.7 a	4.0 a
O. sanctum L	100.3 a	184.2 a	14.3 a	18.7 a	6.06 a	13.2 a	50.8 a	3.3 a
C. argentea	110.4 a	203.1 a	15.0 a	21.8 a	4.46 ab	15.5 a	71.8 a	3.8 a
Hoe weeding (control)	101.2 a	200.8 a	15.3 a	21.3 a	4.34 ab	19.6 a	95.8 a	4.2 a

in to the wheat field, controlled weed by 40-50% and increased grain yield by 15%. It was observed that weed suppression occurred due to the release of sorghum allelochemicals in to the soil. Moreover it has been reported that the use of cover crops in developing countries reduces input costs while improving soil productivity and crop yields (Akemo *et al*., 2000). A research conducted by Tursun *et al*. (2018) on soil management in apricot orchards reported mowing or soil incorporation of living cover crop can increase weed suppression efficacy.

The effect of herbaceous weeds on soil chemical properties at 6 and 12 month after establishment (MAE) is shown in figure 2. Total available N content 6 MAE was greater in control treatment, probably as consequence of use of N by both herbaceous weeds and papaya plants. 12 MAP increased amount of total available N was observed in all treatments except control, possibly as a consequence of incorporating mowed herbaceous weed materials with the soil. But there was no significant increment compare to the control where also hoe weeded biomass was incorporated with soil. It is well known phenomenon that the N fertilizer can easily loss from leaching or denitrification from soil profile. Similarly rapid release of N from decaying plant parts can also happen at field condition with tropical environmental condition. Therefore, measuring increment of N levels after decomposing moved herbaceous weeds at field level is a difficult task.

A significant influence of herbaceous weed cover on available P, extractable K and total organic

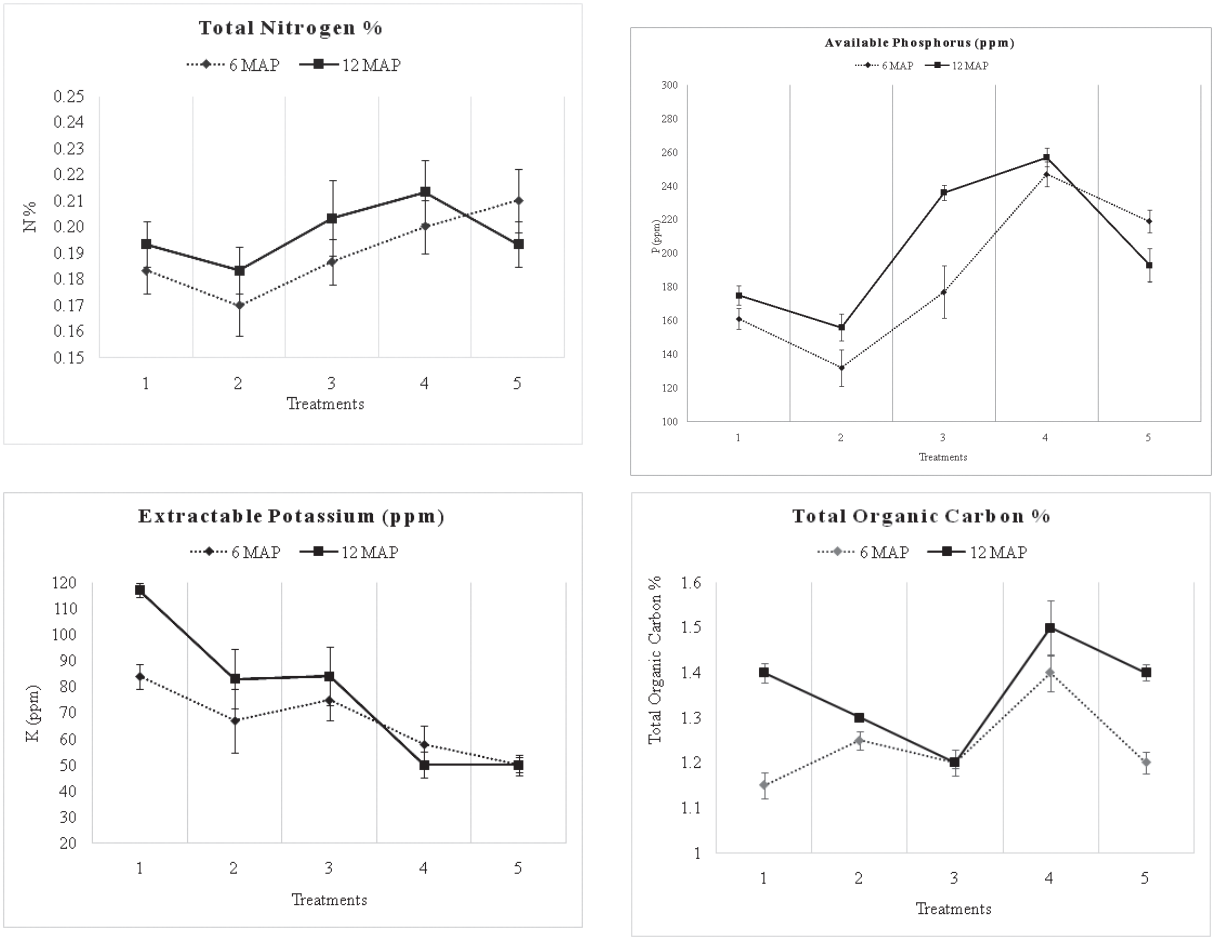

Figure 2: Soil total Nitrogen , available Posperous , extractable Potassium and total organic carbon levels as affected by different cover crops at 6 and 12 month after cover crop establishment. P <0.05 . Vertical bars show standard errors of the means. T1-*Cleome viscose*, T2-*Andrographis paniculata*, T3-*Ocimum sanctum* L., T4-*Celosia argentea* L. and T5- *hoe weeding*)

C contents of the soil was observed in this study. *Celosia argentea* (T4) and control treatments showed significantly higher values for available P in 6 MAE. *Celosia argentea* and Ocimum *sanctum* showed significantly higher amount of available P. Available P contents were increased in 12 MAE in all treatments except control than the valued observed in 6 MAE. Similar trend was observed in extractable K and total organic C % also. This indicates that there is a long term effect on this practice for soil nutrient contents (figure 2). Higher biomass production by herbaceous weeds and residue application by slashing can increase the soil properties long term. This result also agreement with the study conducted by Sainju *et al*. (2002). They reported increased soil organic carbon and nitrogen concentration in no tillage system with the application of cover crop residues of hairy vetch and winter weeds. And also Diacono and Montemurro, (2011) reviewed that decomposition of organic matter is done by heterotrophic microorganisms and this process is affected by temperature, moisture and ambient soil conditions and leads to the release and cycling of plant nutrients. According to the observations, cover cropping of *C. argentea* (T4) showed maximum performance in increment of soil nutrient except soil extractable potassium level.

CONCLUSION

The hoe weeding method is labour intensive method than intercropping of herbaceous weeds.

Thus intercropping of *Celosia argentea* was nearly as productive as the hoe weeding methods by means of economicall advantage and organic weed management method. Similarly keeping orchard floor green in throughout the period and adding weed trashes time to time can improve soil nutrient status and structure. This practise is supported more sustainable orchard floor management.

REFERENCES :

Akemo, M.C., Bennett, M.A., and Regnier, E.E. 2000. Tomato Growth in Spring-sown Cover Crops. *Hortscience,* **35(**5):843–848.

Ayoola, P. and Adeyeye, A. 2010. Phytochemical and nutrient evaluation of *Carica papaya* (pawpaw) leaves. *Ijrras,* **5**: 325-328.

Cheema, Z. and Khaliq, A. 2000. Use of sorghum allelopathic properties to control weeds in irrigated wheat in a semi arid region of Punjab. *Agriculture, Ecosystems & Environment*, **79**: 105-112.

Diacono, M. and Montemurroo, F. 2011. Long term effect of organic amendmends on soil fertility. *Sustainable Agriculture*, **2**: 761-786.

Islam, A. and Kato-Noguchi, H. 2014. Phytotoxic activity of *Ocimum tenuiflorum* extracts on germination and seedling growth of different plant species. *The Scientific World Journal*, : 1-8.

Jana, A. and Biswas, S.M. 2011. Lactam nonanic acid, a new substance from *Cleome viscosa* with allelopathic and antimicrobial properties. *Journal of Biosciences*, **36**: 27–35.

Linares, J., Scholberg, J., Boote, K., Chase, C.A., Ferguson, J.J. and Mcsorley, R. 2008. Use of the cover crop weed index to evaluate weed suppression by cover crops in organic citrus orchards. *Hort. Science,* **43:** 27-34.

Mandal, M.P., Pal, V., Kumar, S. and Mandal, S.K., 2016. Allelopathic Effects of Leaf Extracts of Kalmegh on Seed Germination and Seedling Growth of Wheat (*Triticum aestivum* L.). Research and Reviews: *Journal of Botanical Sciences*, **5**: 50-53.

Nandi, P. and Ghosh S.N. 2016. Effect of medicinal plants as intercrop on plant and soil of Mosambi sweet orange gown in laterite oil. *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, **2**(2): 11-13.

Nagaraja, T. and Deshmukh, S. 2009. Phytotoxic effect of *Andrographis paniculata* Nees on metabolism of *Parthenium hysterophorus* L. *Journal of Biopesticides*, **2**: 165-167.

Natarajan, A., Elavazhagan, P. and Prabhakaran, J. 2014. Allelopathic Potential of Billy Goat Weed *Ageratum Conyzoides* L. and *Cleome Viscosa* L. on Germination and Growth of *Sesamum Indicum* L. *International Journal of Current Biotechnolog.*, **2**: 21-24.

Niranjan, A., Tewari, S.K. and Lehri, A. 2010. Biological activities of kalmegh (*Andrographis paniculata* Nees) and its active principles: A review. *Indian Journal of Natural Products and Resources*, **1**(2):125-135

Purohit, S. and Pandya, N. 2013. Allelopathic activity of *Ocimum sanctum* L. And *Tephrosia purpurea* L. Pers. Leaf extracts on few common legumes and weeds. *International Journal of Research in Plant Science*, **3**: 5-9.

Sainju, U.M., B.P. Singh, and W.F. Whitehead. 2002. Long-term eff ects of tillage, cover crops, and nitrogen fertilization on organic carbon and nitrogen concentrations in sandy loam soils in Georgia, USA. *Soil Tillage Res*., **63**:167–179.

Saritha, P. and Sreeramulu, A. 2013. Allelopathic effects of *Celosia argentea* L. root extracts on crop plant seed germination. *International Journal of Life Sciences Biotechnology and Pharma Research,* **2**: 142-154.

Singh, S. and Singh, M. 2009. Interactions of basil (*Ocimum sanctum* L.) with some weed species-competition or allelopathy? *Indian Journal of Weed Science*, **41**: 12-22.

Tursun, N., Isik, D., Demir, Z. and Jabran, K. 2018. Use of living, mowed, and soil incorporated cover crops fro weed control in apricot orchards. *Agronomy*, **8** (150):1-10

Vij, T. and Prashar, Y. 2015. A review on medicinal properties of *Carica papaya* Linn. *Asian Pacific Journal of Tropical Disease,* **5**:1-6.

Workneh, T., Azene, M. and Tesfay, S. 2012. A review on the integrated agro-technology of papaya fruit. *African Journal of Biotechnology,* 11:15098-15110.