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Global Challenges and Predictions about Bt Soybean (*Glycine max* L.)

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Despite the successful Bt crop production and advantages, its acceptance around the world is a major obstacle which restricts its entry into the production chain. Soybean (*Glycine max*) is a crop which is infestated with many insect pest and cause severe economic damage to the crop. Though Bt crops are successful in their expression of transgene providing resistance to several insect pest, yet it's production does not follow the major route. Because of the development of resistance in the insect and overcome the transgene expression of the plants. There is a need to integrate several methods into the Bt crop like gene pyramiding and silencing of RNA to increase the level of field resistance against pathogenic organisms. Thus there is need to develop new technique which involve gene stacking such as Cry1Ac, Cry1AF and phosphoinothricin acetyltransferase (PAT) proteins.

Introduction

Around the world, the cultivation of genetically modified crops has increased more than 90 fold since, 1966. Genetically modified crops that express transgene taken from bacillus thuringenesis (soil bacterium), has increased acreage since its commercial cultivation. Crops that express Bt (*bacillus thuringenesis*) are used against insect pest of Lepidoptera and coleopteran family and are an important tool for integrated pest management. A science based environmental risk assessment (ERA) is conducted to evaluate the potential for unintentional adverse effect on beneficial microorganism that are present in agricultural ecosystem. Soybean (*Glycine max*; fabaceae; phaseoleae; 2n=40) is a native crop of East Asia which gained importance for its nutritional benefits. Commercially soybean with crystal (cry) proteins taken from Bt is referred to as Bt-soybean. Annually 20-30% of destruction happens because of insect pest damage. This ongoing increase in population has build up a pressure on agricultural sector to diversify the method of crop production to match global food demand. Today farmers have spiked their interest in cultivating genetically modified crops. Genetically modified soybean has gained farmers interest because of its herbicide tolerant potential or insecticidal activities.

But in spite all the advantages of transgenic crop approach to improve plant qualities and agronomic character over classical breeding; the recalcitrance of people towards acceptance of transgenic food limits the rate at which they can enter the market. Major technique for the development of Bt soybean has been the agro bacterium mediated transformation into the cotyledonary node and somatic embryo particle bombardment method (Yamada et al 2012). Bt soybean "Roundup ready "(MON87701*MON89788) MON87701-expressing Cry1Ac protein for insect resistance, MON89788- glyphosate tolerance for

herbicide has some benefits that had exposed the crop to phytopathogens and new emerging destructive insects. Nowadays most cultivated Bt soybean expresses Cry1Ac, Cry1Ab, Cry1Af and phosphoinothricin acetyltransferase proteins.

Global predictions of commercialized Bt soybean

The first generation of Bt crops offered a boost in yield and production by increasing crop tolerance from insect pest disease and weeds. According to this Bt soybean will be predominantly produced by 2050, and that global production is anticipated at 311.10 and 377.30 million metric ton in 2020 and 2030, respectively (FAOSTAT 2012). Consequently by 2030 90% of worlds genetically modified soybean will be supplied by Argentina, USA, Brazil, China, while India will be supplying high-yielding conventional soybean. The worlds total farmed area will increase by 1.5 times, land occupied by soybean would increase to 140.90 million hectare by 2030. This could result in serious unintentional global challenge to production of other crops due to insufficient area for farming. But despite of rising output of genetically modified soybean, global acceptance is still low, although Bt soybean haven't shown any substantial damage to animals , environment, and human health(James 2010, 2015). But some countries do not permit the commercialization of transgenic plants and that's a major obstacle.

Type of delta-endotoxins engineered in commercialized soybean

Since the discovery of Ishiwata in Japan ,the first isolation of *Bacillus thuringenesis* from silkworm larvae and the discovery of insecticidal delta endotoxin crystal protein(Cry),lead to the oil formulation , granules and powder of bt protein to curb insect grazing. This is because action of protein is to kill larvae by causing perforation and swelling in the insecticidal gut. And target order Lepidoptera (especially by Cry1Ab, Cry1Ac), dipteral (Cry4Aa Cry4Ba). This mechanism is eco friendly and eliminates the chewing insect pest but poses a threat for resistance. Bt reduces dependence on chemical insecticide. Advances in the field of biotechnology have led to the development of bt toxin induced genetically modified soybean which led to the development of Bt insecticide, exposed to biodegradation and wash off. Moreover, specificity of Cry-protein reduces insecticide use and lower production cost, and minimizes the exposure of hazardous chemical. Till date, Cry1Ac, Cry1AF, Cry1F, Cry2Ab2 are most used proteins in Bt-soybean.

Current field performance of Cry genes in Bt-soybean and insect tolerance

Reports suggested that when Cry1Ab was introduced into a soybean line imparts partial resistant to defoliating insects, the T1 plants deterred feeding, development , and survival of velvet bean caterpillar *Anticarsia gemmatalis*, but it never entered into the production chain. The first BT soybean was introduced in January 2009 that express Cry protein against insect resistance. Till 2013, Monsanto stacked MON87701*MON89788 and then released in phased 3 trial in Brazil (Stein and Rodriguezo 2009) and eventually became first commercial Bt-soybean in Brazil in 2010 and Argentina in 2012. The developments of Bt-soybean DAS-81419-2 (Conkesta technology) expressing Cry1Ac, Cry1F and phosphinothricin acetyltransferase (PAT) proteins in Brazil have shown high resistance towards lepidopterian insect. (Marques et al 2017; fast et al 2015).

Synthetic Cry 1Ac was developed by engineering fertile Bt-soybean by Cregan et al who identified two quantitative trait loci (QTLs 229-H and 229-M) from native lines conferring antibiosis and antixenosis against lepidopterian insect. By utilizing (gene pyramiding) these QTLs with synthetic Cry1Ac enhanced the plant defence against destructive insect pest (Cregan et al 1999). When plant has a detrimental effect on insect growth and development this phenomenon is antibiosis. Antixenosis is a type of resistance mechanism which does not attract insect for oviposition or colonization or feeding (Kogan

and Ortman 1978). Expression of synthetic Cry1Ac significantly reduced the incidence of lepidopterian population.

Climatic condition alters the performance of Cry genes in Bt soybean

We found from literature search that major problem associated with Cry proteins is the low expression level in field condition. That is below 3ng/mg of soluble protein in plant generation before to (parent) plants. This happens because the native regulatory sequence for the translation of Cry protein is not properly available and secondary structure hinders mRNA translation of Cry protein (Perlak et al. 1990). Also the phenotype and expression of transgene is not stable in plants. Another major point is the difference in cultivar which reacts differently with the environment and the factors like temperature, relative humidity, light and soil affect the expression of plants (Kranthi et al 2005). And by subsequent studies it was found out that the expression of Bt protein remain restricted with the leaves only and generally fall towards anthesis and gradually regain after the phenomenon. This whole scenario suggests that the change in climatic condition can affect the expression of Bt and thus can alter the global status of the Bt-soybean.

Future of Bt-soybean in India

Acceptance of transgenic crop in India surrounds a social stigma of involving foreign gene in our food. But what we eat regularly as our meal is also foreign DNA of other living bodies. Foreign DNA when enter our body is broken down to small basic molecule and are not integrated into the human genome blueprint. There is no such evidence of transgene affecting our health or of its biomagnifications till now. India being a country where more than half of it's population are undernourished because of not incorporating enough nutrition in their diets. Bt-crops can provide a boost to the production with low maintenance cost. Till now Bt-cotton is the only crop which is widely accepted and grown because cotton is mainly used in the textile industry which does not involve its consumption. Before the introduction of Bt-soybean, Bt-brinjal was introduced but it was not accepted in India due to concern about ethical risk and human health issues. Another major problem with the acceptance of these crops is that they produce enough yields with the conventional method of production and does not require a supplemented boost in the present scenario.

First generation Bt crops provide only protection against the prevalent insect pest i.e. they improve the crop agronomic traits. Second generation crop will integrate nutrients into the crop which increase their value in terms of nutritional health. In India till date agronomically superior cultivars of soybean are present and cultivated with high yield and are predicted to be continued till 2030. But change in climatic condition and rapid evolving new strains of pathogen will soon become dominant over the present day cultivar and will adversely affect the cultivation. Bt-soybean promise several advantage and no potential threats as of now, except the emergence of new strains of pathogen which will eventually around itself due to mutation in nature thus by 2030 it is predicted that India will move towards the acceptance of more Bt-crops to fulfil the agricultural demand.

Conclusion

In this era where human population is increasing minute by minute, there is an urgent need of increase in food production with such limited resources. Genetically modified crops seem a way forward to this problem because it reduces the dependence on herbicide and insecticide and reduces the cost of production. The drawback which is development of resistance in the pest can be actively worked out by integrating new technologies and concept, and this seems a way forward. Bt soybean helped to curb the problem of lepidopterian and coleopterian insect and protect the environment from harmful insecticide and herbicide. In upcoming time the potential use of Bt crops should increase, and to enhance the effectiveness gene

pyramiding can be performed to integrate two different Cry proteins with two different receptors. Care must be taken not to compromise on human health, animal health and abrupt collapse of biota due to elimination of non target pest.

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