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Jumping Plant-Lice of the Family Psyllidae (Hemiptera: Psylloidea) From West-Cameroon: Biodiversity and Host Plants

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From 2005 to 2007, field studies undertaken in West-Cameroon permitted to enrich the biodiversity of Psyllids of Psyllidae family. This family include 7 sub-families which are: Aphalaroidinae with *Yangus* genus (4 species); Ciriacreminae with 3 genus and species (*Heteropsylla cubana*, *Ciriacremum* sp., *Kleiniella* sp.); Diaphorininae with 2 genus, *Diaphorina* (4 species) and *Epipsylla* (1 species); Paurocephalinae with 2 genus, *Paurocephala* (5 species) and *Diclidophlebia* (1 species); Rhinocolinae with 2 genus, *Cerationotum* (2 species) and a new genus with 1 species; Spondyliaspidinae with 2 genus, *Ctenarytaina* (1 species) and *Blastopsylla* (1 species); Psyllinae sub-family is the most diverse with 14 genus among which only 4 genus are knew; *Cacopsylla* (1 species), *Acizzia* (1 species), *Psylla* (3 species), *Palaeolinbergiella* (4 species); 5 genus are new to Science. Among the 37 species captured during this survey, 35 are unknown and *Blastopsylla occidentalis*, *eucalyptus* psyllid is captured for the first time in West- Cameroon. Host plants belong to more than 16 families. The damages caused by psyllids are mainly leaves folded, wrapped, deformed, discolourated with necrosis and these leaves become dry. (*Journal of Entomology* 6 (1): 1-17, 2009; doi: 10.3923/je.2009.1.17)

An Overview of *Bactrocera* (Diptera: Tephritidae) Invasions and Their Speculated Dominancy over Native Fruit Fly Species in Tanzania

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The dominancy of introduced *Bactrocera* species (Diptera: Tephritidae) over the native fruit fly species was assessed based on data collected from a trapping and sampling program in Morogoro, Tanzania, from 2004 to 2006. Two invasions by *Bactrocera* species namely the invasive fruit fly *Bactrocera invadens* Drew, Tsuruta and White and the Solanum fruit fly *Bactrocera latifrons* (Hendel) have been recorded in 2003 and 2006, respectively. These add to an earlier introduced melon fly *Bactrocera cucurbitae* (Coquillett). Points and exact times of entry of these species are still unknown. Dominance of *Bactrocera* species over the native *Ceratitidis* species has been speculated from other parts of the world. Results of this study also suggest the dominancy of *Bactrocera* species over native *Ceratitidis* species in Tanzania. *B. cucurbitae* seems to dominate the other cucurbit infesters

in terms of abundance and infestation rate. Similarly, *B. invadens* seems to dominate the native *Ceratitis* species in orchard fruits in terms of abundance, host range and infestation rate. *B. latifrons*, whose distribution in the country is still unclear, seems to be the dominant species in its main hosts from family Solanaceae. The outcome of the competition resulting from these introductions is speculated upon. Presence of these pests calls for strong surveillance systems and quarantine regulations to protect the infant fruit industry of Tanzania. (*Journal of Entomology* 6 (1): 18-27, 2009; doi: 10.3923/je.2009.18.27)

Survey of Arthropod Biodiversity in the Brinjal Field

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Field experiment was conducted to study the arthropod biodiversity in the brinjal field during February to August. Twenty species of harmful arthropods under 17 families were observed belonging to 6 different orders. The brinjal shoot and fruit borer (*Leucinodes orbonalis*), jassid (*Amrasca biguttula biguttula*), epilachna beetle (*Epilachna* sp.) white fly (*Bemisia tabaci*) and aphid (*Aphis gossypii*) were found as the most common and major insect pests of brinjal. Ten plant dwelling predaceous arthropod families were found in the field among them 42.44% were occupied by three families under Coleopteran insect. Spider under lycosidae family possessed 30.23%, which was ranked as the second most important arthropods. Surface dwelling arthropods caught in pitfall traps were grouped into 17 families among them 7 families were identified as predators. Formicidae was occupied 67% of the total surface dwelling predaceous arthropod. (*Journal of Entomology* 6 (1): 28-34, 2009; doi: 10.3923/je.2009.28.34)

Genetic Variation in a Chitinase Gene of *Beauveria bassiana*: Lack of Association Between Enzyme Activity and Virulence Against *Hypothenemus hampei*

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Like other entomopathogenic fungi, *Beauveria bassiana* produces enzymes that degrade cuticle for penetration in the host at the time of infection. Chitinases are considered important enzymes for chitin hydrolysis, one of the main insect exoskeleton components. In this study, polymorphism in *B. bassiana* chitinase gene was analyzed by PCR-RFLP and compared with the enzymatic activity and

mortality caused on adults of coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae). Thirty *B. bassiana* isolates obtained from different insect species and geographic origins were used. The activity of chitinases was not directly related with the mortality rate of each strain, emphasizing the hypothesis that the virulence is multifactorial. The chitinase gene analyses showed low variability between isolates, as only four isolates presented polymorphism. Therefore it was not possible to correlate the polymorphism with virulence and chitinolytic activity. Lack of association between chitinase gene polymorphism and enzyme activity suggests that the polymorphic region studied may not be involved in enzymatic activity of this gene. Further, lack of association between enzyme activity and virulence suggests that there may be other enzymes and factors that could contribute to infection ability. No association between polymorphism in chitinase gene with that of geographic region or origin was observed. (*Journal of Entomology* 6 (1): 35-41, 2009; doi: 10.3923/je.2009.35.41)

Prey Preference of *Orius niger* (Wolf.) and *O. minutus* (L.) from *Thrips tabaci* (Lind.) and *Tetranychus urticae* (Koch.)

S.A.A. Fathi and G. Nouri-Ganbalani

The two-spotted spider mite (TSSM), *Tetranychus urticae* Koch and onion thrips (OT), *Thrips tabaci* Lindeman, are two serious pests of potato and *Orius niger* (Wolff) and *O. minutus* (Linnaeus) are major predators of these pests in the potato fields in Ardabil region. Therefore, we compared the predation potential and fecundity of these predator when they fed on 2nd instar larvae of thrips and female mites on potato leaves in the no-choice and choice experiments in a growth chamber that was set at 24±1°C, 50±5% RH and 16: 8 h (L:D) photoperiod. In the no-choice tests, *O. niger* showed lower nymphal mortality percentage, higher fecundity and higher killing rate (k_m) when fed on 2nd instar larvae of thrips than female mites. *O. minutus* showed lower nymphal mortality percentage, higher fecundity and higher killing rate (k_m) on female mites than 2nd instar larvae of thrips. In the choice tests, the number of 2nd instar larvae of thrips consumed by different nymphal instars and the adult pairs of *O. niger* were significantly higher than the number of female mites consumed. Different nymphal instars and the adult pairs of *O. minutus* consumed significantly more female mites compare to 2nd instar larvae of thrips. Based on these results it can be concluded that *O. niger* and *O. minutus* are effective natural enemies of OT and TSSM in the potato fields, respectively. (*Journal of Entomology* 6 (1): 42-48, 2009; doi: 10.3923/je.2009.42.48)

Cotton Production in the Presence of *Pectinophora gossypiella* (Saunders) in Central Greece

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The aim of the present research was to study fluctuations of populations of *P. gossypiella* in various areas in the Prefecture of Larissa. Data were analyzed to found the relation between population density of the insect and cotton production and additionally, to explore year and local (area) conditions as factors affecting damage levels. Correlations on data between years (across all communities) revealed that, when cotton production was high then the number of adult male insects of *P. gossypiella* captured in pheromone traps was also high ($r = +0.93$). Our data indicate that, when the environmental conditions of specific years favored cotton production, then the population of *P. gossypiella* was high due to the availability of food (more flowers and bolls), in a kind of synchronization. In parallel, the presence of increased numbers of useful insects that predate cotton enemies may result in lower damages on cotton production. In years 2002 and 2003, the presence of the insect may contribute in lower cotton production in the areas where population of adult males trapped was high. The mean cotton production was generally low in the areas where population of *P. gossypiella* was high. In this case, although statistically not significant, the tension was negative ($r = -0.37$). Local conditions within each area have been proved important and these results were completely different compared to data concerning years. The specific conditions within each area determine the balance between the insect population and level of damage on cotton production. There were areas where the insect showed increased populations resulting in low cotton production. These areas may need special treatment with insecticides or other techniques in order to decrease insect populations. (*Journal of Entomology* 6 (1): 49-55, 2009; doi: 10.3923/je.2009.49.55)

Integrated Pest Management of Cotton's Spiny Bollworm (*Earias insulana*) with Spray of Diazinon and Release of Green Lacewings

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Cotton (*Gossypium hirsutum*) was planted, in a Complete Randomized Block Design (CRBD) in an experimental field of Agricultural faculty of Razi University in Kermanshah, Iran, for a two years period. Four treatments applied, 3 different

concentrations of an organophosphorous insecticide, Diazinon, plus control (without spraying of any insecticide). One month after spray of insecticide, release of 2nd instar larvae and or eggs of green lacewing *Chrysoperla lucasina* was done. The number and weight of attacked, blind, or blossomed bolls, was considered as index of efficacy, of certain insecticide concentration, together with release of lacewing. (*Journal of Entomology* 6 (1): 56-61, 2009; doi: 10.3923/je.2009.56.61)

Deleterious Effects of Cotton leaf curl virus on Longevity and Fecundity of Whitefly, *Bemisia tabaci* (Gennadius)

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Cotton leaf curl virus (CLCuV) has a complex association with their whitefly vector. To further understand these relationships, longevity and fecundity of viruliferous and non-viruliferous *Bemisia tabaci* (Gennadius) was compared on three different ages of cotton plants (25, 45 and 55 days old). *Cotton leaf curl virus* infection reduced the fecundity and longevity of *B. tabaci* compared with non-viruliferous whiteflies. Both viruliferous and non-viruliferous whiteflies survived longer on older plants than on younger plants. Female whiteflies survived longer than the male whiteflies irrespective of their being viruliferous or non-viruliferous. Plant age did not affect the fecundity however egg viability declined with increasing age of plants. (*Journal of Entomology* 6 (1): 62-66, 2009; doi: 10.3923/je.2009.62.66)

Effects of Seasonal Changes on the Microflora In the Hindgut of Wood-Eating Termites

T.O. Femi-Ola and E.Y. Aderibigbe

The bacterial population in the hindgut of the higher wood-eating termite, *Amitermes evuncifer* Silvestri was estimated at both dry and wet seasons. The total bacterial counts in the soldier and worker termites were $1.46 \pm 0.26 \times 10^6$ and $2.51 \pm 0.31 \times 10^6$ cfu mL⁻¹ during the wet season; while it was $5.30 \pm 1.1 \times 10^4$ and $5.8 \pm 0.9 \times 10^4$ cfu mL⁻¹ during the dry season, respectively. There was no significant difference in the total bacterial count in the hindgut of the worker and soldier termites in both seasons. The total bacterial count in the dry season was significantly lower ($p \leq 0.05$) than the population during the wet season. The bacterial species were identified to be *Bacillus subtilis*, *B. cereus*, *Micrococcus luteus*, *Streptococcus* sp. and *Serratia marcescens*. (*Journal of Entomology* 6 (1): 67-71, 2009; doi: 10.3923/je.2009.67.71)

Combining Effect of *Beauveria bassana* (Bals.) and *Eretmocerus mundus* Mercet (Hymenoptera: Aphelinidae) on Sweetpotato Whitefly, *Bemisia tabaci* Gennadius (Aleyrodidae; Hemiptera)

Mohammad A. Al-Deghairi

Combined effects between the entomopathogenic fungi, *Beauveria bassana* (Bals.) and whitefly parasitoid, *Eretmocerus mundus* Mercet on *Bemisia tabaci* (Genn.) were investigated under laboratory conditions. The competitive interactions among them were also evaluated either alone or in combination, in respect of the positive and negative effects. The deleterious effects on the parasitoid were extremely low, particularly when the parasitized nymphs exposed to the fungus later. In direct contact bioassay, fungus caused 5.1-15.3% mortality in post-releasing trial and from 8.9-22.1% in pre-releasing trial. Three to five days after treatment, *B. tabaci* nymphs were rejected as a host by *E. mundus* females due to the fungal infection. In infected nymphs, the majority of *E. mundus* females were not laid and no parasitism was detected. The control efficiency of the two natural enemies of *B. tabaci*, when used separately or in combination, varied according to the tested biological agent. *E. mundus* alone reduced pest populations by 19.4 and 51.1% in pre- and post-releasing trials, respectively. *B. bassana* caused 38.1% in pre-releasing trial and 29.4% in post-releasing trial. Meanwhile, the interaction between fungus and the parasitoid in combination reduced the pest population by 51.2 and 72.3% in pre- and post-releasing trials, respectively. (*Journal of Entomology* 6 (2): 72-81, 2009; doi: 10.3923/je.2009.72.81)

Sublethal Effects of Some Conventional and Biorational Insecticides on Ectoparasitoid, *Habrobracon hebetor* Say (Hymenoptera: Braconidae)

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This study was carried out to assess the effects of sublethal dose of profenofos, spinosad, thiodicarb and field recommended dose of hexaflumuron on demographic and biological parameters of *H. hebetor*. Gross reproductive rate in control (68.87) was significantly higher than insecticide treatments. The highest

and the lowest gross reproductive rate between insecticides were related to the profenofos and spinosad, respectively. Higher intrinsic rate of increase in control (0.17) compared with insecticide treatments indicated harmful effects of insecticides on it. Hexaflumuron and spinosad had the highest (0.15) and the lowest (0.1) intrinsic rate of increase between insecticides, respectively. Number of laid eggs was significantly affected by insecticides and it was approximately 2 times more than insecticide treatments in control. In this study, hexaflumuron had tremendous sublethal negative effects on biological parameters of *H. hebetor* with no lethal effects on adult wasps. The female longevity in control (29.41) had no significant difference with the means of profenofos and hexaflumuron, but differences between spinosad and thiodicarb with control was significant. Spinosad had the lowest longevity (12.79). However hexaflumuron, profenofos and spinosad had lower generation time compared with control and thiodicarb but differences between treatments were not significant. Sex ratio of *H. hebetor* offsprings was significantly affected by insecticides. In control, it was lowest (39.23) which indicated that proportion of female to male was highest (≈ 2 time) and it was highest in spinosad (54.94) which means that spinosad caused higher male production in population. In all treatments, especially spinosad and thiodicarb, increase in female age caused increase in male production. (*Journal of Entomology* 6 (2): 82-89, 2009; doi: 10.3923/je.2009.82.89)

Seasonal Activity and Predatory Efficacy of the Water Bug *Sigara hoggarica* Poisson (Hemiptera: Corixidae) Against the Mosquito Larvae *Culex quinquefasciatus* (Diptera: Culicidae) in Riyadh City, Saudi Arabia

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Bioefficacy of the water bug *Sigara hoggarica* Poisson (Hemiptera: Corixidae) was assessed in the laboratory and in the field (at El Haeir area, South of Riyadh City) in relation to larval and pupal densities of *Culex quinquefasciatus* Say (Diptera: Culicidae) during winter and summer seasons. The results revealed that the predatory efficacy was highest against the first larval instar and it decreased as the larvae grew older. The predatory efficacy of the bug during summer was significantly higher than winter. The population of *Sigara hoggarica* started to increase gradually in November and a peak was attained in next April, when the Mean Water Temperature (MWT), Mean Ambient Temperature (MAT) and Relative Humidity (RH) were 28, 25.5°C and 39.6%, respectively. The activity

of the bug started to decline in June and it reached the lowest during August to October, when the water temperature varied between 28 to 30.5°C, the ambient temperature ranged between 26.6 to 34.9°C and the relative humidity varied between 15.5 to 23.1%. It is concluded that the water bug *Sigara hoggarica* has great potential for control of mosquito larvae in permanent and semi permanent water habitats in Riyadh City, but further studies on prey-predator relationship are required. (*Journal of Entomology* 6 (2): 90-95, 2009; doi: 10.3923/je.2009.90.95)

Life Cycle Parameters of *Empoasca decipiens* Paoli (Hom.: Cicadellidae) on Four Potato Cultivars (*Solanum tuberosum* L.) in Iran

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Empoasca decipiens Paoli (Hom.: Cicadellidae) has been causing damage in potato fields of Ardabil region in Iran. There has been an increasing interest in controlling of *E. decipiens* using resistant cultivars. The resistance of four commonly planted cultivars including Diamant, Agria, Casmos and Omidbakhsh to *E. decipiens* was compared using some life cycle parameters of this pest in greenhouse at 24±1°C, 50±5% RH and 16:8 h (L:D) photoperiod. Incubation period, development time of 1st, 2nd and 3rd instar larvae were not significantly different on the cultivars studied. Fourth and 5th instar larvae development time and female and male life span of *E. decipiens* decreased among the cultivars in the order of Diamant >Camos >Omidbakhsh >Agria. The percentage of larval survival of *E. decipiens* on Diamant and Casmos were significantly lower than on Omidbakhsh and Agria. Sex ratio of *E. decipiens* on four cultivars was not significantly different. High correlation coefficients were observed between the density of simple and glandular trichomes with the percentage of larval survival, larval development time, female and male life span of *E. decipiens*. These results indicated that among the cultivars that were investigated, Diamant and Casmos were resistant and Omidbakhsh was tolerant to *E. decipiens* damage. The results of this study also confirmed that the density of glandular trichomes may have more affects on the life cycle of *E. decipiens* than the density of simple trichomes by restricting larvae and adult feeding. These results are useful in an integrated management program of *E. decipiens* in potato fields. (*Journal of Entomology* 6 (2): 96-101, 2009; doi: 10.3923/je.2009.96.101)

Variation in Germination and Growth Rates of Two Isolates of *Beauveria bassiana* (Balsamo) Vuillemin (Deuteromycota: Hyphomycetes at Different Temperatures and their Virulence to *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae)

Adaku A. Lawrence and Ayub Khan

This study aims to determine the effect of temperature on conidial germination, colony radial growth and virulence of two isolates of *Beauveria bassiana* (ARSEF-1186 and IMI-351833) to the cowpea weevil, *Callosobruchus maculatus* under controlled laboratory conditions. Isolates grown on Potato Dextrose Agar plates indicated that the rate of conidial germination was slower at 20°C than at 25 and 30°C and was expressed by the following 50% Germination Time (GT₅₀) values: 17.23±1.02 h for ARSEF-1186 and 16.46±1.02 h for IMI-351833. The lowest GT₅₀ value was estimated as 12.33±1.02 h for IMI-351833 at 25°C. ARSEF-1186 showed significantly faster colony radial growth rate (K_r) than IMI-351833 for all temperatures investigated. Bioassays using *Cajanus cajan* seeds dipped in conidial suspensions of both isolates indicated that the highest virulence against *C. maculatus* adults was observed with ARSEF-1186 at 30°C. This isolate exhibited both the lowest LC₅₀ (2.29×10⁵ spores mL⁻¹) and LT₅₀ (4.17 days) values. (*Journal of Entomology* 6 (2): 102-108, 2009; doi: 10.3923/je.2009.102.108)

Biological Activity of Methanolic Extracts of *Ipomoea murucoides* Roem et Schult on *Spodoptera frugiperda* J.E. Smith

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This study was carried out to assess the biological activity of methanolic extracts and fractions from *Ipomoea murucoides* [Roem et Schult (Convolvulaceae)] on *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae). The extracts were incorporated into a meridic diet in 2 mg mL⁻¹ and fed to 1st instars larvae of *S. frugiperda* and incubated at 27°C with a photoperiod of 16:8 (L:D) h. After 7 days, surviving larvae were counted and weighed; surviving pupae were incubated until moths emerged, sexed and females allowed to lay eggs on paper foil. Fecundity was measured. The crude leaf extracts produced up to 46.16% mortality with effects on development, reduction in larval weight to 42.26 mg in 3rd instar and 59.6% in 5th instar, increased time for pupation and in reaching the

adult stage; there was no effect on number eggs laid. The LC_{50} calculated for methanolic leaf extract had a value of 2.692 mg mL^{-1} . The partially purified fractions showed no toxicity toward *S. frugiperda*, but had the highest effect on larval weight reduction, to 76.3% in 3rd instar and 74.6% in 5th instar, increased time for pupation and time to reach adult stage and had an effect on number eggs laid. These results indicate that the tested compounds delayed larval development. (*Journal of Entomology* 6 (2): 109-116, 2009; doi: 10.3923/je.2009.109.116)

Quantitative PCR Detection of Cholinesterase and Carboxylesterase Expression Levels in Acaricide Resistant *Rhipicephalus (Boophilus) microplus*

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This study was done with the objective of developing a methodology for cholinesterase and carboxylesterase expression measurement in acaricide resistant *R. microplus*, for that purpose the expression levels for these enzymes were measured by real time PCR quantification of mRNA specific detection, comparing acaricide sensitive with multiple acaricide resistant strains of ticks known as Mora and San Alfonso. Acaricide susceptible ticks were used as standard cholinesterase and carboxylesterase expression level and adjusted as a baseline of 1 Relative Expression Units (REU). A statistical significance was observed in cholinesterase gene expression level as 13.07 ± 3.49 REU for Mora strain and 10.81 ± 2.98 REU for San Alfonso strain compared to the susceptible strain. Also, carboxylestrase expression found statistically significant for Mora and San Alfonso strains (6.9 ± 1.14 and 12.11 ± 1.81 REU, respectively) compared to the susceptible strain. Present results proved that the carboxylestrase and cholinesterase genes expression increased by acaricide pesticide exposure in Mora and San Alfonso, *R. microplus*, which explained as an overexpression of AchE2 at the singanglion level for OP resistant ticks, as well as increased levels of esterase gene CzEST9 implicated in pyrethroid resistant strains. (*Journal of Entomology* 6 (2): 117-123, 2009; doi: 10.3923/je.2009.117.123)

Phenology and Migration of Tef Epilachna, *Chnootriba similis* Thunberg; (Coleoptera: Coccinellidae) in Ethiopia

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Studies were conducted on the phenology of tef Epilachna, *Chnootriba similis* Thunburg, formerly known as *Epilachna similis*, from 2003 to 2005 along two

selected rivers and from 2004 to 2005 in two agricultural fields. Abundance of the insect was observed in barley fields every week and fortnightly along the rivers using 0.25 m² quadrates and insect sweep nets, respectively. It survives along rivers during the dry period as adult in diapause, which terminates around mid-January, with increased feeding and initiation of mating. The adults then migrate to agricultural fields between March and April. This may be delayed because of the reduced cumulative rainfall in January and February. Termination of diapause and adult migration is influenced by rainfall. It is a bivoltine insect. The adults from the second generation migrate to rivers between September and October as they require moisture to overwinter during the dry period of the year, while the majority of the first generation adults remain in the agricultural fields. The ovipositional, larval and pupal periods of both generations was investigated and the duration of the developmental stages of the first generation were longer than in the second. This insect is mainly a pest of seedlings. (*Journal of Entomology* 6 (3): 124-134, 2009; doi: 10.3923/je.2009.124.134)

Evaluation of Infestation Levels of the Ectoparasitic Mite *Varroa destructor* Infesting Honeybee *Apis mellifera* and its Control Using Essential Oil in Qassim Region, Saudi Arabia

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Survey study of the ectoparasitic mite *Varroa destructor* Anderson and Treuman infesting bee colonies was conducted to evaluate its infestation level for the first time in Qassim Region, Saudi Arabia. The infestation levels were variable according to the season and locality. Mite population parasitizing worker bees gradually increased from April and May and may reach its peak in June and July. Apiaries in Melida-1 presented the highest infestation level and declined significantly in Onayzah-2, Bakeriah and Melida-2 (18 to 13%), while Buraydah-1 and 2 and Onayzah-1 presented only 12% of the total annual mite population, respectively. The mites found on the bottom of bee hives started to increase in February and March and reached the peak during summer months (June-September). Apiaries in Melida-1 significantly recorded the highest level of infestation and followed by Buraydah-1, Onayzah-1 and 2, Bakeriah, Melida-2 (28 to 8%), while Buraydah-2 had the lowest infestation level with only 5% of the total annual mite population, respectively. For contamination of bee products purposes, certain local essential oil, safe to worker bees, including aloa, camphor, garlic, black seed and cloves were extracted in laboratory. Data showed that cloves was the most effective substance causing 62% mortality in *Varroa* mites, while garlic, camphor and black seed reduced mite infestation to 51, 47 and 43% 1 day after treatment, respectively. After 7 days, black seed was more effective

than Garlic and camphor where they reduced mite infestation to 72, 66 and 56%, respectively. Aloe extract was the weakest extract causing reduction of only 34 and 45% for 1 and 7 days after treatment. Data showed that mite mortality percentage was positively correlated with time after treatment. (*Journal of Entomology* 6 (3): 135-144, 2009; doi: 10.3923/je.2009.135.144)

Effectiveness of Entomopathogenic Nematodes against Sweet Potato Weevil (*Cylas puncticollis* Boheman (Coleoptera: Apionidae)] Under Semi-Field Conditions in Kenya

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Sweet potato (*Ipomoea batatas* (L.) Lam.) ranks second in production and value after cassava among the root crops in Kenya. Its production has been declining mainly due to the damaging effects of *Cylas puncticollis* Boheman (Coleoptera: Apionidae), its primary pest. Therefore, this study was done to determine effectiveness of two Entomopathogenic nematodes (EPNs) against *C. puncticollis*. The experiment was conducted under semi-field conditions using potted plants at Kibwezi, Eastern Kenya in two consecutive growing seasons in 2002 and 2003. Two species of EPNs were used and their efficacy compared: *Steinernema kari* Waturu, Reid and Hunt (Rhabditida: Steinernematidea) and *Heterorhabditis indica* Poinar, Karunakar and David (Rhabditida: Heterorhabditidea). Both EPNs significantly suppressed emergence of adult weevil from the tubers. The EPNs were also very effective on larvae and reduced the number of pupae significantly. The effect of the pest on the tuber quality was significantly high compared with its effect on tuber quantity. Among the EPNs, *H. indica* was more efficient in reducing the pest population and damage. In addition, the EPNs persisted in the soil for more than three 3 after their release. It is suggested that these EPNs have field potential in controlling the *Cylas* weevil and may provide the local solution to this pest problem in Kenya. (*Journal of Entomology* 6 (3): 145-154, 2009; doi: 10.3923/je.2009.145.154)

Colour Variation and Genetic Diversity in Tea Mosquito Bug [*Helopeltis theivora* (Hemiptera: Miridae)] Population from Badlabeta Tea Estate, Upper Assam, India

M. Sarmah and T. Bandyopadhyay

Tea mosquito bug [*Helopeltis theivora* Waterhouse (Hemiptera: Miridae)], one of the major pests of tea, have been studied in a randomly collected population

sample from Badlabeta tea estate, upper Assam. DNA isolated from insects, separated on the basis of pronatum colour, show polymorphism using Randomly Amplified Polymorphic DNA primers-Polymerase Chain Reaction (RAPD-PCR) with seven primers. Phenograms on the basis of banding patterns were constructed using Numerical Taxonomy System (NTSYS-pc) version 2.02e. A similarity matrix based on the simple matching coefficient was generated by the SIMQUAL program and cluster analysis performed with the Unweighted Pair Group Method with Average (UPGMA) in the Sequential Agglomerative Hierarchical and Nonoverlapping (SAHN) program. The constructed phenogram shows that one colour variant is distinctly different from the rest three. The study indicates that the population consists of discontinuous phenotypes among individuals within a freely interbreeding population which has many of its hosts in the vicinity. Genetic variation among the phenotypes within a population focuses on some evolutionary mechanisms which may resist the effect of pesticide. (*Journal of Entomology* 6 (3): 155-160, 2009; doi: 10.3923/je.2009.155.160)

Effects of Some Insecticides on Functional Response of Ectoparasitoid, *Habrobracon hebetor* (Say) (Hym.: Braconidae)

Hooshang Rafiee Dastjerdi, Mir Jalil Hejazi, Ghadir Nouri Ganbalani and Moosa Saber

In this research, the effects of profenofos, thiodicarb, hexaflumuron and spinosad were studied on functional response of *Habrobracon hebetor* to different densities of last instar larvae of *Anagasta kuehniella*. Two day-old mated females were exposed to LC₂₅ of the insecticides and distilled water as control. Host densities of 2, 4, 8, 16, 32 and 64 were offered to treated females wasps for 24 h in 10 cm petri dishes. Experiments were conducted in 8 replications and were carried out in controlled conditions, 26±2°C, 70±5% RH and 16:8 (L:D) h. The type of functional response was determined using logistic regression and the parameters, searching efficiency (a) and handling time (T_h) were estimated by non-linear regression using SAS software. Functional response was type II in control and all of insecticide treatments. Searching efficiency in control and insecticide treatments were 0.0935, 0.0132, 0.0511, 0.0864 and 0.0905 h⁻¹ and handling times were 0.4542, 1.0646, 0.5381, 0.5275 and 0.4896 h, respectively. The maximum attach rates (24/T_h) were estimated 22, 52, 44, 45 and 49, respectively. Spinosad and hexaflumuron had the most and the lowest effect on searching efficiency of *H. hebetor*, respectively. (*Journal of Entomology* 6 (3): 161-166, 2009; doi: 10.3923/je.2009.161.166)

The Behavior and Feeding Preference of the 12-Spotted Beetle *Epilachna indica* MULSTANT (Coleoptera: Coccinellidae: Subfamily Epilachninae) Towards the Black Nightshade *Solanum nigrum* (Family: Solanaceae)

Fauziah Abdullah and Faizah Abdullah

The behavior of fifty one 12-spotted ladybird beetles *Epilachna indica* (Coleoptera: Coccinellidae: subfamily: Epilachninae) on ten black nightshade *Solanum nigrum* (Solanaceae) plants was observed from 08:00 to 19:00 h in the field at Ulu Kelang, Selangor, Malaysia. 29.26% time was spent feeding compared to 7.22% mating, 51.05% resting and walking and 12.45% flying. Optimal feeding time in the field was from 08:00 h to 10:00 h with peak feeding occurred at 09:30 h. Leaf disc choice bioassay showed that *E. indica* prefers to feed on both *Solanum melongena* and *S. nigrum* leaf discs. In the laboratory, 72 h continuous observation on ten beetles showed that the leaf area consumption of *S. nigrum* was $1.202 \pm 0.085 \text{ mm}^2 \text{ h}^{-1}$ for one beetle. This study indicates that *S. nigrum* is a potential trap plant for pest management of the economically important egg plant, *Solanum melongena*. Future study on feeding stimulant on *S. nigrum* will enlighten the understanding of host selection in *E. indica*. (*Journal of Entomology* 6 (4): 167-178, 2009; doi: 10.3923/je.2009.167.178)

Evaluation and Identification of Superior Polyvoltine Crossbreeds of Mulberry Silkworm, *Bombyx mori* L.

C. Ramesha, S.V. Seshagiri and C.G.P. Rao

In the present study, the existing polyvoltine germplasm resource material of the Silkworm Breeding and Research and Development Institute (APSSRDI), screened for the desired qualitative and quantitative traits. After fixation of the desired traits, 5 inbred parental breeds (APM4, APM6, APM8, APM10, APM12) utilized as Lines for the preparation of 25 crosses in Line×Tester method with the five bivoltine breeds (SDD1, SDD2, SDD3, APS12, APS105) as Testers. The hybrid testing was conducted and assessed for three different seasons for their performance on eight important economical genetic traits. The data obtained on the traits such as fecundity, yield per 10,000 larvae by number, single cocoon weight, shell weight, shell ratio, filament length and reliability was analyzed with the assistance of statistical tools. Based on two popular evaluation methods such as multiple traits Evaluation Index (EI) and Sub-ordinate Function (SF)

methods, the 5 new hybrid combinations (APM12×APDR105, APM6×APS12, APM4×PDR105, APM10×SDD1 and APM10×SDD3) shown above 50 EI values with SF values varied from 5.663 to 7.596 were identified as superior over the control hybrid and recommended for large scale in laboratory trail. Further, based on the lab and field performance promising crossbreed will be identified and adjudicated for the commercial exploitation at farmers level. (*Journal of Entomology* 6 (4): 179-188, 2009; **doi:** 10.3923/je.2009.179.188)

New Records of Insect Vectors of Rice Yellow Mottle Virus (RYMV) in Côte d'Ivoire, West Africa

F.E. Nwilene, A.K. Traore, A.N. Asidi, Y. Sere, A. Onasanya and M.E. Abo

The study aimed to investigate the vectorial capacity of twelve insect species to transmit Rice Yellow Mottle Virus (RYMV) from diseased seedlings of a susceptible rice variety (Bouaké 189) and a perennial wild rice (*Oryza longistaminata*) to seven alternative host plants. Results indicated that *Trichispa sericea*, *Chaetocnema pulla*, *Chnootriba similis*, *Conocephalus longipennis*, *Oxya hyla*, *Paratettix* sp., *Zonocerus variegatus*, *Euscyrtus* sp., *Cofana spectra*, *Cofana unimaculata*, *Locris rubra* and *Locris maculata* were capable of transmitting RYMV from infected Bouaké 189 and *Oryza longistaminata* to alternative weed hosts *Leersia hexandra*, *Imperata cylindrica*, *Digitaria horizontalis*, *Echinochloa colona*, *Echinochloa crus-gavonis*, *Eleusine indica* and *Brachiaria lata*. Only *Chaetocnema pulla*, *Trichispa sericea*, *Chnootriba similis*, *Oxya hyla*, *Zonocerus variegatus*, *Euscyrtus* sp., *Paratettix* sp., *Cofana spectra*, *Cofana unimaculata* and *Locris rubra* played an important role in transmitting the disease from rice to *O. longistaminata*, *Leersia hexandra* and *Imperata cylindrica*. The present study confirmed the vectorial capacity of these vectors out of which eight were reported for the first time in West Africa. (*Journal of Entomology* 6 (4): 189-197, 2009; **doi:** 10.3923/je.2009.189.197)

Effect of Tukra (Mealybug) Infected Mulberry Leaves on the Quantitative Traits of New Polyvoltine Strain of Silkworm, *Bombyx mori* L.

C. Ramesha, S.V. Seshagiri, H. Lakshmi, S.S. Kumari and C.G.P. Rao

The influencing effect of tukra infected mulberry leaves on 5th instar polyvoltine silkworm breed of APM₁, rearing was studied since, the maximum leaves consuming at this stage of silkworm life cycle and by utilizing non-infected healthy

leaves as control. Interestingly in the experimental batch, larval duration was found to be 12 h lesser than the control batch. Mulberry leaves consumption efficiency and economical characters of silkworm like larval weight, pupation rate, cocoon weight, shell weight and reeling parameters were found higher in the experimental batch than the control batch. The result indicated that tukra infected mulberry feed has no adverse effect on silkworm rearing. Moreover, overall improvement was noticed in tukra infected leaves fed batch and sturdily suggest that even mealybug infected mulberry leaves can also be effectively utilized for the silkworm rearing in acute shortage of healthy mulberry leaves. (*Journal of Entomology* 6 (4): 198-205, 2009; *doi*: 10.3923/je.2009.198.205)

Effect of Si/Al Ratio of Allophane on Competitive Adsorption of Phosphate and Oxalate

M. Abdalla Elsheikh, N. Matsue and T. Henmi

Allophane is a soil clay constituent with high adsorption capacity for cationic and anionic solutes and the adsorption characteristics depend on its Si/Al molar ratio. Adsorption experiments of phosphate and oxalate on two natural allophane samples with low (0.67; KyP) and high (0.99; KnP) Si/Al ratios were conducted at initial adsorbate concentration of up to 0.6 mM and at pH of 5.0 to 7.0. In both single and binary (equimolar phosphate and oxalate) adsorbates systems, KnP had less capacity for adsorption of both phosphate and oxalate than KyP had, because in the structure of KnP, accessory Si is already adsorbed onto aluminol groups to which phosphate and oxalate will be adsorbed. For KyP with lower Si/Al ratio and higher adsorption capacity, the efficiency of phosphate to depress the adsorption of coexisting oxalate, E_{OX-P} , was always greater than the reverse efficiency, E_{P-OX} , at a same condition; the ratio of oxalate/phosphate adsorbed in the binary system was less than unity and the ratio decreased with increasing pH and initial adsorbate concentration. These indicated higher selectivity of KyP for phosphate than for oxalate and the selectivity increased with increasing the competition between phosphate and oxalate toward KyP. KnP with higher Si/Al ratio showed higher selectivity for phosphate than KyP did, but the ratio of oxalate/phosphate adsorbed was almost constant when pH and initial adsorbate concentration were raised. This means that even under the lowest pH and the lowest adsorbate concentration examined (pH 5.0, 80 μ M), the competition between phosphate and oxalate toward KnP was already severe and further increase in the phosphate selectivity was not caused. (*International Journal of Soil Science* 4 (1): 1-13, 2009; *doi*: 10.3923/ijss.2009.1.13)

Determination of Critical Levels of Micronutrients by Plant Response Column Order Procedure for Dryland Wheat (*T. aestivum* L.) in Northwest of Iran

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Plant response column order procedure was used to determine critical levels of Fe, Mn, Zn, Cu and B for dryland wheat in West Azarbaijan, East Azarbaijan, Kurdistan and Kermanshah Provinces of Iran. Series of experiments were conducted in randomized complete block design with 4 treatments of each micronutrients (0, 5, 10 and 15 kg ha⁻¹ Fe as iron chelate (NaFeEDDHA); 0, 5, 10 and 15 kg ha⁻¹ Mn as manganese sulfate; 0, 5, 10 and 15 kg ha⁻¹ Zn as zinc sulfate; 0, 2.5, 5 and 7.5 kg ha⁻¹ Cu as copper sulfate and 0, 1.5, 3 and 4.5 kg ha⁻¹ B as boric acid) with three replications for four years (1998-2002). The collected data were used in plant response column order procedure and interaction chi-square (probability of no interaction between soil classes) models. The results for boundary of between soil deficient and sufficient classes or critical levels by plant response column order procedure and interaction chi-square model for Fe, Mn, Zn, Cu and B critical values were determined as 4.7, 11.2, 0.7, 1.4 and 0.5 mg kg⁻¹ soil, respectively; predictable values for critical levels of micronutrients were also calculated as 99.5, 94, 87, 88 and 78%, respectively. From the results, it can be concluded that soil Fe, Mn, Zn, Cu and B requirements and dryland wheat response relationships can be determined by plant response column order procedure and interaction chi-square methods. These methods can be applicable for classifying and prediction of soil micronutrient needs in dryland wheat cultivation in Northwest region of Iran. (*International Journal of Soil Science* 4 (1): 14-26, 2009; doi: 10.3923/ijss.2009.14.26)

Effects of Ammonium and Iranian Natural Zeolite on Potassium Adsorption and Desorption Kinetics in the Loess Soil

M. Rezaei and S.A.R. Movahedi Naeini

Information about the adsorption and desorption kinetics of potassium and the consequent alterations with zeolite additions are limited in Golestan Province loess soils with illite dominance in the clay fraction. The kinetics of potassium adsorption and desorption with different KCl concentrations (0, 40, 60, 80, 110 and 140 mg L⁻¹) and KCl+NH₄Cl concentrations (K80,N60; K80,N120; K60,N60; K110, N120; K80, N90 and K110, N90 mg L⁻¹) on the soil, the zeolite and their

incorporation (within 2 and 1800 h) were investigated with this research using batch method. Potassium adsorption and desorption was initially fast (first 48 h) but continued with low speed (after 48 h) until the end of the experiment. Results shown increasing of K^+ concentration increased rate of adsorption and desorption in soil, zeolite and their incorporation and zeolite increased adsorption and decreased desorption rate by incorporation with soil. Ammonium presence decreased potassium adsorption and it increased potassium desorption. K/NH_4 desorption rate did not follow exactly K/NH_4 adsorption ratio for all treatments. The kinetic equations used to estimate data were zero order, first order, simple Elovich, parabolic diffusion and power function. The Elovich model described the adsorption and desorption processes on soil and soil with zeolite ($0.88 < R^2 < 0.99$). Elovich and power function models described adsorption and desorption processes, respectively for zeolite well ($0.65 < R^2 < 0.97$). The models indicated that K^+ adsorption and desorption was diffusion controlled. Potassium adsorption and release by batch method did not simulate potassium uptake by wheat. (*International Journal of Soil Science*, 4 (2): 27-45, 2009; doi: 10.3923/ijss.2009.27.45)

Copper Correlation of Irrigation Water, Soils and Plants in the Cukurova Region of Turkey

Seyyid Irmak

In this study, copper content of soil and irrigation water and copper content of leaves and grain of wheat (*Triticum* spp.) were studied. Study samples of soil, leaf and grain were collected from wheat (*Triticum* spp.) fields in Cukurova Region of Turkey. Soil samples taken from the root area of plants where the leaf and grain samples were collected and analyzed for copper (Cu) content. The leaf samples taken during the stem elongation and the grain samples taken at the time of maturation were also analyzed for Cu content. The correlation analysis between soil-Cu contents and leaf and grain-Cu contents was performed to determine the relationships among the variables. The Cu content of the soil samples collected in 2005 was between 0.78 and 1.56 mg kg⁻¹. The Cu content of the soil samples collected in 2006 was between 1.12 and 1.96 mg kg⁻¹. The copper content of the majority of soil samples, collected in 2005 was observed above the critical level which is 1 mg kg⁻¹. The Cu content of the leaf samples was ranged from 26.30 to 67.60 mg kg⁻¹ in 2005 and 3.06 to 18.02 mg kg⁻¹ in 2006, whereas the copper content of the grain samples was ranged from 11.77 to 17.89 mg kg⁻¹ in 2005 and 7.37 to 14.06 mg kg⁻¹ in 2006. According to data analysis performed in collected samples, the Cu content of the leaf and grain samples was directly correlated with the Cu content of the soil. Correlation between copper content of

soil and copper content of leaf in 2006 are significant at the 0.01 level based on the statistical analysis. Also, correlation between copper content of soil and weight of 1000 grain in 2005 and in 2006 are significant at the 0.01 level in respect of statistical analysis. (*International Journal of Soil Science*, 4 (2): 46-56, 2009; *doi*: 10.3923/ijss.2009.46.56)

Influence of Compaction Curve Modeling on Void Ratio and Pre-Consolidation Stress

S. Narra

The objective of this study is to investigate the influence of different consolidation curve models on the initial void ratio values and through which on the obtained pre-consolidation stress. Further, this study verifies the dependence of pre-consolidation stress on the initial void ratio value measured at 1 kPa. This was done in order to check the trend between the consolidation curve models and the deviation in pre-consolidation stresses. Three different Oedometer tests have been carried out which were denoted as undisturbed, disturbed and disturbed-rewetted. The curves were fitted using two different curve models (Assouline and Van Genuchten models) and the graphical calculation of the pre-consolidation stress was done using two different methods (Casagrande and Silva methods). The curve models are applied on the compaction data obtained from the soil classified as loamy sand. A good consolidation curve fit to the data (R^2 ranging between 0.97 and 0.99) has been verified for a wide range of applied stresses (0 to 2500 kPa), including stresses less than the pre-consolidation stress. Huge differences in the initial void ratio values (Δe ranging between 0.003 and 0.423) have been observed with different curve models and with which a huge difference in pre-consolidation stresses (ΔP ranging between 0 and 57 kPa) have been observed. This study clearly showed that the pre-consolidation value obtained was mainly dependent on the curve fitting model and also on the calculating method. This study also showed a dependence of pre-consolidation stress over the void ratio measured at 1 kPa. (*International Journal of Soil Science*, 4 (2): 57-66, 2009; *doi*: 10.3923/ijss.2009.57.66)

Soil Enzymes Activities in Irrigated and Rain-Fed Vertisols of the Semi-Arid Tropics of Sudan

Mubarak A. Abdalla and Uwe Langer

Soil management practices that involve intensive traditional ploughing and disking may affect soil quality. Soil enzymes activities were investigated from crop

rotations in irrigated and rain-fed areas. Soil samples collected from long term (79 years), medium-term (46 years) and short-term (22 years) irrigated cotton (*Gossypium hirsutum*) schemes and rainfed cultivation of sorghum (*Sorghum bicolor*) and sesame (*Sesamum indicum*) in a semi-arid tropical Vertisol. Alkaline phosphatase was significantly higher in both short-term (661 $\mu\text{g p-nitrophenol g}^{-1} \text{ soil h}^{-1}$) and rain-fed cultivation (605-747 $\mu\text{g p-nitrophenol g}^{-1} \text{ soil h}^{-1}$). Long- and medium-term cultivation in the irrigated sector had significantly less protease activity [3.75-4.73 $\mu\text{g tyrosine g}^{-1} \text{ soil (2 h}^{-1})$] compared to other cultivation systems [11.54-15.09 $\mu\text{g tyrosine g}^{-1} \text{ soil (2 h}^{-1})$]. Except, long-term cultivation, there was a general separation in the activity of β -glucosidase between irrigated [average of 21.9 $\mu\text{g saligenin g}^{-1} \text{ soil (3 h}^{-1})$] and rainfed Vertisols [17.9 $\mu\text{g saligenin g}^{-1} \text{ soil (3 h}^{-1})$]. Correlation analysis and Principal Component Analysis (PCA) revealed that only alkaline phosphatase activity was positively correlated with total soil N and carbon contents. These results may draw attention on the impact of intensive application of agro-chemicals (pesticides, herbicides and fertilizers) on soil health in the world biggest Gezira cotton scheme. (*International Journal of Soil Science* 4 (3): 67-79, 2009; doi: 10.3923/ijss.2009.67.79)

Reuse of Date Palm by-Products for Efficient Use of Nitrogen Fertilizer

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The present study aims to improve the efficiency of nitrogen fertilizer applied to soil by reuse of date palm by-products after grinding and mixing with sandy loam soil. The date palm by-products collected from different areas, then air dried and grinded. Two fractions selected (i.e., less than 0.5 and 1-2 mm size). The powder mixed with sandy loam soil at the rates of 0.0, 1.0, 2.5, 5.0, 7.5 and 10.0% (w/w). The treated soil incubated at field capacity in plastic container for 30 days. After the incubation period, the soil was air dried and passed through a 2.0 mm sieve. The physical and chemical analyses of sandy loam and treated soils performed. The PVC transparent columns with of 6.0 cm diameter and 30.0 cm length packed with sandy soil at 1.6 g cm^{-3} soil bulk density to 20 cm depth and then a 5 cm surface layer of treated soil applied. The soil columns arranged as follows: 1) size fraction of date palm by-product, 2) the rate of date palm by-products applications and 3) rate of water applied (5 and 10 pore volumes). The fertilizer applied at the required rate (250 mg L^{-1}) to soil surface and then the water applied at required rates (0.2 and 0.4 cm min^{-1}). The leachate out of soil columns received. Volume of leachate and concentration of NO_3 was determined.

At the end of experiment, the soil was cut to 2.5 cm slices for determining the soluble NO_3 . Total NO_3 in soil and percolate were calculated and then the loss of fertilizers and fertilizer use efficiency calculated under the experimental conditions. The results showed that increasing the rate of date palm by-products reduced the NO_3 in leachate and increased NO_3 in soil columns. In addition, increasing water application rate increased fertilizers loss in the leachate. The fine fraction of date palm by-products reduced the NO_3 leaching out of soil by about 14.86 and 5.90% for low and high water application rate, respectively in case of fine fraction, reduced nitrate losses. The corresponding values for coarse fraction were 9.73 and 4.35%, respectively. According to the present results, it is possible to reuse the date palm by-products for increasing the fertilizers use efficiency and reduces the problems of groundwater pollution and accumulation of these by-products in farm. (*International Journal of Soil Science* 4 (3): 80-92, 2009; **doi:** 10.3923/ijss.2009.80.92)

Spatial Variability of Soil Organic Carbon in Oil Palm

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This study aimed at quantifying the spatial variability of SOC and estimating SOC concentration in oil palm. This study was carried out in a commercial oil palm plantation bearing 27 year old palms. A systematic design was employed for soil sampling at the 0-20 cm depth based on a cluster of 4 palms that included three operational areas Weeded Circle (WC), Frond Heap (FH) and Harvesting Path (HP). A total of 60 sampling clusters were established. SOC was analyzed using dry combustion method. All measurement points were geo-referenced by a differential Global Positioning System (dGPS). The SOC data were first explored using descriptive statistics, normality check and outlier detection. This followed by variography and interpolation techniques to quantify the spatial variability of SOC. Results showed that all three operational areas exhibited a definable spatial structure and were described by either spherical or exponential models. SOC from WC and HP showed moderate spatial dependence while that from FH showed a strong spatial dependence. The FH had a shorter effective range than other operational areas. Contour maps for WC, FH and HP clearly showed spatial clustering of SOC values. All three operational areas fulfilled the interpolation accuracy criteria. This study suggests that site-specific management could be considered as a strategy to increase SOC sequestration in oil palm. (*International Journal of Soil Science* 4 (4): 93-103, 2009; **doi:** 10.3923/ijss.2009.93.103)

Carbon and Nitrogen Storage in Soil Aggregates from Different *Terminalia superba* Age Plantations and Natural Forest in Kouilou, Congo

J. Goma-Tchimbakala

A comparative study was carried out in Mayombe, between the soil of natural forest and the soil under three *Terminalia superba* plantations of 7, 12 and 48 year-old. In each plantation type and natural forest composite soil samples were taken in 0-10 cm layer. The goal was to investigate the dynamic of total carbon and nitrogen in whole and soil aggregate fraction in order to assess the impact of reforestation on the soil fractions. Organic carbon was analyzed by the modified Walkey and Black method. Total nitrogen was determined using the Kjeldhal procedure. Statistically differences between the sites were tested using the Analysis of Variance (ANOVA). The results showed that in the surface soil the carbon content and total nitrogen were respectively 22.2 and 1.56 $\mu\text{g g}^{-1}$ in the forest. The carbon content was between 14.9 and 23.5 mg g^{-1} while total nitrogen was between 1.31 and 2.24 $\mu\text{g g}^{-1}$ in the plantations. The results also revealed that plantation aging had a marked impact on the total carbon and nitrogen concentration of soil aggregate fractions. The carbon and the nitrogen associated with the sand and the clay exhibited a significant increase. The carbon concentration was between 1.51 and 2.09 mg g^{-1} in the light aggregate fractions and between 0.95 and 1.04 mg g^{-1} in the organomineral aggregate fraction. The accumulation of total carbon in the whole soil and soil aggregate fractions and their increase during plantation aging suggested that the *T. superba* plantations could facilitate significant carbon storage. (*International Journal of Soil Science* 4 (4): 104-113, 2009; doi: 10.3923/ijss.2009.104.113)

Correlation Study Between Soil Nutrient Indices and Yield of Wheat and Barley in the Ganjabasar Region of Azerbaijan

V.V. Bashirov

The objective of this study is to investigate the correlation between soils nutrient regime indices and the yield of winter wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*), the main cereal crops of the Ganjabasar region. Using experiments planning method a regional (the Ganjabasar region of Azerbaijan) conceptual and mathematical model was developed for soils fertility management. In this regional fertility model, all indices of fertility criteria of researched soils were combined in 5 blocks (agroecology, soil content, soil nutrient regime, soil

properties and agromelioration). Unlike the prior models, included are Immediate Nutrient Reserve (ImdNR), Intermediate Nutrient Reserve (IntNR) and Potential Nutrient Reserve (PNR) forms to the list of criteria of soil nutrient regime block in the regional fertility model using the Gorbunov method. The majority of the correlation relations were consistent ($0.56 < r < 0.89$). Among the variables of soil nutrient regime, total nitrogen content, Cation Exchange Capacity (CEC), Immediate Nutrient Reserve (ImdNR) of phosphorus and potassium consistently correlated and Intermediate Nutrient Reserve (IntNR) of phosphorus and potassium were slightly correlated in yield, of which CEC and IntNR of P and K was steady but others were dynamic variations. It revealed that in the final mathematical models, 71% of wheat yield variability was accounted for variation in above dynamic indices. (*International Journal of Soil Science* 4 (4): 114-122, 2009; doi: 10.3923/ijss.2009.114.122)

Irrigation Water Quality Evaluation of Al-Mendasah Groundwater and Drainage Water, Al-Madenah Al-Monawarah Region, Saudi Arabia

Omar A. Al-Harbi, G. Hussain and O. Lafouza

Groundwater and drainage water samples were collected from Al-Mendasah area, North-West of Al-Madinah Al-Munawarrh for irrigation water quality evaluation. The well waters were classified as C4S2 to C4S4 waters i.e., very high salinity and medium sodium to severely saline and very high sodium waters. The drainage waters were classified as C3S2 to C4S3 i.e., high salinity and medium sodium to severely saline and high sodium waters. The groundwater is dominated by Na and Cl ions. The Saturation Indices (SI) showed that the groundwater is unsaturated with respect to anhydrite, halite, gypsum and fluorite; and saturated with respect to calcite and dolomite. The concentration of calcium is much higher than that of Mg. The nitrate contents are much higher than the recommended safe limits of 30 mg L^{-1} for drinking and other uses. The fluorite (F) concentration in 40% of well waters was higher than the recommended safe limits for drinking water. The strong correlation between SAR vs. adj. SAR and adj. R_{Na} , Na vs. Cl, Mg vs. Cl and Mg vs. SO_4 ions indicate the dissolution and precipitation reactions in the rock-water interface that affect groundwater chemistry. The soil infiltration rate will not be affected either by well water or drainage water irrigation. Only, 12% well waters are safe for irrigation directly without serious soil and crop production problems. The use of remaining 78% well waters requires the adoption of certain management practices such as adequate drainage, selection of salt tolerant crops and application of leaching requirements. (*International Journal of Soil Science* 4 (4): 123-141, 2009; doi: 10.3923/ijss.2009.123.141)

Quality Evaluation of Gliadins from Zhengmai 9023×99E18 in Wheat

Wu Xiao-lan, Lan Xiu-jin, Wei Yu-ming, Pu zhi-en and Zheng You-liang

Although it is known that the compositions of gliadins have effects on bread-making quality of wheat, it is still not clear which gliadins confer improved bread-making quality and whether those gliadins interact with glutenins and other gliadins. Using a hard red winter wheat line 99E18 and zhengmai9023 with good bread-making quality as well as their progeny we identified gliadins associated with the bread-making quality. SDS-PAGE and APAGE method were used to analyze the gliadin composition and HMW-glutenin subunits of 45 wheat inbred lines and their relationships to bread-making quality were conducted. The significance of difference was calculated between the omega gliadins and bread-making quality. The positive and negative effects have been detected between the particular gliadin bands and baking quality. Thus, gliadin could be used as parameters when breeding for bread-making quality. (*Journal of Plant Sciences* 4 (1): 1-9, 2009; *doi*: 10.3923/jps.2009.1.9)

The Rooting Performance of Shea (*Vitellaria paradoxa* C.F. Gaertn) Cuttings Leached in Water and Application of Rooting Hormone in Different Media

J. Yeboah, S.T. Lowor and F.M. Amoah

In order to improve the rooting performance of shea stem cuttings to enhance the establishment of shea plantation, an investigation was carried out in 2003/2004 at the Cocoa Research Institute of Ghana Substation, Bole in a polythene propagator. The propagating structures for the experiment were kept under a shade net (50% shade) to create a microclimate for the cuttings. The treatments employed were leaching, different growth media and hormone application. Rejuvenated (coppiced cuttings) shoots that were not leached (not dipped in water) gave significantly higher rooting than the leached cuttings while Seradix 3 powder applied cuttings produced significantly higher ($p < 0.05$) rooting than the control. Significantly high in number, more developed and longer roots per cutting were recorded for the rice husk medium than the sand and sand+top soil (1:1) media. The biochemical analysis significantly recorded high levels of sugar and phenol for cuttings that were not leached in water. The results of this study demonstrated that rice husk medium was the best for rooting shea cuttings. (*Journal of Plant Sciences* 4 (1): 10-14, 2009; *doi*: 10.3923/jps.2009.10.14)

Antioxidant Activity of Isolated Phytoconstituents from *Casuarina equisetifolia* Frost (Casuarinaceae)

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The aim of the present study was to isolate the active constituents responsible for antioxidant activity. Radical scavenging activities of chromatographically isolated compounds from methanolic extracts of wood, bark, fruit and leaf were measured by the 1, 1-Diphenyl-2- Picrylhydrazyl (DPPH) method. The structures of isolated compounds were confirmed by spectroscopic techniques comprising of UV, IR, ¹³CNMR, P-NMR, Mass spectral and Co-TLC studies. The compound ANA 01, ANA 02 and ANA 04 were isolated from bark and confirmed as catechin, ellagic acid and gallic acid, respectively. The leaf extract resulted in separation of compounds ANA 03 (quercetin). The free radical scavenging activity of the different isolated compounds from methanolic extracts of *Casuarina equisetifolia* increased in a concentration dependent manner. ANA 04 (gallic acid) exhibited very strong antioxidant activity and when compared to ANA 01 (catechin), ANA02 (ellagic acid), ANA 03 (quercetin) and ANA05 (lupeol). This study suggests that the *Casuarina equisetifolia* could be pharmaceutically exploited for antioxidant properties. (*Journal of Plant Sciences* 4 (1): 15-20, 2009; *doi: 10.3923/jps.2009.15.20*)

Development of a Low Cost Micropropagation Technology for an Endangered Medicinal Herb (*Picrorhiza kurroa*) of North-Western Himalayas

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The current study was undertaken with the objective that tissue culture conditions need to be optimized for obtaining vigorous shoot growth coupled with modifications in the nutrient medium so as to reduce the cost of nutrient medium. Axillary shoot tips cultured on MS +IBA (2 mg L⁻¹) + KN (3 mg L⁻¹) + sucrose 3% (w/v) + agar-agar 0.8% (w/v) was the best medium for multiple shoot formation with 86.3% shoot apices forming multiple shoots. The sucrose was replaced with table sugar and agar-agar was omitted completely. Out of 6 low-cost media combinations tested, MS liquid medium supplemented with Indole-3-Butyric Acid (IBA) (2 mg L⁻¹) + kinetin (KN) (3 mg L⁻¹) + table sugar 3% (w/v) was found to be the best with 27 shoots/explant. Seventy percent shoots formed roots on half strength MS salts supplemented with IBA (3 mg L⁻¹) + table

sugar 3% (w/v) + agar-agar with an average of 5.6 roots per shoot. The study has resulted in the identification of a low-cost medium combination for rapid multiplication of *P. kuura* with a potential that the technology can be up-scaled to a large-scale production. (*Journal of Plant Sciences* 4 (2): 21-31, 2009; **doi:** 10.3923/jps.2009.21.31)

Effect of Signal Molecules and Hormones on the Expression of Protein Kinase Gene *OrMKK1* in Rice

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A putative protein kinase gene was isolated from *Oryza rufipogon* using the *OsMKK1* as template for primer synthesis. This gene was used to analyse the involvement of signal molecules and hormones in signal transduction of mitogen-activated protein kinase. The 352 amino acids long MAPK has a molecular weight of 37 kDa and a pI value of 6.1. The gene sequence contained a dual-phosphorylation activation motif TDY (Thr-Asp-Tyr) and four activity domains (catalytic loop, activation loop, ATP binding site and substrate binding site). The 5'UTR of the gene was also analysed and was shown to contain the MYBCORE, ERE, GT-1 and GATA box, all of which have a role to play in MAPK function. Here we have treated the *OrMKK1* lines with Jasmonic Acid (JA), salicylic acid (SA), ethylene (ET), benzothiadiazole (BTH) and abscisic acid (ABA) to determine the involvement of these molecules and hormones in MAPK signal transduction. *OrMKK1* gene was induced by JA, SA, BTH and ET but was delayed and weak in ABA. The highest level of expression is seen in JA treated plants. The transcript level of this gene was also studied in various tissues and organs of rice and the results show that the gene is developmentally regulated as clearly seen from the Northern analysis conducted on rice tissues. The results from this study suggest that *OrMKK1* may be activated by signal molecules and hormones and this gene may play a role in the plant defense mechanism. (*Journal of Plant Sciences* 4 (2): 32-42, 2009; **doi:** 10.3923/jps.2009.32.42)

The Effects of Steviol Glycosides Blending Liquid on Seeding Growth and Development in Upland Rice

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Using the method of liquid culture and selecting the variety of Handao502, the effect of Steviol glycosides Blending Liquid (SBL) on seeding growth and

development in upland rice had been studied in phytotron. Many indexes were studied including the germination rate of seed, the fresh weight and dry weight, the indexes of physiology and biochemistry in seeding stage. The results indicate that the appropriate treatment of SBL increases the seed germination rate, promotes the growth of shoot and the roots in the seeding stage, increases the fresh weight, dry weight and the ratio of root to shoot, increases the peroxidase (POD) activity, the free proline content and the root vigor, decreases the malondialdehyde (MDA) content. So, proper SBL increases the unsuitable resistance ability in the growth and development of seeding stage in upland rice. This study provides a certain foundation for the high yield cultivation of upland rice. (*Journal of Plant Sciences* 4 (2): 43-48, 2009; doi: 10.3923/jps.2009.43.48)

Pre-Planting (Cold) Treatment of *Allium sativum* Cloves Improves its Growth and Yield Under Open Field and Open Shade Conditions

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The effects of open field and open shade environmental conditions on the growth and yield of untreated and cold treated cloves of *A. sativum* were investigated. Plants from untreated cloves grew higher under open shade, while those from treated cloves grew higher in the open field. Leaf production was influenced under open field condition and not by pre-planting cold treatment of cloves. There was no significant difference in the total leaf area and fresh weight of plants from untreated cloves grown in the open field and those of treated cloves grown in the open shade until day 56 and 70, respectively. Pre-planting cold treatment of garlic cloves enhanced total leaf area, fresh and dry weight of plants under open shade. Plants from treated cloves had better yield (clove/bulb, clove size, clove dry weight and allicin content/clove) than plants from untreated cloves irrespective of the light condition. Results show that pre-planting treatment of garlic cloves did not only enhance dry matter production but also the allicin content of harvested cloves even under open shade conditions. Plants from treated cloves grown in the open field had the best growth while plants of untreated cloves grown under open shade had the worst (50% less than the former). However, plants from treated cloves grown under open shade had very close growth characteristics with plants from untreated cloves grown in the open field. Results show that the cold pretreatment of garlic cloves help to improve its yield and ability to utilize light. (*Journal of Plant Sciences* 4 (3): 49-58, 2009; doi: 10.3923/jps.2009.49.58)

Molecular Characterization of the *Waxy* Gene in Einkorn Wheat

Ya-Xi Liu, Wei Li, Yu-Ming Wei, Guo-Yue Chen and You-Liang Zheng

This study characterizes 15 *waxy* genes from 15 accessions of the einkorn wheats *Triticum urartu*, *T. boeoticum* and *T. monococcum*. The mature protein coding sequences of *waxy* genes were analyzed. Nucleotide sequence variations in these regions resulted from base substitution and/or indel mutations. This work identified 8 distinct haplotypes from the diploid wheat *waxy* gene sequences. A main haplotype was found in 7 gene samples from the A^u genome and A^m genome. The *waxy* gene sequences from the A^u and A^m genomes could be obviously clustered into two clades, but the sequences from the A^m genome of *T. boeoticum* and *T. monococcum* could not be clearly distinguished. The phylogenetic analysis revealed that the *waxy* gene sequences from the A^m genome had accumulated fewer variations and evolved at a slower rate than the sequences from the A^u genome. These results would contribute to the understanding of functional aspects and efficient utilization of *waxy* genes. (*Journal of Plant Sciences* 4 (4): 114-121, 2009; doi: 10.3923/jps.2009.114.121)

Study of Air Pollution Effects on Some Physiology and Morphology Factors of *Albizia lebeck* in High Temperature Condition in Khuzestan

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The main purpose of this study is to determine some physiological and morphological characters of *Albizia lebeck* grown in high temperature condition of Khuzestan in Iran. The location was selected because of high rate of industrial pollution that is caused by petrochemical companies. *Albizia lebeck* Benth. is a deciduous tree with compound leaves, flat oblong fruits, round cream colored seeds, grows wild and planted in almost south of Iran. The plant is found throughout tropical and subtropical Asia and Africa. The concentrations of chlorophyll A, B total chlorophyll, carotenoid, soluble sugar, proline and morphological effects were examined in the leaves of tree species (*Albizia lebeck*), growing in polluted area in comparison with natural condition. In the polluted regions higher concentrations of soluble carbohydrate, proline, chlorophyll A, B, carotenoid were observed in comparison with trees in the unpolluted regions. The morphological characters such as leaf area showed decrease. (*Journal of Plant Sciences* 4 (4): 122-126, 2009; doi: 10.3923/jps.2009.122.126)

Ethnobotanical Utilization and Conservation of Chewing Sticks Plants Species in Ekiti State, Nigeria

Joshua Kayode and Michael A. Omotoyinbo

Surveys and direct field observation were carried out to determine the endangered chewing stick species in Ekiti State, Nigeria. The survey involved the use of semi-structured interviews which were conducted with a fairly open framework that allowed for focused, conversational and two-way communication. Also group interviews were conducted in order to determine group consensus on the chewing sticks plant species. The relative abundance of the identified species was determined by the time it would take to physically come across the plant specimen in the study area. Results obtained revealed that a total of 49 plant species belonging to 28 different families were observed to be in use as chewing sticks. Most of these species were indigenous species; previous studies had revealed that these species were essentially rich in various natural products. The relative abundance test revealed that, 33, 51 and 16%, respectively, of the chewing sticks species were presently common, frequent and occasional on the abundance scale used in this study. Most of the species were uncultivated species whose wildlings were usually preserved in the study area and were in high demand in the study area. Other products widely derived from these species in the study area were identified. Thus the endangered species required urgent conservation efforts. Features that could enhance their conservation in the study area were defined. (*Research Journal of Botany* 4 (1): 1-9, 2009; doi: 10.3923/rjb.2009.1.9)

Induction of Seed Germination in *Cistus heterophyllus* (Cistaceae): A Rock Rose Critically Endangered in Spain

José A. Navarro-Cano, Diego Rivera and Gonzalo G. Barberá

Seed germination from the only European population of the Iberian-North African endemism *Cistus heterophyllus* Desf. was studied by using germination inducing pretreatments. A seeding-cultivation method with flowerpots in a greenhouse was also tested and compared with the usual germination method using Petri dishes in a growth chamber. Seeds were collected in three different years. Germination percentages ca. 43% were obtained without pretreatment. This can be considered a high percentage in the genus *Cistus* and abnormally large for an isolated population composed by only nine individuals. A large variability in seed germination was found among the samples from the same population collected in different years. The dry-heat pretreatment ($87\pm 3^{\circ}\text{C}$ for 12 min and soaking in

water at 20°C for 48 h) significantly increased the germination percentage, reaching 81.5%. Germination in greenhouse was as effective as in growth chamber. The seeds maintained their viability until at least 6 years after collection and storage in a dry atmosphere at laboratory temperature. These results mean the first contribution to the germination ecophysiology of this species and they are fundamental to the recovery plan of the last remnant population of *C. heterophyllus* in Spain. (*Research Journal of Botany* 4 (1): 10-16, 2009; doi: 10.3923/rjb.2009.10.16)

Taxonomic Significance of Foliar Epidermis in Some Members of Euphorbiaceae Family in Nigeria

D.O. Aworinde, D.U. Nwoye, A.A. Jayeola, A.O. Olagoke and A.A. Ogundele

A detailed morphological study of the leaf epidermis of the tropical genera of some species *Acalypha*, *Bridelia*, *Euphorbia*, *Hura*, *Jatropha*, *Manihot* and *Ricinus* in Nigeria is presented. The study revealed several interesting epidermal features some of which have not previously been reported in the genera. Leaf epidermal characters such as pattern of epidermal cells, types of stomata and presence of trichomes are constant in some species and variable in others and thus of great significance in understanding the relationships between and within species. Leaves are amphistomatic in all species except in *Bridelia ferruginea*, *Euphorbia heterophylla*, *Euphorbia pulcherrima* and *Jatropha gossypifolia* which are hypostomatic. The stomata length, width, density and index also vary in different species. (*Research Journal of Botany* 4 (1): 17-28, 2009; doi: 10.3923/rjb.2009.17.28)

Female Gametophyte in Two Kenyan Species of *Inversodicraea*- (Podostemaceae)

S. Sikolia and J.C. Onyango

This study aims to elucidate the ontogeny and organization of the female gametophyte. Further, provide evidences for the strike phenomenon in the Podostemaceae. The female gametophyte ontogeny in *Inversodicraea bifurcata* Engl. *I. keniensis* sp. nov. Nagendran et Sikolia conforms to the Apinagia type of the monosporic category. The primary chalazal nucleus degenerates at the two-nucleate stage. The strike phenomenon met in the family is discussed. The organized female gametophyte is four-nucleate, four-celled and consists of two pear shaped synergids, a large central egg cell and a polar cell. Filiform apparatus

are present in the synergids. Based on the female gametophyte ontogeny, there are no antipodal cell(s). Earlier reports of double fertilization are not confirmed, but only single fertilization take place in the family. The nucellar plasmodium is rationalized on its organization and ontogeny and is formed before fertilization in *Inversodicraea*. Effects of tension force and lytic enzymes during nucellar plasmodium organization and its ultimate significance are discussed. (*Research Journal of Botany* 4 (1): 29-39, 2009; doi: 10.3923/rjb.2009.29.39)

Accumulation of Raphides Crystals in *Euterpe oleracea* Mart. Embryo

M.A.M. Neto, A.C. Conceição, A.S. Mendes, R.C.L. Costa and A.K.S. Lobato

The aim of this study was to determine if the crystals of the calcium oxalate present in the *Euterpe oleracea* embryo has function of calcium reserve during the germination process and if the accumulation is dependent of fruit production. In the experiment 1 the design was entirely randomized, with 3 evaluation periods (September, November and December). In the experiment 2 the design was entirely randomized, with 3 treatments (without cultivation, MS-CaCl₂ after 30 cultivation days and MS + CaCl₂ after 30 cultivation days). The results not confirm the function of calcium reserve of the raphides in *Euterpe oleracea* embryos, however was determined that the calcium oxalate crystals of the embryo are monohydrated and that the production and accumulation is dependent of the season, in which the accumulation is higher in the period of smaller fruit production. (*Research Journal of Botany* 4 (1): 40-47, 2009; doi: 10.3923/rjb.2009.40.47)

An Illustrated Description of *Selaginella imbricata* and *Selaginella yemensis* from Saudi Arabia

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Selaginella imbricata (Forssk) Spring and *Selaginella yemensis* (Swart) Spring, are described in detail in light of numerous recent collections from Saudi Arabia. The two species are recorded for the first time in El-Baha region and Shammaran and Muhayl valley of Asir region. The two species are investigated and compared with those of other countries. A key to the two species is providing. The presence of *Selaginella* species in five different localities in Saudi Arabia indicates that the species are native and not invasive plants. (*Research Journal of Botany* 4 (1): 48-54, 2009; doi: 10.3923/rjb.2009.48.54)

Phytosociological Investigation and Life Form Pattern of Grazinglands under Pine Canopy in Temperate Zone, Northwest Himalaya, India

S. Kukshal, B.P. Nautiyal, A. Anthwal, A. Sharma and A.B. Bhatt

In temperate region of Northwest Himalaya, drier slopes are dominated by *Pinus roxburghii* and are known for rich ground herbaceous flora predominated by grasses. These regions serve as grazingland for livestock and cattle. Present study deals with vegetation analysis, phytosociology and life form pattern of such grazingland between 1100-1400 m a.s.l. across the altitudinal gradient and varying slopes. *Capillipedium parviflorum* is identified as dominant species based on Importance value index, although the area is exhibited by large number of herbs in comparison to grasses and sedges. Vegetation of the area is contagiously distributed and predominantly represented by therophytes and geophytes indicating the degree of anthropogenic activities. The native vegetation is disturbed by overgrazing and life forms of the flora of each of the association are maintained by the intensity of grazing. In the sites under observations, besides grazing, fire was main detrimental factor for dominating the flora by therophytes. Codominance of geophytes may be assigned to its propagation through underground perennating organs as the fire type in these ecosystems is crown fire type. The study describe all these features. (*Research Journal of Botany* 4 (2): 55-69, 2009; **doi**: 10.3923/rjb.2009.55.69)

Rapid and Efficient Method of Genomic DNA Extraction from Pistachio Trees (*Pistacia vera* L.)

M.G. Al-Saghir

This study was conducted to develop a rapid and efficient protocol for extracting high quality DNA from Pistachio trees suitable for PCR and molecular studies. Genomic DNA was extracted from 12 Pistachio trees using modified QIAGEN DNeasy Plant Mini Kit. The results showed that the modified protocol successfully produced a sufficient amount of DNA with high quality, which was highly confirmed by the purity index values of DNA samples (1.45 to 2.01). In conclusion, the modified protocol can produce high quality DNA from Pistachio trees suitable for PCR studies such as RAPD and AFLP and it can be easily adjusted for other *Pistacia* species. (*Research Journal of Botany* 4 (2): 70-73, 2009; **doi**: 10.3923/rjb.2009.70.73)

Cryopreservation of *Brassia rex* Orchid Shoots Using PVS2 Technique

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In vitro grown shoots of *Brassia rex* orchid hybrid was cryopreserved by means of plant vitrification solution 2 (PVS2) technique. For the preculture treatment, the shoots were excised into two standard sizes of 0.5-1.0 and 1.0-1.5 cm and were precultured on half-strength Murashige and Skoog (MS) semi solid medium supplemented with different concentrations of sucrose (control (0.06 M), 0.1, 0.25, 0.5 and 0.75 M) for 24 and 48 h. For the PVS2 dehydration treatment, the 0.1 M precultured (48 h and 1.0-1.5 cm) shoots were chosen for further experiment where the shoots were dehydrated in PVS2 solution at various durations (5, 10, 15, 20, 25 and 30 min) at 0 and 24°C for positive and negative storage in Liquid Nitrogen (LN). The viability of the cryopreserved cells were determined by 2, 3, 5-triphenyltetrazolium chloride (TTC) assay and chlorophyll extraction techniques. The best condition of PVS2 treatment was at 20 min of PVS2 treatment at 0°C prior to storage in liquid nitrogen. In chlorophyll determination based on chlorophyll assay, the highest concentration of total chlorophyll concentration (56.250 µg g⁻¹) was obtained from shoots that were dehydrated for 25 min in PVS2 solution at 0°C without storage in liquid nitrogen. (*Research Journal of Botany* 4 (3): 74-88, 2009; doi: 10.3923/rjb.2009.74.88)

Genetic Diversity of Indian Liverwort *Plagiochasma appendiculatum* Revealed by RAPD Marker

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Genetic diversity of the Monoceious thalloid liverwort *Plagiochasma appendiculatum* was investigated by Rapid Amplified Polymorphic DNA (RAPD) analysis. The species is explained and demonstrated with its genetic diversity on the basis of morphological variations. Samples were collected from different parts of India growing on different habitat at variable altitude. After the study of its morphology, it has been observed that the population of this taxon shows significant variation in plant size, shape, colour, ventral scales, appendages of scales, rhizoids, position of male and female receptacles etc. Based on such morphological variations, we have used the RAPD marker to estimate the genetic diversity within and between the populations. Approximately 75% of the variations have been observed within and between genotypes of *P. appendiculatum* as revealed with both phenotypic and genotypic data. The RAPD markers are being

used increasingly to analyze the phylogenetic relationship among the liverworts to give the exact framework of taxonomic identification of naturally occurring liverwort *P. appendiculatum*. (*Research Journal of Botany* 4 (3): 89-100, 2009; **doi**: 10.3923/rjb.2009.89.100)