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REVIEW ARTICLE

THE ROLE OF BIOTECHNOLOGY IN THE AGRICULTURAL DEVELOPMENT IN KSA: A REVIEW

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Abstract

Traditional biotechnology is defined as using organisms to make products, improve plants, animals or microbes in purpose of using them in agriculture, industry, medical purposes and environment protection through traditional methods, e.g. hybridization, mutants or fermentation. While, modern biotechnology is basically the same, but through employing modern genetic engineering techniques, e.g. recombinant DNA, monoclonal antibodies or cell and tissue culture. It is clearly indicated that there is a global increase of the cultivated area of genetically modified crops (e.g. soybeans, corn, tomatoes, canola and sugar beet) from 1996 to 2014. Moreover, industrial crops such as cotton combat the adverse environmental conditions and solve the problems of desertification, drought and food production, medicine and afforestation of desert land. In conclusion, we see an excellent possibility of employing biotechnology applications for solving environmental and agricultural problems of Saudi Arabia, especially water, feed and food shortages. It is worthwhile for the Saudi government to include biotechnology applications in the Saudi “2030 Vision” and to subsidize biotechnology research and applications in order to overcome the drought and salt tolerance barriers, especially for the mainstays of food and feed in the kingdom such as Date Palm, Barley, Millet and Alfalfa. Besides the potential of investment in biofuels research and production, there is a good niche for the conservation and utilization of the available genetic resources in Saudi Arabia. Hence, there is an urgent need for Saudi Arabia to establish a legal foundation in agricultural biotechnology for future applications in order to encourage the research and investment in biotechnology and to increase the public awareness and acceptance.

Introduction:-

The word of biotechnology consists of two parts, the first is Bio and that come from the Latin word *Bios* which means life and the second is *technology* which means the organized method to make things. Biotechnology are combination between practical methods to solve problems (technology) and production of useful goods (biologically), this is the simple understanding since thousands of years. This understanding changed since 70 years ago, when some microorganisms and yeasts were used to produce antibiotics and vaccines. Then, the definition of biotechnology changed after discovering chromosomes, genes, DNA and its fine structure. After using the cell components in biological application, the understanding of biotechnology is developed into very specific definition based on the application. By this way, the new definition of biotechnology varied between scientific schools (Zika*et al*., 2007).

There is more than one definition for biotechnology; a) British definition: biotechnology is the biological applications, systems and stages of industrial production; b) Japanese definition: biotechnology is a technology uses biological phenomena to copy and produce useful biological products; c) American definition: biotechnology is the organized use of organisms i.e. microorganisms or biological components for useful purposes; d) European definition**:** it explained the science of inputs and tools, biotechnology is interdisciplinary use of biochemistry, microorganisms and genetic engineering sciences in order to achieve industrial application of microorganisms and tissue culture or part of it (Zika*et al*., 2007).

In general, biotechnology can be defined broadly as “the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services” (OECD, 2005). This definition encompasses both *traditional biotechnology applications* – such as fermentation, and plant and animal hybridization – and *modern applications* – such as genetic modification and RNA interference. Traditional biotechnologies such as fermentation have been used for thousands of years to produce goods such as bread, beer, and cheese. The benefits (economic and otherwise) of these applications have long been understood and incorporated by modern society. Starting in the early 1970s, the advent of recombinant DNA technology marked the beginning of modern biotechnology, which created a new set of (previously unforeseen) economic possibilities based on the use of cellular, molecular, and genetic processes in the production of goods and services (Zika*et al*., 2007).

According to the Organization for Economic Cooperation and Development (OECD), biotechnology has several industrial, environmental and energy-related applications. It is used to produce goods such as fuels (e.g. bioethanol and biodiesel), bulk chemicals (e.g. citric acid), specialty chemicals (such as enzymes, amino acids, vitamins, antibiotic derivatives), and biopolymers. Moreover, biotechnology processes are proving to be an alternative to traditional chemical processes used in the production of foodstuffs, pulp and paper, detergents, textiles, and chemicals (OECD, 2009).

The history of biotechnology is frequently divided into three waves. Despite having started at different points in time, each of the three waves now overlaps and impacts one another. The first wave, the green wave, relates to agricultural biotechnology. Biotechnology has long been used to improve breeding and propagation techniques. More recently, genetic modification has allowed for the alteration of genes in order to obtain a desirable outcome. Crops can now be genetically modified so that they become herbicide tolerant, pest resistant or express certain agronomic traits. The second wave, the red wave, pertains to pharmaceuticals and medical biotechnology. Biotechnology has been used in the development of novel therapeutic techniques, diagnostic methods, and vaccines. The pharmaceuticals produced through biotechnology include both small molecule and large molecule drugs. A wide range of experimental therapies are based on biotechnology, including cell-based therapies, genetic therapies, and antisense and RNA interference therapies. Prophylactic and therapeutic vaccines, as well as in vivo and in vitro diagnostics also make up part of the red wave of biotechnology. The more recent is the third white wave; it marks the beginning of industrial biotechnology. The study of genomics has opened a wide range of possibilities related to the use of biotechnology in industrial production: from the use of enzymes in food manufacturing, to the production of chemicals and bioplastics. The development of biofuels (bioethanol and biodiesel),the bio-mining techniques that enables the extraction of metals with a higher degree of success than previous methods and the improved bioremediation techniques are among many other possible biotechnology applications (OECD, 2009).

Agricultural Biotechnology:-

Today, there are many biotechnology applications in agriculture, horticulture, forestry, environmental remediation, medicine, and forensic sciences (Fukuda-Parr, 2006; Mannion, 2007 and Murphy, 2007). Genetic manipulation has been most widely applied in agriculture and horticulture to produce crops with resistance to herbicides and insects. The first staple crops with engineered traits became commercially available in 1996; they were: maize (corn), rape (canola), soybean and cotton. Such crops met with a mixed reception and continued to be controversial today. The technology was embraced in North, South America and China but in Europe GM crops have yet to be adopted due to vociferous anti-GM campaigns. Numerous commentators (Mannion 1995a, b and c; Morse, 1995; You *et al*., 1993 and Fox, 1993) drew attention to the potential pros and cons of GM crops. Later in May-July, 2012, it is the time to revisit the controversy; this is especially appropriate in the light of protests at Rothamsted Research Station near Harpenden, UK, against the growing of wheat plants engineered to produce a pheromone that repels aphids.

The genetically-modified (GM) varieties of major economic crops, specifically soybean, maize, rape (canola) and cotton, were first grown commercially in 1996. In 2012, they were grown on 170 million hectares, representing 6% increase in 2011 (James, 2012), though there was only a small increase in the number of countries involved from 29 to 30. Notably, there remains an absence of participants from Europe where proponents continue to voice concerns about possible adverse impacts on human and environmental health as well as the dominance of a few international companies that market such seed.

In terms of energy investment, GM crops are 'greener' than non-GM crops because reduced insecticide applications lowers energy input (the carbon footprint). Ecologically, non-target and beneficial organisms have benefitted from reduced pesticide use, surface and ground water contamination is less significant and fewer accidents occur to cause health issues in farm workers. The most important adverse characteristic of GM crops is the capacity of insect pests and weeds to develop resistance to GM induced insect resistance in crops or to herbicides used in conjunction with GM induced pesticide resistant crops. Such resistance is not confined to GM crops as resistance in target insects and weeds is evident in non-GM contexts; it does, however, indicate that current GM approaches are relatively transitory in the battle against crop pests and that their viability will depend on good management. In relation to socio-economic impacts, GM crops have increased income for large- and small-scale commercial and subsistent farmers with associated downstream impacts through investments (James, 2012).

Top ten facts in agricultural biotechnology (James, 2014):-

1- The year 2014 is the 19th year of successful commercialization of biotech crops:-

Since the first plantings in 1996, an unprecedented cumulative acreage of more than 4 billion acres (more than 1.8 billion hectares) have been successfully cultivated, equivalent to ~80% more than the total land mass of China or the United States. Biotech crop hectares were planted in 28 countries in 2014 and hectarage has increased more than 100-fold from 1.7 million hectares in 1996 to 181.5 million hectares in 2014 at an annual growth rate of 3 to 4%. A 100-fold increase makes biotech crops the fastest adopted crop technology in recent times because they deliver benefits. Number of biotech countries has more than quadrupled from 6 in 1996 to 28 in 2014.

2- Number of farmers planting biotech crops:-

In 2014, 18 million farmers, of which 90% were small and poor, planted 181 million hectares of biotech crops in 28 countries. Farmers are the masters of risk-aversion and improve productivity through sustainable intensification. Thus, 7.1 million small farmers in China and 7.7 million in India elected to plant over 15 million hectares of Bt cotton in 2014 because of the significant benefits it offers. Similarly in 2014, 415,000 small farmers in the Philippines benefited from biotech maize**.**

3- New biotech crops recently approved for planting include the most important food staple, potato, in the US and the vegetable brinjal (eggplant) in Bangladesh:-

Potato is the fourth most important food staple globally and can contribute to food security in countries like China (6 million hectares of potato), India (2 million) and the EU (~2 million**)**. In 2014, the US approved two new biotech crops for cultivation: Innate™ potato, a food staple with lower levels of acrylamide, a potential carcinogen, less wastage due to bruising; and a reduced lignin. And alfalfa event KK179 (HarvXtra™) with higher digestibility and yield (alfalfa is #1 forage crop in the world). Indonesia approved a drought tolerant sugarcane. Brazil approved Cultivance™, an HT soybean, and a home-grown virus resistant bean, ready for planting in 2016. Vietnam approved biotech maize (HT and IR) for the first time in 2014. In addition to the current biotech food crops which directly benefit consumers (white maize in South Africa, sugar beet and sweet corn in the US and Canada, and papaya and squash in the US) new biotech food crops include the queen of the vegetables (brinjal) in Bangladesh.

4- Strong political will, allowed Bangladesh to commercialize Bt-brinjal (eggplant) for the first time:-

Notably, Bangladesh, a small poor country with 150 million people, approved the prized vegetable Bt-brinjal (eggplant) on 30 October 2013, and in less than 100 days after approval, small farmers planted Bt-brinjal on 22 January 2014. This would not have been achieved without strong Government support and political will, particularly from the Minister of Agriculture Matia Chowdhury; the experience is exemplary for small poor countries. Bangladesh is already field testing biotech potatoes and exploring biotech cotton and rice.

5- The top 5 countries planting biotech crops:-

The US continued to be the lead country with 73.1 million hectares (40% of global) with over 90% adoption for the principal crops of maize (93% adoption) soybean (94%) and cotton (96%). Whereas Brazil has been #1 in year-to-year hectare growth for the last five years, the US ranked #1 in 2014, with 3 million hectares, compared to 1.9 million hectares for Brazil. Notably, Brazil planted the stacked HT/IR soybean on a record 5.2 million hectares in its second year after the launch. Argentina retained third place, down marginally with 24.3 million hectares, from 24.4 million in 2013. India ranked fourth, had a record 11.6 million hectares of Bt cotton (11.0 in 2013), and 95%

adoption. Canada was fifth at 11.6 million hectares also, with more canola and a high 95% adoption. In 2014, each of the top 5 countries planted more than 10 million hectares providing a broad, solid foundation for future sustained growth.

6- The first biotech drought tolerant maize planted in the US in 2013 increased more than 5-fold in 2014:-
Biotech DroughtGard™ tolerant maize, first planted in the US in 2013, increased 5.5-fold from 50,000 hectares in 2013 to 275,000 hectares in 2014 reflecting farmer acceptance. The same event was donated to the public-private partnership, Water Efficient Maize for Africa (WEMA) aimed at delivering biotech drought tolerant maize to selected countries in Africa by 2017.

7- Status of biotech crops in Africa:-
The continent continued to make progress with South Africa, marginally lower at 2.7 million hectares mainly due to drought. Sudan increased Bt cotton hectarage by almost 50%, whilst drought precluded a potentially higher hectarage than 0.5 million hectares in Burkina Faso. An additional seven countries (Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria and Uganda) conducted field trials on pro-poor crops, the penultimate step prior to approval. Importantly, the WEMA project is scheduled to deliver the first stacked biotech drought tolerant (DT) maize with insect control (Bt) in South Africa in 2017. Lack of science-based and cost/time-effective regulatory systems is the major constraint to adoption. Responsible regulation is urgently needed to suit the needs of small famers and poor developing countries.

8- Status of biotech crops in the EU:-
Five EU countries continued to plant 143,016 hectares down marginally by 3% from 2013. Spain led with 131,538 hectares of Bt maize, down 3% from 2013, but with a record 31.6% adoption. In summary, there were modest increases in three EU countries and slight decreases in two countries, mainly due to less planting of maize and bureaucracy.

9- Benefits offered by biotech crops:-
A new and rigorous 2014 comprehensive global meta-analysis was performed by Klumper and Qaim (2014) included 147 published biotech crop studies over the last 20 years, confirmed the significant and multiple benefits that biotech crops have generated over the past 20 years (1995 to 2014). The meta-analysis confirmed that "on average GM technology adoption has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68%". These findings confirm the earlier and consistent results from other annual global studies. The latest provisional data for 1996 to 2013, showed that biotech crops contributed to Food Security, Sustainability and Environment/Climate Change by: increasing crop production valued at US$133 billion; providing a better environment, by saving ~500 million kg of pesticides from 1996 to 2012; in 2013 alone reducing CO2 emissions by 28 billion kg, equivalent to taking 12.4 million cars off the road for one year; conserving biodiversity by saving 132 million hectares of land from 1996-2013; and helped alleviate poverty for >16.5 million small farmers and their families totaling >65 million people, who are some of the poorest people in the world. Biotech crops are essential but are not a panacea; adherence to good farming practices such as rotations and resistance management, are a must for biotech crops as they are for conventional crops.

10- Future prospects:-
Cautiously optimistic with modest annual gains expected due to the already high rates of adoption (90% to 100%) in the current principal biotech crops, leaving little room for expansion in mature markets in both developing and industrial countries. The pipeline is full of new biotech crop products which could (subject to regulatory approval for planting and import) be available during the next 5 years or so; a list of over 70 potential products are listed in the full Brief. They include, a broad range of new crops and traits as well as products with multiple modes of resistance to pests/diseases and tolerance to herbicides; Golden Rice is progressing with field testing and late-blight resistant potatoes are being field tested in Bangladesh, Indonesia, and India. In the US, Simplot has already requested approval for an enhanced Innate™ potato with late-blight resistance and lowered reducing sugars; pro-poor crops, particularly in Africa, such as fortified bananas and pest resistant cowpea, look promising; public-private partnerships (PPP) have been relatively successful in developing and delivering approved products.

Application of agricultural biotechnology in Saudi Arabia:-
As we have mentioned above, biotechnology applications benefited the poor countries more than the developed ones, because it presented a real safe economic solutions for their problems. There is an excellent possibility of

employing biotechnology applications for solving problems of Saudi Arabia environmentally and agriculturally, specially water, food and feed shortages.

Below, there are examples of solving some of these problems on the research levels, but we could not trace any clues or references for end products or commercial applications.

Tissue culture is a technique mainly used for bulk rapid propagation of several commercial plant species including date palm (*Phoenix dactylifera*). Normally, date palm is propagated *in vitro* by three methods: the first method is by embryogenesis in which vegetative embryos can continuously be formed from embryogenic callus. The embryogenesis method is characterized by its ability to produce many plants in shorter periods. The second procedure is organogenesis which provides date palm buds that eventually give plantlets without passing through the callus stage. However, since plantlets are produced directly from tissues of mother plant without passing through callus stage, they are typically identical to mother plant. The third method is *in vitro* propagation using young flowers in which vegetative embryos can be inducing from embryogenic callus (Alkhateeb, 2008). This technique depends on culturing of date palm young flowers on nutritional media with high auxin concentrations to induce callus formation. There are some major obstacles in practical application of date palm tissue culture in the laboratory such as: browning of cultured tissues, vitrification of tissues, bacterial and fungal contaminations, early rooting of tissue cultured buds, deterioration of embryonic callus and its inability to form embryos, callus formation on bases of rooting plantlets. The identified abnormalities and variations in date palm plants produced from tissue culture, such as failure of fruit set, multiple carpels, dwarfism of date palm trees, albinism of leaves, abnormal growth and development of leaves and fruit strands, terminal bud bending, dryness of apical bud and changes in fruit quality were also discussed. In conclusion, most of these abnormalities mentioned previously recover in most cases as the plants get old (10-year-old).

Attia*et al*. (2012) improved a protocol for in vitro propagation of *Rosa hybrida* L. cv. Al-Taif Rose was established using nodal segments harboring axillary buds as explants. In vitro stages of shoot initiation, multiplication and elongation were performed. Explants were cultured on solid Murashige and Skoog medium (MS) supplemented with different concentrations of benzyl aminopurine (BAP, 1, 2 and 3 mg/l) in combination with 1 mg/l kinetin (Kn). Effect of different concentrations and combinations of indole-3-acetic acid (IAA) and indole-3-butyric acid (IBA) on root formation of shoots were studied. The highest percentage of shoot initiation (85%) was observed on MS medium containing 2 mg/l BAP + 1 mg/l Kn, whereas maximum average number of multiplied shoots (2.7) was produced on MS medium with 3 mg/l BAP + 1 mg/l Kn. Highest average number of elongated shoots (26.7) was noticed on MS medium containing 1 mg/l BAP and 1 mg/l Kn. For rooting, highest percentage (66.7%) of rooted shoots was obtained on MS medium supplemented with 2 mg/l IBA. Plantlets with 4 to 5 roots of 3 to 5 cm length were successfully transferred to pots containing sterile peat moss for acclimatization**.**

Taif-roses are a famous rose type that cultivated in Taif region and well known with their deep and intensive fragrance in the Arabian World. Despite of the great economic importance of Taif-roses for the kingdom of Saudi Arabia, their genetic origin has not been yet elucidated. The present study was mainly aimed to assess the genetic relationship between Taif-roses and some rose genotypes that grown in some kingdom neighboring countries using molecular markers and aromatic amino acids contents. Three Taif-roses genotypes namely Hada, Shafa-1 and Shafa-2 were compared to nine different rose genotypes that are grown in Egypt and Syria. Out of 12 RAPD, 8 ISSR and 8 SSR primers used, clear and repeatable band profile of 8, 6 and 7 primers was obtained from the three markers, respectively. Total of 111, 64 and 15 bands with polymorphism of 96.4, 90.6 and 93.3% were obtained using RAPD, ISSR and SSR, respectively. The discriminating power of the three markers has led to efficient grouping of the 12 rose genotypes using Unweighted Pair Group Method (UPGMA). Among the 12 genotypes, Syrian-Gory rose shown the highest genetic similarity of 75, 92 and 65% with the three Taif-roses genotypes Hada, Shafa-1 and Shafa-2, respectively. The established dendrogram was clearly separated the 12 rose genotypes into four major groups in which the three Taif-roses genotypes were clustered in the same group with the Gory rose-Syrian genotype. Moreover, the data revealed that among the studied rose genotypes, the contents of aromatic amino acids in Syrian-Gory rose and the Taif rose-Hada was the highest and followed by the Egyptian Balady rose 1. While Dutch rose 1, 2, 3 and Dutch tulip 1, 2 were recorded to be the lowest. Together, these results indicate that Taif-rose has closed genetic relations to the Gory rose-Syrian cultivated in Syria. Additionally, a reproducible protocol for *In vitro* propagation, of Taif-rose genotype (Hada) was developed (El-Assal*et al*., 2014 and El-Awady& EL-Tarras, 2011).

In order to improve the salt tolerance of some canola genotypes to be suitable for cultivation in Kingdom of Saudi Arabia (KSA), the salt tolerance gene (mt1D) encoding for mannitol-1-phosphate dehydrogenase was introduced to the canola plants using the agrobacterium-mediated transformation (El-Awady and EL-Tarras, 2011). To achieve that, five canola genotypes were selected as a relatively salt tolerance among 15 canola genotypes tested. The regeneration potential of the selected five genotypes was tested. A high percentage of callus induction ranged from 95 to 99% among the 5 cultivars with no significant differences were obtained within two weeks in the presence of 1 mg/ l of 2, 4-D. However, the cultivars showed a varied response to shoot regeneration. The cultivars Paketol and Sarow-8 showed higher regeneration frequency (66% and 61.5%, respectively) compared with the other cultivars using 4.5 mg/l BA. Hence the cultivars Paketol and Sarow-8 were genetically transformed with the salt tolerance gene (mt1D) encoding for mannitol-1-phosphate dehydrogenase.

The mt1D gene was isolated from *Escherichia coli* using PCR cloning, sequenced, sub-cloned in the plant expression vector pBI121 and transferred to the hypocotyls explants exceeded from 6 days seedlings of canola plants. After infection with Agrobacterium, calli were transferred to the regeneration medium supplemented with 100 mg/L kanamycine. Transformation of the regenerated shoots was confirmed by PCR assay. The transformation efficiency calculated as 18 and 11% in cultivars Paketol and Sarwo-8, respectively (El-Awady and EL-Tarras, 2011).

In order to study the effects of salinity on rose and the alleviation of its effects by GA3, different salinity concentrations i.e. 0, 1, 2 and 4 dSm-1 NaCl and GA3 at 0, 50 and 100 mgL-1 on growth and some physiological and biochemical as well as mineral content were investigated (Ali *et al*., 2014). Salinity treatments significantly decreased plant height, branch number and both leaf and stem dry weights compared with the control. Salinity treatments also reduced leaf area and relative water content (RWC), however the stomatal density was increased. Leaf chlorophyll content, N, P, K, Ca and Mg were reduced with increasing salinity concentrations. Meanwhile, Na, Cl and total soluble sugars were gradually increased with increasing salinity concentration. Membrane permeability, proline accumulation and the antioxidant enzymes activities (SOD, CA and POD) of rose leaves were increased by salinity. GA3 treatments alleviated the negative effects of salinity on the growth and physiological and biochemical parameters previously mentioned. The obtained results suggest that GA3 play an important role in the defense system against salinity in rose plant through increasing the antioxidant enzyme activities and proline content as well as preventing ion homeostasis.

Isoflavones are large group of secondary metabolites produced in legumes such as soybeans. They have essential biological functions as nutraceutical and health functions for human. They are involved in plant resistance to biotic and abiotic stresses, symbiotic relationship with nitrogen-fixing organisms and plant competition (allelopathy). El-Shehawi*et al*. (2013) reported that isoflavonoids were expressed in wheat (*Triticumaestivum*) via introducing the key enzymes Isoflavone Synthase (IFS). Transgenic callli induced from wheat immature embryos were propagated and prepared for bombardment. Five gene constructs were prepared; the binary vector (plasmid) pAHC25, 35S-CRC, 35S-IFS, Oleocin-IFS, Oleocin-IFS-CHI and were used for wheat calli transformation. Putative transgenic calli were used to regenerate transgenic wheat plants. Evaluation of recovered transgenic plants was carried out using PCR, southern blotting of PCR products and IFS-specific probe and HPLC analysis of transgenic plant tissue extracts. Genistein and naranigenin were detected in transgenic plants carrying IFS gene, indicating that the introduced IFS was able to use the endogenous substrate from wheat. IFS showed activity under 35S promoter as well as oleocin promoter. The activity of oleocin promoter in monocots provides a good tool to use plant promoters to drive plant gene expression in plants. This also represents promoter compatibility that the cis acting elements of the oleocin promoter represent binding targets for trans-acting elements of wheat. Engineering the isoflavonepathway in wheat would lead to enhancement of nutraceutical value of wheat grains and improvement of wheat resistance to diseases.
Tomato (*Solanum lycopersicum*L.), is considered one of the most important vegetable crops grown in KSA. Recently, salinity and using of the costly desalinized water decrease the production and increase its cost. Development of high salt tolerance cultivars are important demand for expansion of tomato cultivation in the kingdom. El-Awady*et al*. (2014) optimized a transformation protocol that can be used efficiently with the valuable Egyptian salt-tolerant cultivar Edkawy as well as to explore the further potentials improvement of its salt tolerance. Simultaneously, we optimized the transformation protocol and used one of the safe, plant origin and effective salt tolerance gene, AtNHX1 for transformation. Hypocotyls explants exceeded from 8 days seedlings were co-cultivated with agrobacterium for 48 h before transferring to shoots induction medium. Adventure shoots were successfully obtained directly from the explants or from callusing explants using MS medium supplemented with 1 mg L−1 2IP and 0.1 mg L−1 naphthaleneacetic acid (NAA). The regeneration frequency was calculated as more

than 90 %. Number of shoots/ explants was increased after subculture in MS medium containing 1 mg L−1 IBP and 0.3 mg L−1 Kinetin. Rooting was successfully performed in MS medium containing 0.18 mg L−1 indolacetic acid (IAA) and 2% sucrose. After confirming the transformation events in the F0 plants by PCR analysis and prove the expression of the reporter GUS gene, the transformation efficiency was calculated as a 24%. F1 plants expressed the BAR gene were selected after germination of F1 seeds in MS medium containing the herbicide, pasta as a selection agent for 3 weeks. These data indicates the successful transformation of the local tomato cultivar, Edkawy with suitable transformation efficiency using 2IP that replaces the costly plant growth hormone Zeatin. The present reported protocol can be used for further improvement of the Edkawy cultivar and the obtained transgenic F1 plants will be evaluated for their salt tolerance capabilities.

Conclusion:-

As biotechnology applications aim at solving the agricultural and environmental problems in a safe and economic ways that made the poor and developed countries attracted for its adoption more than the developed countries, we see an excellent possibility of employing biotechnology applications for solving environmental and agricultural problems of Saudi Arabia, especially water, feed and food shortages. It is worthwhile for Saudi government to include Biotechnology application in the Saudi "2030 Vision" and to subsidize the applications of biotechnology and their research programs in order to overcome the drought and salt tolerance barriers, especially for the mainstays of food and feed in the kingdom such as Date Palm, Barley, Millet and Alfalfa. Also, Saudis should invest in biofuels research and production. Moreover, there is a good niche for biotechnology research and applications to conserve and employ the available genetic resources in Saudi Arabia.

To our knowledge, besides the membership of Saudi Arabia in Cartagena protocol, there is no clear regulatory platform that regulates biotechnology applications in KSA, except the presence of national biosafety committee, established in King Abdulaziz City for Science and Technology (KACST), and its decree. According to OECD (2009), in order to establish a legal foundation in agricultural biotechnology for future applications, these policies should encourage the application of biotechnology to improve plant and animal varieties through improving access to technologies for use in a wider range of plants, expanding the number of firms and research institutes that can use biotechnology (particularly in developing countries), and fostering public dialogue. Additionally, in industry, to increase support for the adoption and use of internationally accepted standards for life cycle analysis, along with other incentives to reward environmentally sustainable technologies (e.g. boosting research into high energy density biofuels). Hence, there is an urgent need for Saudi Arabia to establish a legal foundation in agricultural biotechnology for future applications in order to encourage the research and investment in biotechnology and to increase the public awareness and acceptance.

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