Advances in Environmental Biology, 11(2) February 2017, Pages: 34-41

AENSI Journals

Advances in Environmental Biology

ISSN-1995-0756 EISSN-1998-1066

Journal home page: http://www.aensiweb.com/AEB/

Study of a co-culture tomato / Datura model (*Solanum lycopersicum* L. - *Datura stramonium* L.) in plain field

[1]Samira Morsli, [1]Samira Setbel, [2]Ramila Guendez-karmia, [3]Miloud Hammache and [3]Salaheddine Doumandji

[1]*University of Mouloud Mammeri, Agronomic department, Agronomic and science faculty , Tizi Ouzou, Algeria.*
[2]*Preparatory School in the science of nature and of life, El Harrach, Algiers, Algeria.*
[3]*The National High School of agronomy, Department of Agriculture and Forestry Zoology, ENSA (ENSA/1603), El Harrach, Algiers, Algeria.*

Address For Correspondence:
Samira Morsli, University of Mouloud Mammeri, Agronomic department, Agronomic and science faculty , 1500, Tizi Ouzou, Algeria

Received 18 December 2016; Accepted 12 February 2017; Available online 26 February 2017

ABSTRACT

The Co-cultivation associates small plants (usually solanaceous) and large-sized plants. There is every reason to believe that co-culture can double production per unit area and work, although no systematic research has confirmed this. Our study is based on this hypothesis; during 2012, an experimental protocol has been set up, on the whole one variety of tomato "TIZIRI" is implanted in association with *Datura stramonium* L as intercropping, The objective of this trial is to study the evolution of cultivars but also in a biological way without using chemicals products, and the identification of diseases due to insect attacks on the crop. And also to evaluate the production of tomatoes. Some agronomic parameters, in this case the number and size of the fruits, cumulative production, were studied. concerning the production, this technique of co-culture has made it possible to improve the total yield of the tomato, and to reduce the rate of insect and other disease-induced insect attacks, Up to 87.01%, the number of fruits per plant is of the order of 12 fruits per plant, our test provided other information concerning the alleopathic effect, in these plots tomatoes Datura contained less weeds as well as testing the most suitable tomato and Datura cultivars for intercropping and determining best Crop protection, weed control and predator control.

KEYWORDS: Co-culture, Tomato, *Datura stramonium* L, intercropping, Alleopathic.

INTRODUCTION

The tomato (*Solanum lycopersicum* L.) is a species of the great Solanaceae family [10, 55, 12]. It is considered as the first vegetable after the potato and second world food resource after cereals. It is adapted to a wide variety of growing conditions and intended for consumption in fresh or industrial processing. It is widely produced in the field and in gardens [49].

Annual global tomato production has increased steadily from over 110 million tons in 2000, from 129 million tons in 2005 to 152 million tons in 2010. In 2013, around 163 million tons of tomatoes were produced in the world [17].

In Algeria, tomatoes occupy a prominent place in the agricultural economy. According to [17], tomato production in Algeria is estimated at 975 075 tons in 2013. The latter remain low and quite distant from those recorded in other Mediterranean countries (Tunisia, Morocco, Spain, France and Italy) producers of tomato.

Actually, one third of the world's agricultural production is annihilated from one year to another due to various bacterial, fungal and insect pest diseases. Each year, the latter consume on average of 10% of the plant production in natural systems and are responsible for more than 15% of crop losses in the world [52]. As well, in order to survive in such environments, plants have had to develop various strategies during evolution to reduce the damage caused by their natural enemies and in particular by phytophagous insects [13].

Moreover, in the *Solanaceae*, the production of secondary metabolites plays a predominant role in the defense processes of the plants [23]. These are called upon to respond actively to the attacks of phytophagous [13]. Actually, several techniques are exploited in agriculture to encourage these natural mechanisms of defense in plants. Among these methods, the biological and intercropping culture which is widely used by farmers producing organic foods with high nutritional value. As well as the interplant plants act as cover crops of the soil by limiting the erosive effect caused by the rains, and improving the structure and the soil aeration. As a result, they also reduce the risk of compaction, runoff and soil erosion. The improvement of all these aspects induces a better penetration of the water. Moreover, this technique is gaining interest especially as it contributes to the organic cultivation while preserving the biodiversity in the edge of plots and in the neighboring biotopes [54, 32].

In our study we have used *Datura stramonium* in co-culture with tomato, as this species has many applications in many fields such as ornamentation, environment (water and soil pollution control) and especially in the fight Biological control of pests such as mites and whiteflies [5]. The study will allow us to evaluate the influence of a co-culture (*Datura*- tomato) on the parameters of production and on the different diseases of the tomato.

MATERIALS AND METHODS

a. Biological material:

The co-culture of the tomato (*Solanum lycopersicum* L.) of the Tiziri variety is associated with *Datura stramonium* L., it is carried out in intercropping, and the experiment is carried out on a plot of 140 m2, at the level of the High National School of Agronomy (ENSA). It is located at 20 km east of Algiers (Algeria) at 48 m altitude, in the sub-humid bioclimatic stage (rainfall: 630 mm) characterized by a mild Mediterranean climate and on a type clayey, sandy, silty soil that is permeable.

B. Experimental methods:

Planting of the two species (tomatoes and Datura) is carried out in April 2012, in 72 (6 cm x 12 cm) alveoli. After three weeks of cultivation, the plants are transplanted into the experimental plot, they are divided into three experimental units (UE), the interval between two UE, is 0.50 m each experimental unit is divided into micro-plots of $6m^2$ (3m X 2m) and spaced 2m each one from another. Each micro-plot corresponds to a treatment and contains five (05) lines spaced 0.60 m each one from another. The spacing between two plants is about 0.6m for both species. The fertilization is applied as soluble fertilizers during irrigation. The macro elements (N, P, K) are brought in equilibrium (15-15-15) with varying amounts depending on the stage of development of the crop. Maintenance of the crop was limited to the size of the auxiliary buds of the tomato, the removal of leaves from the base of the plants and the old leaves of both species, and manual weeding. No pesticides were used on the plots throughout the trial period. The measurements were carried out from the date of transplanting of the plants (Early May) to the end of the life cycle of the tomato (Early October), with regard to irrigation, the latter is carried out by the drop-by- drop.

The experimental setup is carried out in total randomization with four treatments: T_0: control (tomato only), T_1: plant / plant (tomato / *Datura*), T_2: line / line (tomato / *Datura*) and T_3: Treatments is repeated three times. Each elementary plot is made up of a total of 25 plants. The measurements are made only on tomato plants to understand the influence of intercropping on the development of the latter. The parameters studied are:

Estimated fruit losses:

After fruit harvesting, the effectiveness of the treatments is judged by counting the total number of healthy fruit (TNHF) and the number of damaged fruits (NDF) by the insects.

Inventory of different diseases on leaves:

The different diseased plants are taken into account to know the different diseases and to classify them according to their origin (insect), two plants are sampled by row. 09 leaves per plant are carefully observed (3 from the base, 3 in the middle and 3 at the apex). A total of 18 sheets per row and 54 sheets per micro-plot are 162 sheets for each treatment.

% Infestation = (Number of infested leaves / Total number of leaves) X 100

Agronomic parameters:

Three production parameters were used to evaluate the response of the crop to the infill: (FW) the average fruit weight per treatment in (g) and (NFP) the average number of fruits per plant and finally the average size of the fruit per treatment (ASF).

Statistical analysis:

Data analysis is performed using the "Statgraphics" software (version 15.1.0.2). The variables studied are first subjected to an analysis of variance (ANOVA) to a classification criterion. If the ANOVA test is significant, the study is supplemented by the Student LSD test (Leat Significant Difference). At the 5% threshold when there is a significant difference, the graphs are made by using software stratigraphics version 15.2.05

RESULTS AND DISCUSSIONS

It is recognized today that in the solanaceae there is production of secondary metabolites having a main role in the processes of defense of the plant [23]. There have been brought during evolution to respond actively to the attack of phytophagous plants [13].The protocol puts in place initially allowed to identify and quantify the diseases of the tomato cultivated in intercropping in the presence of *D. stramonium* in plain field.

Estimated fruit losses:

The loss of tomato fruits remains low for all applied treatments (tomatoes and Datura), and varied between 5.88 and 3.88% compared to the control (Tomato only) which records a accumulation of loss of 29.86%. This fluctuation is certainly due to the presence of intercropping (*Datura stramonium*), which contributes effectively to the reduction of insect attacks and physiological diseases by reducing losses from 80.31 to 87, 01% for treatments T_3 and T_2 (Tab.1).

Table 1: Percentage of fruit loss per treatment

Treatments	PN	TNHF	TNHF	NDF	L	RLC
T_0	25	221	155	66	29,86	-
T_1	25	286	274	12	4,19	85,97
T_2	25	283	272	11	3,88	87.01
T_3	25	323	304	19	5,88	80,31

PN: Plants' numbers TNF: Total number of fruit, TNHF: Total number of healthy fruit, NDF: Number of damage fruit, L: Loss (%) RLC: reduction of Loss Control (%)

Fruit loss factors are mainly caused by insects showing higher proportions in the control plots (18.1%) compared to plots with *Datura*, these infestation rates remain low in the range of 1.4 to 3.4 % (Tab.2). These results are due to the presence of Datura stramonium at the treatment level. It is known that this species has trichomes that secrete toxic bimolecular that act on herbivorous insects [53, 64, 36, 14, 62, 37, 23]. A study by [59] on the role of these foliar trichomes in the defense mechanism against herbivores shows that the density of trichomes is an integral component of plant resistance to herbivores in most populations of *Datura Stramonuim*.

Table 2: Impact of rejected harvest factors expressed as a percentage

Treatments	total rejection on fruit	blossom-end rot (%)	blight (%)	Insects (%)
T_0	29,86	4,5	7,2	18,1
T_1	4,19	0.7	0,2	2,3
T_2	3,88	2,4	0,0	1,4
T_3	5,88	2,3	0,1	3,4

So, this weak rate of the herbivors attack on the culture supposrts the hypothesis that the foliar trichomes are the source of the limitation of the insects attack in the intercropping plots, thereby limiting the progress of cryptogamic deseases generally conveyed by these latters[43, 44, 60, 61,15].

The *D. stramonium*, like many other medicinal plants, shows a good tolerance and considerable insecticide and nematicidal activities [45, 11, 29, 21]. The *Datura* works like an insect repellent which protects plants from these potential pests [50] as well as *Zanthoxylum alatum* and *Cannabis sativa* that cause the reduction of gall nematode infestation *Meloidogyne incognita*.

Concerning the apical rot (physiological disease) observed in the tomato, the most common assumption is that this rot is due to the lack of calcium partially, generally accented by water stress [9], outdoor culture and in summer period. In certain cases, other factors contribute in the rot induction such as the long sunlight periods and high temperatures [8].

However, the quantity of tomato downgraded by downy mildew is insignificant in the three treatments T_1, T_2 and T_3. The first symptoms are reported by mid-June on the control plots, thereafter, downy mildew is stopped by the unfavorable dry conditions to its spread.

Several studies have also reported the effect and efficiency of the *Datura stramonium* against different bacteria and fungi, to the example *Myrothecium roridum*, *Alternaritenuis* and *Xanthomonas campestris malvacearum* which attack cotton plants and also against *fusarium oxysporum*, *fusarium mangiferae*, *rizoctonia solani* [58]. Other authors note its efficiency against downy mildew *phytophthora infestans* by limiting its spread in the tomato fields [56]. Moreover, many authors have shown that the attack of phytophagous insects induces biochemical or physiological changes in the plants, the fact that has negative consequences on the feeding and growth of these herbivores and positive consequences on the plant fitness.

Infestation rate by insect category on the tomato leaves:

The inventoried insects reveal largely the existence of certain pests such us green aphids (*Aphidae sp., Aphis sp.*) and dipteral (*Liriomysa sativa*) and Lepidoptera as well (*Tuta absoluta*). The results of the tomato infestation rate are recorded in Tab. 3.

Table 3: Infestation rate of different insect categories on the leaves

Treatments	Analysed leaves number	Infestation on the leaf (%)	Green aphid (%)	*Tuta absoluta* (%)	*Liriomysa sativae* (%)	Moths (%)
T_0	162	14,82	3,7	5,32	3.7	2.1
T_1	162	1.4	1.2	0	0.2	0
T_2	162	2.3	2.2	0	0.1	0
T_3	162	2.2	2.1	0	0.1	0

The most recurring and most damaging insect attacks on tomatoes are related to suckers and Lepidoptera. Among the suckers, the aphids are present with a rate of 3.7%, the percentage of attack remains at this moment, their precedence causes deformations or even wrapped leaves on themselves, which hinders flowering. Lepidoptera are mainly moths such as *Helicoverpa armigera* which consumes fruit, causing low losses of tomatoes (2.1%) on the control. As for the Diptera *Lirionyza sativae*, their damage to the field is estimated at 3.7%. On the other hand, the tomato leaf miner reports its precedence on leaves of the tomato alone, the *Tuta absoluta* at an infestation rate of the order of 5.32%; it remains a high rate compared to the other treatments from where Tuta Was not observed. It is known that Datura is a plant that produces secondary compounds usually these are alkaloids, the latter are produced in all parts of the plant at different rates, *D. stramonuim* shows a very toxic and anti-appetizing effect Against beetles [1].

Analyzes of the secondary metabolites scopolamine and hyoscyamine carried out on Datura stramonium on the same plots show that the average hyoscyamine (HS) content is higher than that of scopolamine (SC) with 0.723 ± 0.11 mg g $^{-1}$ and 0.277 ± 0.04 mg.g^{-1} MS [41], this rate of production of these alkaloids depends on several environmental factors, stage of plant, development and edaphic conditions, and environmental humidity [26, 7, 18], in particular phytophagous insects which are selection agents on these alkaloids [51]. Most alkaloids are important for the survival of the plants that produce them, since they contribute to their protection against herbivores and / or phytopathogenic microorganisms [22, 63]. During an attack or infection, for many plants, the secondary metabolism accelerates; the biosynthesis of new compounds (phytoalexins) takes place and the concentration of the already existing compounds increases [63]. Jasmonic acid is known as a cell signal that triggers the induction of secondary metabolites involved in defense against attack [16].

Many authors believe that there is a real co evolution between the production of secondary metabolites and insect attacks [6, 40, 54], this co evolution results in reduction in scopolamine and stabilization of hyoscyamine [54]. [20] Highlighted this phenomenon by showing that the consumption of potato leaves *Solanum tuberosum* by the larvae of the Colorado potato beetle *Leptinotarsa decemlineata* induces a rapid accumulation of protease inhibitors in the leaf of the plant. These allow to retard the growth of the phytophagous plants which ingests it [28, 48], which made it possible to improve the resistance of the plant against the pest [24, 47].

According to [13], the response of the plant to attacks can also be specific to the consumer species; the type of damage inflicted or even of the larval stage, attacking the plant. Substances present in the saliva of herbivores and brought into contact with plant cells during the feeding of the phytophagus explain the specificity of the response of plants to insects [38, 3].

Production Parameters:

The harvest takes place over two months (beginning of August until the beginning of October). The analyzes of the variances of the studied parameters show highly significant effects for all the traits studied, this explains the positive effect of the co-culture (tomato and Datura) on each other. Tab. 5 shows that the production varies according to the treatments applied, except for the control which produces less than the other treatments according to the LSD test at the 5% threshold.

Table 5: Production characteristics for each treatment

Treatments	NFP	PF (g)	FAC (mm)
T_0	$09 \pm 04{,}51^{b}$	411 ± 328^{c}	67 ± 10^{ab}

T_1	11 ± 04,18[ab]	596 ± 216[ab]	59±9,94[b]
T_2	11 ± 04,48[ab]	558± 188[b]	68±10,46[a]
T_3	12. ± 04,40[a]	688± 118[a]	64±9[ab]

The letters next to the numbers represent the homogeneous groups. The values having different letters are statistically different at 5%. NFP: Average number of fruit per plant, PF: Fruit average weight, FAC: Fruit average caliber.

The analysis of the variance of the production data reveals 02 homogeneous groups, concerning the average number of fruit per plant (NFP) and showing three homogeneous straddling groups, concerning the weight of fruit (PF) shows the precedence of two Homogeneous groups a and b. These last two characters express fairly well the production and the quality of the fruit for each treatment. Treatments T_1 and T_2 produce (596 g / plant and 558 g / plant respectively) for T_3 treatment, it is of the order of 688 g / plant that occupies the first row, this parameter is markedly lower for the T_0 control with 411 g / plant. In general, the analysis of the evolution of production has made it possible to demonstrate the effectiveness of the different treatments.

Concerning the average number of fruits per plant, it is significant and falls into the yield components. The average number of fruits per plant varies according to the treatments. It is the lowest for T_0 (09 fruits), it evolves similarly and intermediate for T_1 and T_2 (11 fruits per plant) and higher for T_3 (12 fruits). Despite the low levels of damage, herbivorous insects decreases plant production, the analysis of variance shows a significant difference. For the average fruit size (CMF), the Tiziri variety has a large size with a value that exceeds 60% between 57 and 67 mm. There is a large difference in the size of the fruit.

In general, the analysis of the evolution of production has made it possible to demonstrate the effectiveness of the different treatments. Thus, the highest yield is observed in the treated units (tomato and Datura) and lowest in the control plots (in the absence of Datura). Average fruit production per plant varies from one treatment to the next but remains higher compared to controls with clearly superior and well-bearing fruit sizes with no traces of disease on the latter. The rate of fruit loss remains much reduced for treatments (tomato and Datura). This difference is due to the improvement of the techniques of cultivation in the plots (regular irrigation and Fertilizer input). Indeed, the intercropping of tomatoes and Datura yields interesting results; they contain fewer weeds than the cultivation of tomatoes alone (the allopathic effect). Thus intercropping suppresses weeds by competition or allopathy [33, 27, 4]. In addition, several studies have shown that the ability to control weeds by a crop is very different (or variable) from one variety to another. This difference is partially explained by the ability of these crops to secrete chemicals that affect weed growth, namely allopathy [46, 4]. This practice can be particularly useful in organic farming, where herbicides are not an option [35]. We see that intercropping provides us with more flexibility. With more than one species at a time, in order to limit the risk of propagation of phytosanitary problems, several choices are possible in intercropping [33, 27], Datura can be particularly advantageous in combination with other crops (it is annual, with very high growth [58]; It is likely to have positive effects on soil quality improvement [33, 27]. Indeed, a study by Levitt and Lovett, 1984 on different soil types to show the allochemical activity of *D. stramonium*, Shows the positive effect of this plant on the increase of the resistance of the soil, it can affect the germination of the seeds and so delay it, or the development of the plants is inhibited [31, 4] The alkaloids present in Datura such as Tropanes including scopolamine and hyoscyamine were present in soil extract, both are at equal concentrations [34].

Conclusion:

Tomato plants are green and healthy much longer; they are a little affected by disease. The fruits harvested are of excellent quality, round brilliant, good firmness and very well colored; it nonetheless has variability in the caliber: mostly (57 and 67mm) which make tomato fruit more attractive to the consumer. The intercropping technique allows the improvement of the quality of soil "biological quality of soil" [19] but also by reduction of the numerous populations of the pathogen with a good yield and an improvement of the quality of the fruit without use of chemical product.

However, if chemical defense is costly, secondary metabolites should be closely regulated and strongly correlated with defense against insects [39, 54]. During an attack or infection, for many plants, the secondary metabolism accelerates; the biosynthesis of new compounds (phytoalexins) takes place and the concentration of the already existing compounds increases [30]. At low doses, tropical alkaloids may have important pharmaceutical applications: muscle relaxants, analgesics, tranquilizers and psychotropic drugs [24, 30]. For this purpose, intercropping offers the possibility of harvesting the Datura to be used for the production of secondary metabolites in pharmacology. This justifies the great potential to exploit alkaloids in Algeria provided that an adequate research approach is implemented, including an inventory, characterization and valorization of potentially interesting species [42].

Thanks:

The authors would like to thank Dr. Morsli Abdelkader, and Prof. Kelifi Lakhdar, teachers at the National High School of Agronomy (ENSA) El Harrach, Algiers for their collaboration.

REFERENCES

[1] Abbasipour, H., M. Mahmoudvand, F. Rastegar, M.H. Hosseinpour, 2011. Bioactivities of jimsonweed extract, *Datura stramonium* L. (Solanaceae), against *Tribolium castaneum* (Coleoptera: Tenebrionidae), Turk J Agric For., 35: 623-629.

[2] Agrawal., A.A., 1998. Induced response to herbivory increased plant performance. Science, 279: 1201-1202.

[3] Alborn., H.T., T.C.J. Turlings, T.H. Jones, G. Stenhagen, J.H. Loughrin and J.H. Tumlinson, 1997. An elicitor of plant volatiles from beet armyworm oral secretions. Science, 276: 945-949.

[4] Belaidi, A., 2014. Évaluation du potentiel biocide des extraits foliaire aqueux de (*Datura stramonium* L. et *Nerium oleander* L.). Thèse master, Université, kasdi Merbah , Ouargla, Faculté des Sciences de la Nature et de la Vie., p: 78.

[5] Beliard, E., C. Met and E. Morel-Krause, 2002. Protection alternative des cultures ornementales sous serre bilan de deux années de suivi de la lutte contre les ravageurs et les maladies dans cinq villes de la région centre. Phytoma-La Défense Des Végétaux, pp: 42-44.

[6] Berenbaum, M.R., 1983. Coumarins and caterpillars: a case for coevolution. Evolution, 37: 163-179.

[7] Berkov, S., T. Doncheva, S. Philipov, K. Alexandrov, 2005. Ontogenetic variation of thetropane alkaloids in *Datura stramonium*. Biochemical Systematics and Ecology, 33: 1017-1029.

[8] Bovey, R., M. Baggiolini, A. Bolay, E. Bolay, R. Corbas, G. Mathys, A. Meylan, R. Murbach, F. Pelet, A. Savary, G. Trivelli, 1972. La défenace des plantes cultivées. Edition Payot Lausanne. Paris, pp: 863.

[9] Carrier, A., 2010. La pourriture apicale de la tomate, Agriculture, Pêcheries et Alimentation Québec, p: 38.

[10] Chaux, C., et C. Foury, 1994. Production légumière. Tome 3. Ed Tech et Doc Lavoisier, p: 563.

[11] Chitwood, D.J., 2002. Phytochemical based strategies for nematode control. Ann, Rev. Phytopathol., 40: 221-249.

[12] Dupont, F., J.L. Guignard, 2012. Botanique les familles de plante. Edition Elsevier Masson. France, p: 300.

[13] Dugravet, S., 2004. Les composes secondaires soufres des *allium* : rôle dans les systèmes de défense du poireau et actions sur la biologie des insectes. Thèse de doctorat, université de tours. p: 198.

[14] Eigenbrode, S.D., J.T. Trumble, K.K. White, 1996. Trichome exudates and resistance to beet armyworm (Lepidoptera, Noctuidae) in *Lycopersicon hirsutum f. typicum* accessions Environ. Entomol., 25: 90-95.

[15] Elle, E., M. Nicole, N.M. Van Dam and D. Hare, 1999. Cost of glandular trichomes, a “resistance” character in *Datura wrightii* Regel (solanaceae) .Evolution, 53: 22-35.

[16] Enyedi, A.J., N. Yalpani, P. Silverman, I. Raskin, 1992. Signal molecules in systemic plant resistance to pathogens and pests. Cell, N° 70: 879-886.

[17] Faostat., 2015. Food and Agriculture Organization of the United Nation, FAO,http://faostat.fao.org.

[18] Felidj, M., Z. Hoummani, 2006. Domestication de *Datura stramonuim* sous stress hydrique pour optimisation de la production en alcaloïdes d’intérêt thérapeutique. International Symposium on Perfume, Aromatique and Medicinal Plants: from production to valorization.

[19] Girardin., P., 2010. L’agriculture biologique, un champ de recherche pour l’agronomie, courrier de la cellule environnement, n°12 : 25-31.

[20] Green, T.R. and C.A. Ryan, 1972. Wound-induced proteinase inhibitor in plant leaves: A possible defense mechanism against insects. Science, 175: 776-777.

[21] Ch. M. Sh. Hanif., M. Ul-hasan., M. Sagheer, Sh. Saleem, S. Akhtar and M. Ijaz, 2016. Insecticidal and repellent activities of essential oils of three medicinal plants towards insect pests of stored wheat. Bulgarian Journal of Agricultural Science, 22(No 3), 470-476.

[22] Harborne, J., 1993. Introduction to Ecological Biochemistry. Academic Press, London.

[23] Hare, J.D., 2005. Biological activity of acyl glucose ester from *Datura wrightii* glandular trichomes against three native insect herbivores. Journal of chemical ecology, 31(7): 1475-1491.

[24] Hilder, V.A , A.M.R. Gatehouse, S.E. Sheerman, R.F. Barker and D. Boulter, 1987. A novel mechanism of insect resistance engineered into tobacco. Nature, 300: 160-163.

[25] Hopkins, W.G., 2003. Physiologie végétale. Ed. De Boeck Université, Bruxelles, p: 514.

[26] Houmani, Z., L. Cosson, F. Corbineau and D. Com, 1994. Etude de la teneur en hyoscyamine et en scopolamine d’une population sauvage de *Datura stramonium* L en Algérie. Acta. Bot, Gallica, 141(1): 61-66.

[27] Jobin, P., Y. Douville, 1997. Engrais verts et cultures intercalaires. Centre de développement d’agrobiologie, Sainte-Élizabeth-de-Warwick, Québec, p: 20.

[28] Johnson, R., J. An, G. Narvaez and C.A. Ryan, 1989. Expression of proteinase inhibitors I and II in transgenic tobacco plants: Effects on natural defense against *Manduca sexta* larvae. Proc. Natl. Acad. Sci. USA, 86: 9871-9875.

[29] Kayani., M.Z., T. Mukhtar, M.A. Hussain, 2012. Evaluation of nematicidal effects of Cannabis sativa L.

and Zanthoxylum alatum Roxb. against root-knot nematodes, Meloidogyne incognita, Crop Protection, 39: 52-56.
[30] Khelifi., L., B. Harfi, R. Amdoun, A. Morsli, D. Zaoui, M. KhelifI-Slaoui, 2010. Effets de l'élicitation et de la perméabilisation sur la biomasse et le rendement en hyoscyamine des chevelus racinaires de *Datura* sp. Revue des Régions Arides – Numéro spécial – 24. Actes du 3ème Meeting International ''Aridoculture et Cultures Oasisennes :Gestion et Valorisation des Ressources et Applications Biotechnologiques dans les Agrosystèmes Arides et Sahariens''Jerba (Tunisie), 999: 1006.
[31] Kruse, M., M. Strandberg and B. Strandberg, 2000. Ecological Effects of Allelopathic Plants: a Review. NERI Technical Report No. 315. National Environmental Research Institute, Silkeborg, Denmark. p: 66.
[32] Laliberté, G., 2014. Implantation du ray-grass en culture intercalaire dans le maïs grain et ensilage. Organisme de bassins versants de la zone du Chêne. Sainte-Croix, QC, Canada.
[33] Leblanc, M.L., D.C. Cloutier, G.D. Leroux, 1993. Le désherbage du maïs grain combiné à l'utilisation d'herbicides en bande et de cultures intercalaires. Journée d'information scientifique: de la parcelle au champ. 17 Nov. Drummondville, C.P.V.Q. pp: 65-76.
[34] Levitt, J., J.V. Lovett, 1984. Activity of allelochemicals of *Datura stramonium* L. (Thorn-appele) in contrasting soil types, Plant and soil, 79: 181-189.
[35] Liebman, M., E. Dyck, 1993. Crop rotation and intercropping strategies for weed management. Ecological App, 3: 92-122.
[36] Liedi, E., D.M. Lawson, K.K. White, J.A. Shapiro, D.E Cohen, W. Carson, 1995. Acylsugars of wild tomato Lycopersicon pennellii alters settling and reduces oviposition of *Bemisia argentifolii* (Homoptera: Aleyrodidae). Journal of Economic Entomology, 88: 742-748.
[37] Liu, T.X., P.A. Stansly, O.T. Chortyk, 1996. Insecticidal activity of natural and synthetic sugar esters against *Bemesia argentifolii* (Homoptera: Aleyrodidae) J. Econ. Entomol., 89: 1233-123.
[38] Mattiacci, L., M. Dicke and M.A. Posthumus, 1995. Beta-glucosidase: an elicitor of herbivore-induced plant odors that attracts host-searching parasitic wasps. Proc. Natl. Acad. Sci. USA 92: 2036-2040.
[39] Mc key, D., 1979. The distribution of secondary compounds within plants. pp: 56-133.
[40] Miller, J.S. and P. Feeney, 1983. The effect of benzylisoquinoline alkaloids on the larvae of polyphagous Lepidoptera. Oecologia, 58: 332-339.
[41] Morsli, A., M. Derridj, N. Khelifi-Slaoui, R. Bakiri, L. Amdoun, L. Khelifi, 2011. Diversité morphologique et teneur en hyoscyamine/scopolamine de douze provenances algériennes de *Datura stramonium* L., Revue d'écologie, 66: 291-302.
[42] Morsli, A., 2013. Caractérisation de la diversité génétique de quelques espèces de *Datura* L. en Algérie., thèse de doctorat, Université Mouloud Maameri de Tizi Ouzou, p: 83.
[43] Nunez-Farfan, J., R. Dirzo, 1994. Evolutionary Ecology of *Datura stramonium* L. In Central Mexico: Natural Selection for Resistance to Herbivorous Insects, Evolution, p: 48.
[44] Nunez-Farfan, J., R.A. Cabrales-Vargas and R. Dirzo, 1996. Mating system consequences on resistance to herbivory and life history traits in *Datura stramonium.* Am. J. Bot., 83: 1041-1049.
[45] Oduor-Owino, P., 1993. Effects of aldicarb, *Datura stramonium, Datura metel* and *Tagetes minuta* on the pathogenicity of root-knot nematodes in Kenya, Crop Protection, 12: 315-317.
[46] Olofsdotter, M., L.B. Jensen and B. Curtois, 2002. Improving crop competitive ability using allelopathy an example from rice. Plant Breeding, 121: 1-9.
[47] Orozco-catdenas, D., B. McGurl, CA. Ryan, 1993. Expression d'un antisens prosystemin gene in plants de tomates réduit la résistance vers Manduca sexta larves .Proc. Natl. Acad. Sci. USA, 90: 8273-8276.
[48] Royo, J., J. Leon, G. Vancanneyt, J.P. Albar, S. Rosahl and F. Ortego, 1999. Antisense-mediated depletion of a potato lipoxygenase reduces wound induction of proteinase inhibitors and increases weight gain of insect pests. Proc. Natl. Acad. Sci. USA, 96: 1146-1151.
[49] Salunkhe, D.K. and S.S. Kadam, 1998. *Handbook of vegetable science and technology, Production, composition and processing.* Department of cellular biology and technology, University of Auckland, New Zealand, p: 203.
[50] Sanjita, D., P. kumar, S. Basu, 2012. Phytoconstituents and therapeutic potentials of *Datura stramonium* Linn. Journal of Drug Delivery & Therapeutics, 2(3): 4-7.
[51] Schultz, J.C., 2002. How plants fight dirty. Nature, 416: 267.
[52] Severson, R.F., O.T. Chortyk, M.G. Stephenson, D.H. Akey, J.W.J, Jr Neal, G.W. Pittarelli, D.M. Jackson, V.A. Sisson, 1994. Characterization of natural pesticide from *Nicotiana gossei*Hedin, P.A.eds. Bioregulators for Crop Protection and Pest Control. ACS Symposium Series 557. American Chemical Society Washington, pp: 107-121.
[53] Shankara, N., J.V.L. Jeude Goffau, M. Hilmi, B.V. Dam, 2005. La culture de la tomate production, transformation et commercialisation. Ed. Prota, p: 105.
[54] Shonle, I. and J. Bergelson, 2000. Evolutionary ecology of the tropane alkaloids of *Datura stramonium* L. (Solanaceae). Evolution, 54: 778-788.

Advances in Environmental Biology, 11(2) February 2017, Pages: 34-41

[55] Spichiger, R.E., V. Vincent, S.M. Figeat, D. Jeanmonod, 2004. Botanique systématique des plantes à fleurs : une approche phylogénétique nouvelle des angiospermes des régions t'eçoempérées et tropicales. 3eme édition. Lausanne : Presses polytechniques et universitaires romandes, Français, pp: 413.
[56] Smewin, B.J., R.T.A. Cook, 1988. Tomato powdery mildew .Plant. Pathol, 37(4): 594-598.
[57] Susan, E., Weaver and I. Suzanne, Warwick, 1984. The biology of Canadian weeds. *Datura stramonuim*. Cand.J.Plant.Sci., 64: 979-991.
[58]Usha, K., B. Singh, P. Prassetha, N. Deep, D.K. Agarwal, R. Agrawal, A. Nagraja, 2009. Antifungal activity of *Datura stamonuim*, *Calotropis gigantean* and *Azadiracta indica* against *Fusaruim mangifeae* and floral malformation in mango. European Journal of Plant Pathologu, 124(4): 637-657.
[59]Valverde, P.L., J. Fornoni, J. Núñez-Farfán, 2001. Defensive role of leaf trichomes in resistance to herbivorous insects in *Datura stramonium*. Journal of Evolutionary Biology, 14: 424-432.
[60]Van Dam, N.M. and J.D. Hare, 1998*a*. Biological activity of *Datura wrightii* glandular trichome exudate against *Manduca sexta* larvae. Journal of Chemical Ecology, 24: 1529-1549.
[61]Van Dam, N.M. and J.D. Hare, 1998*b*. Differences in distribution and performance of two sap-sucking herbivores on glandular and non-glandular *Datura wrightii*. Ecological Entomology, 23: 22-32.
[62]Wilkens, R.T., G.O. Shea, S. Halbreich, N.E. Stamp, 1996. Resource availability and the trichome defenses of tomato plants. Oecologia, 106: 181-191.
[63]Wink, M., 1999. Biochemistry of plant secondary metabolism. Annual Plant Reviews, 2. Sheffield Academic Press, Sheffield.
[64]Yencho, G.C., J.A.A. Renwick, J.C. Steffens, W.M. Tingey, 1994. Leaf surface extracts of *Solanum berthaultii* Hawkes deter Colorado potato beetle feeding. J. Chem. Ecol., 20: 991-995.