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AGRO-ENVIRONMENTAL CONSEQUENCES OF QUALITY PROTEIN MAIZE (QPM) HYBRID DEVELOPMENT WITH SPECIAL EMPHASIS OF SOIL NITROGEN MANAGEMENT

Saket Kumar[1]*, Abhijit Sarkar[2], Rajeev Pratap Singh[1] and Rajesh Singh[3]

[1]Institute of Environment and Sustainable Development, Banaras Hindu University, Varanasi - 221 005 (U.P.), India.
[2]Laboratory of Applied Stress Biology, Department of Botany, University of Gour Banga, Malda-732 103 (W.B.), India.
[3]Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, B.H.U., Varanasi-221 005 (U.P.), India.

Abstract

Maize (*Zea mays* L.) ranks within the top three widely cultivated and consumed crops worldwide. More than one-third of the global population at both developed and underdeveloped countries depend on maize as their primary dietary supplement. During late 1990's, quality protein maize (QPM) hybrid was developed mainly to provide higher amounts of both the amino acids lysine and tryptophan, essential for humans and monogastric animals, through conventional crop breeding system. As a result of superior hybrid nature, QPM also shows improved tolerance to different environmental conditions and grows across a wide range of agro-ecological zones. In general, QPM inbred lines develop at both winter and summer season. The phenological responses and yield performance of QPM are significantly better than that of normal maize varieties. The nitrogen (N) utilization dynamics of QPM is also very interesting. Usually, it produces higher grain yield under lower N levels. The critical value of N plays an important role in tryptophan and lysine production of QPM. Therefore, lysine and tryptophan fluctuations might act as markers to understand regulatory aspects of amino acid synthesis in QPM plants under different N levels. The present review aims to catalogue previously published works at this sphere, and plans to draw a roadmap for the future researchers.

Key words : QPM, nitrogen, tryptophan, lysine, environmental variables.

Introduction

Maize (*Zea mays* L.) a short day facultative crop, plays an important role in global human diet. As a major coarse cereal, it ranks third after rice and wheat (Mboya et al., 2011). According to global maize production, China and U.S.A. ranks first and second followed by Brazil, Argentina, Ukraine, India, Mexico, Indonesia, etc. (fig. 1). Maize provides at least 30% of the food calories together with rice and wheat to almost 4.5 billion people in developed and developing countries (CIMMYT, 2011). According to Watson (2003), maize contains 71.7% starch, 9.5% protein, 4.3% oil, 1.4% ash and 2.6% sugar (Watson, 2003). As compared to other coarse cereals like – sorghum, barley, oats, rye, and pearl millet, the amount of protein and its quality is significantly better in maize (table 1). In developing and underdeveloped countries of South East Asia, South America and Africa, where sources of animal protein are too expensive, maize can be a proper source of protein for a larger sector of malnourished and poor people (Wegarya *et al*., 2011). In spite of its food value, maize is also used as industrial raw material for manufacturing of different products in industries like – textile and others. As a coarse cereal and alternative crop maize is generally cultivated in marginal lands and faces various extreme climatic conditions as well as diverse biotic and abiotic stressors (Zaidi, 2002; Badu Apraku *et al*., 2006).

Due to its nutritional potential, maize has long been recognized as the prime test material for crop breeders and plant biotechnologists. After years of painstaking research, crop breeders finally achieved Quality Protein Maize (QPM) varieties which are significantly improved in quantity and quality of grain protein. Opaque2 genes are incorporated in QPM genotypes along with associated

Author for correspondence : E-mail: rajeevprataps@gmail.com

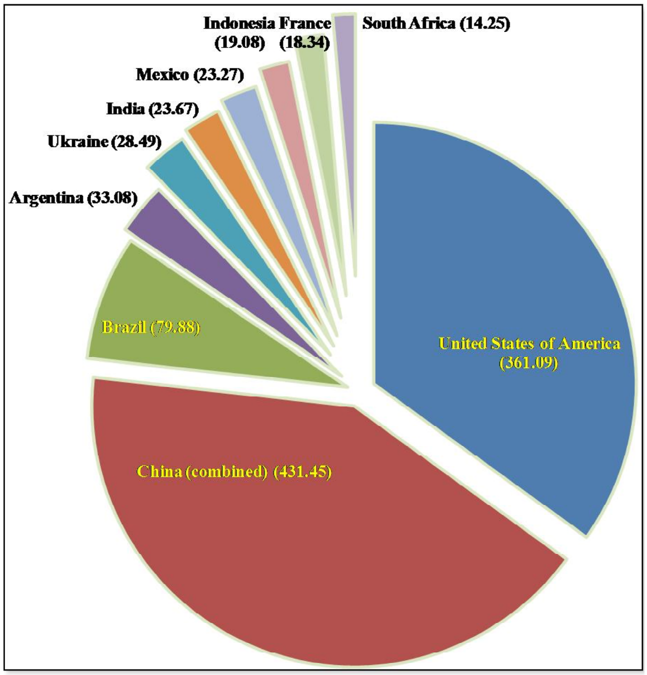

Fig. 1 : Top ten maize producing countries and / or regions as per their rank in order (the amount in bracket is annual production in million MT) [data adopted from FAOSTAT, 2016].

modifier genes, which promote higher amounts of essential amino acids lysine and tryptophan (Krivanek *et al*., 2007). QPM hybrids are superior to normal hybrids for their yield and stress tolerance (Bisht *et al*., 2012; Ganesan *et al*., 2004; Srinivasan *et al*., 2004). Prasanna and Vasal (2001) showed nearly 10% increase in yield in QPM as compared to other maize hybrids. QPM has almost 90% relative nutritional value of milk as compared to the 40% of normal maize cultivars (Mohammad *et al*., 2012). Akuamoa-Boateng (2002) showed that children who consumed QPM grains with higher lysine and tryptophan as dietary supplements became healthier with multiple disease tolerance capacity. Present review aims to catalogue the previously published research works related to the importance and agro-economical consequences of QPM and its responses to optimal soil nitrogen management; hence, a future road map can be drawn for further improvement in this sphere.

Importance of QPM Hybrid Development

QPM hybrid proved to be a major beneficial source of dietary supplement for all developing and underdeveloped countries. After a long research, the approach of the CIMMYT researchers in QPM development has proved to be successful and globally accepted. The prestigious 'World Food Prize' in the year 2000 to maize breeders and principal developers of QPM,

Table 1 : Comparison among protein content and quality of major coarse cereals.

Name of the coarse cereal	Crude protein content (mg g^{-1})	% of available calories from protein	Protein quality (% of casein)
Maize	9.8	9.4	96.8
Sorghum	8.3	11.3	32.5
Barley	11.0	12.5	58.0
Oats	9.3	16.9	59.0
Rye	8.7	14.7	64.8
Pearl millet	11.5	11.8	46.4

[data adopted from FAOSTAT, 2016]

Surinder K. Vasal and Evangelina Villegas is undoubtedly a major recognition of an outstanding example of interdisciplinary teamwork of the CIMMYT researchers and definitely points towards the relevance of QPM to millions of people across the world (fig. 2). QPM is now of major interest to breeders, geneticists, seed producers and the industry, as its large-scale production promise to offer significant benefits. Practically all QPM research programmes in different countries are now using this approach based on the combined use of the o2 gene and the endosperm modifiers (Sofi *et al*., 2009), which allowed the production of large number QPM hybrid populations. Development of early and extra early maize varieties are common practice in the maize breeding program that is drought escaping, to withstand the effect of short rainy season, and prevent drought stress (Bello *et al*., 2014). It normally, adopted for a diverse environment like *Rabi* (Winter) and *Kharif* (Rainy) season and early maturity quality production. Normal maize is converted in QPM together with increasing levels of lysine and tryptophan, composition performance high yield, and improved resistance to drought (Olawuyi *et al*., 2013) (fig. 2). Maize is accession high tryptophan content to the presence of recessive homozygous opaque2 individuals; this indicated that QPM plants had much higher tryptophan content than other population. It also indicated the presence of amino-acid and modifier genes, considering the landmark populations that were completely homozygous for opaque2 and lower values of tryptophan content (Wu *et al*., 2002). The relative chemical composition of maize grains evaluates for commercial purpose as will be used (Baye *et al*., 2006). For example, quality protein maize (QPM) has to produce increased amounts of essential amino acids such as lysine and tryptophan, therefore increase it' s nutritional value for protein-deficient populations (Krivanek *et al*., 2007) and significantly increases the pig weight by QPM feed (Sofi *et al*., 2009). These varieties are given high yield (ranging from 20-

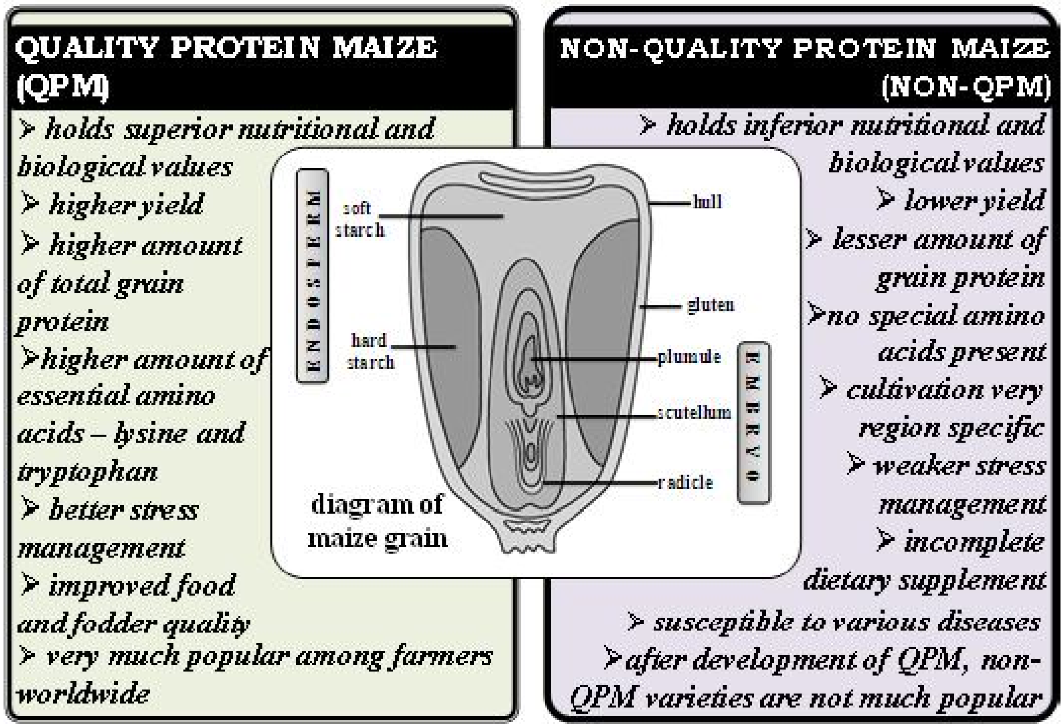

Fig. 2 : Comparison among QPM and Non-QPM varieties as per their characters and impact to agriculture and society.

25% than other maize varieties) with favorable and stable genes and potential across a broad range of water availability (Olaoye *et al*., 2009).

These genotypes were evaluated under supplement optimum, low and high nitrogen in drought condition along with one normal check. Plant breeders were achieving some success in the development of hard and qualitative endosperm o2 after the use of endosperm modifier genes in the usual maize crop in the winter season (Vasal, 2001). Guimarães *et al*. (2000) recover the parental genotypes by use of modified backcross technique and the selection of new QPM traits. The selection of heterozygous male parents (02o2) by crosses with homozygous females (0202) parents. Finally, selection of 02 seeds with desirable QPM traits in F_2 cross (0202). Ignjatovic-Micic *et al*. (2009) analyzed some lines of QPM for protein and tryptophan content under a breeding program. These are essential and unique amino acids for good agronomic performances in the development of germplasm (Vivek *et al*., 2008). Modified backcrosses are performed in the potential develop and release of QPM hybrids, it can be used in other breeding programs to incorporate multiple seed traits as control by recessive alleles and modifier genes (Guimarães *et al*., 2000). This process is more successful, if hybrid performance will be equal to the isogenic counterpart, with the additional traits of interest in maize crop.

Soil Nitrogen Management and QPM Hybrids

Effect of different nitrogen level in amino acid production in QPM hybrids

Nitrogen (N) is an essential fertilizer, required a large amount in maize crop production. In India, the annual production of maize largely depends on the high and low soil N levels. Even diverse released maize varieties responds differently under differential soil nutritional levels (table 2). Maize is easily grown in all types of soil with low N and altered stress conditions. Low N hinders photosynthesis by reducing leaf area development and accelerating leaf senescence during summer season in maize crop. Though, reports also showed that low N improves maize production against drought tolerance by a common adaptation mechanism (Banziger, 1999). Maize also grows faster with uptake low amount of N as fundamental sources (Muza *et al*., 2004). The rate of low N stress has been studied extensively for grain yield and other grain yield-related traits of normal maize (Worku *et al*., 2008). Betrain *et al*. (2003) compared the differences among the yield of diverse maize hybrids (table 2) under lower and higher N environments; and reported about 33% difference in grain yield under higher N environment. Experiments were performed under low N, and reported yields on an average 25 – 35% (1.5-3.5 t ha^{-1}) as compared to favourable maize cultivation

Table 2 : Different released varieties respective to higher and lower doses of fertilizers [data adopted from Kaul *et al.* (2017)].

Maize	Pedigree	Sources	Year	Characteristic Features
Malviya Makka 2	HUZM 185 × HKI 1105	IAS, BHU	2007	Yellow, medium maturity, responsive to higher doses of fertilizers and resistance to MLB
HM 5	HKI-1344 × HKI1348-6-2	HAU	2005	White, medium maturity, dent, responsive to high dose of fertilizers and tolerance to frost
HQPM-1	HKI-193-1 × HKI-163	HAU	2005	Yellow, dent, late maturity, responsive to higher doses of fertilizers, tolerance to frost, common rust and MLB
HQPM-5	HKI-163 × HKI-161	HAU	2007	Orange, flint, late maturity, responsive to higher doses of fertilizers and resistance to MLB
Shaktiman-3	CML-161 × CML-163	RAU	2006	Orange, late maturity, semi, flint, tall 0.73% tryptophan in protein tolerance to MLB and LSM
Vivek QPM-9	VQL-1 × VQL2	VPKAS	2008	Yellow, dent, extra early maturity and perform better yield to low N2

[IAS, BHU: Institute of Agricultural Sciences, Banaras Hindu University; HAU: Haryana Agricultural University; RAU: Rajendra Agricultural University; VPKAS: Vivekananda Parvatiya Krishi Anusandhan Sansthan]

environment (6 – 9 t ha^{-1}). In the tropical areas, some maize hybrids grown under marginal rain-fed environments are mostly affected by multiple biotic and abiotic stressors. Supplement of low-N fertilizer is controlled total productivity of maize crop in the lowland area of drought-affected fields (Zaidi *et al*., 2008). Grain yields increases as N rate increases during *Rabi* (winter) season in maize crop production (Mason and Croz, 2002). Low N rate is mostly affected by drought environment for protein and tryptophan development in maize hybrid crops (Muza *et al*., 2004). Meena *et al*. (2007) in their field study on maize harvest stage reported higher N uptake under higher soil N levels, up to 120 kg N ha^{-1} as compared to 0, 60 and 180 kg N ha^{-1}, on black clay loam soils at Hyderabad and clay soils of Junagadh, India. Singh and Totawat (2002) reported from Udaipur, that number of kernels $cob^{-1}$and kernel yield 100% from a recommended dose (90 kg N ha^{-1}) of N over 50% and 75% of N on clay loam soils.

Mishra *et al*. (2012) reported that protein content was higher in grain during N uptake up to 200 kg N ha^{-1} compared with the lower amount of N on sandy loam soils of Bahraich, Uttar Pradesh, India. Nitrogen is an important macronutrient for development of amino acids and proteins in maize crop (CIMMYT, 2003). Tryptophan amount of a QPM hybrids were increased in both low N and optimum N levels, while the quality index remain unchanged (CIMMYT, 2003). The effect of low amount N and drought in maize resulted in more desirable stress tolerant cultivars (Betran *et al*., 2003). The tolerance levels of maize from low N and droughts are partially related to the development of maize root system that influences nutrient uptake in presence of moisture as well as the water around the maize crop system (Kamara *et al*., 2004).

The protein quality of most QPM hybrids is higher than normal maize hybrids under low N levels and optimal conditions in which tryptophan level was more stable in maize grain across the environmental condition (Pixley and Bjarnason, 2002), and tryptophan amounts were higher in QPM hybrids compared to non-QPM under optimum conditions (CIMMYT, 2003) (fig. 2). Although, QPM hybrids had higher tryptophan and protein than non-QPM cultivars in all environments under low nitrogen conditions. However, quality of lysine and tryptophan levels is unaffected in a low level of N. Protein and tryptophan amount is differentiated in grain during existed crosses of environment due to N fluctuation (Ngaboyiisonga *et al*., 2008).

In the other words, protein quality is maintained, when QPM is grown under drought conditions. But, lack of N enhances kernel abortion and reduces grain numbers; weight and grain yield (Monneveux *et al*., 2005). The green characters of maize leafs were also reflecting to amount of nitrogen during grain filling period (Borell *et al*., 2001). Ngaboyisonga *et al*. (2008) determined the significance of additive and non-additive gene action that conferring concentration of tryptophan and protein in QPM kernels. Amount of soil N and irrigation affects maize crop at genetic level, and determins protein and tryptophan levels too (Ngaboyisonga *et al*., 2008).

Endosperm modification at Low N levels

The endosperm modification was scoring in an optimum environment with low N and drought condition that show genotypes incensement between 0-50% in low nitrogen and 30-100% under drought environments. Drought conditions increased endosperm modification because 68% of genotypes increase superior in drought condition (Ngaboyiisonga *et al.*, 2008). Endosperm modification of QPM hybrids has been less stable in dry environments (Pixley and Bjarnason, 2002). There was very little data were published that indicating stress for modification of endosperm, protein quality and quantity in QPM germplasm (CIMMYT, 2003). A light table is a conventional approach for the molecular analysis of QPM hybrids.

Light table selection (desired level of modified maize) is done to pick out kernels with the o2o2 genotypes by using a degree of opaqueness, due to gene segregation. The endosperm hardness (opaqueness) were varying a degree of softness and hardness in the modified endosperm (Markovic *et al.*, 2007), it was identified and confirmed QPM quality and percentage of amino acids in a laboratory. Value of lysine will be four times that of tryptophan because a kernel is seen o2o2 genotype (soft endosperm) for a complete opaqueness. O2o2 genotype (hard endosperm) is the translucent observation of the opaqueness from 1 to 5 scoring scale on the basis of opaqueness (Vivek *et al.*, 2008). These scores are as follows:

Type 1	(modification score)	:	not opaque
Type 2	(modification score)	:	25% opaque
Type 3	(modification score)	:	50% opaque
Type 4	(modification score)	:	75% opaque
Type 5	(modification score)	:	100% opaque

Biochemical analysis

The sequencing of maize genome and identification of markers associated with protein and grain modification that help rapid identification of genes and responsible for their traits. The syntheses of lysine and tryptophan are carried out in a complex system and strongly regulated metabolic pathway, which has aspartic acid precursor with several enzymes and regulated by feedback inhibition. Cereal seeds constitute a part of proteins and deficit amino acid composition in maize crop. It's study are indicating lysine catabolism that play an important role for lysine accumulation in maize crops and control level of lysine content in seeds (Arruda *et al.*, 2000) (table 3).

(i) Protein Contents Determination

The protein amount was determined by Kjedahl method based on nitrogen determination (Vivek *et al.*, 2008). The most aboundant proteins are zeins in maize grain endosperm. Alpha- zein is poor aboudent protein for lysine and tryptophan development (Gibban and Larkins, 2005). The homozygous o2 mutant causes decrease production of alpha zein fraction of endosperm that corresponding increase proportion of non zein proteins, it naturally contains increase level of lysine and tryptophan (Gibban and Larkins, 2005). The protein was estimated from the following way:

% Protein = % Nitrogen × 6.25 (conversion factor for maize).

(ii) Tryptophan Contents Determination

Tryptophan content was determined by using the colorimetric method of Nurit *et al.* (2009). The color was developed in the reaction of flour hydrolysate (obtained by overnight digestion with papain solution at 65°C) with 2 ml of reagent containing 56 mg of Fe_3. After incubation at 65°C for 30 min, and absorbance are read at 560 nm. Tryptophan content calculated by using a standard calibration curve, developed with known amounts of tryptophan, ranging from zero to 30 μg/μl (table 3).

(iii) Lysine content

Lysine contents were determinations by HPLC, as quality protein breeding manual (Vivik *et al.*, 2008). Lysine contents were highly significant differences existing in additive and non-additive components among parents, and the additive effect were main on lysine content. The lysine content in kernels was tested by using matrix-I type NIRS and the effects of genotypes, locations and their interactions as well as gene action and heterosis were evaluated on corn lysine content in F_2 kernels (table 3).

Genetic basis of QPM Hybrids

Effect of Genotypes and Environmental (G × E) interaction in QPM Hybrid Production

Crop breeders have been trying to development superior genotypes with highly grain yields, short duration maturity and other desirable characters, related to different environmental conditions of India. Genotypes and environmental (G × E) interaction is one of the main complications for selection in crop production. The phenotypic effect of a maize crop is determined by combining effect of the environment and genotypic interaction with each other in stress condition. In India, maize productivity is limited due to abiotic stresses (Araus, 2002). The maize crop production of spring season is low in per year due to high temperature that affects the pollination and seed setting in maize. Among different abiotic stresses, drought is one of the popular and undesirable factors, affecting growth and yield of the maize crop. The QPM production is one of the most vital forces that improve tolerance under stress condition of world food security (Denby, 2005). Low N tolerance is desirable process of normal maize production in *Kharif* (Rainy) season for increased productivity, that observe resistance to cold and drought in three stress condition at per season of year. Drought tolerance accessions of maize crop have been establishment by a core collection (Babic *et al*., 2011).

The genotype of maize crops are effected after some environmental interaction, therefore there traits are analyzed in different season depending upon different morphological soil nature. In this condition o2 genes are exhibit pleiotropic effects from distinct mode of inheritance in different traits of maize crop. Such as a recessive single gene inheritance lysine content of maize crop through cross formation and expression tryptophan amount of QPM in stress and optimum conditions (Mosisa, 2005). These QPM hybrids are across all environmental conditions and stable of traits in maintain protein level and endosperm of maize crop (Zaidi *et al*., 2008). Maize yields are significantly depends on the environmental condition, soil condition, water availability and amount of nutrient supplements in adequate moisture that produce a quality of high genotypic interaction (Banziger and Diallo, 2004). Significant variations are also observed among the different environments. The hybrids performance were not consistent across environments for all testing traits as significant of H × E interactions across optimum nitrogen, low nitrogen stress in all soil environments.

Endosperm modifications were similarly obtained by a survey (Pixley and Bjarnason, 2002), for protein and tryptophan development of grains (Ngaboyisonga *et al*., 2008) in Indian economy. Endosperm modification scores were tended to increase low nitrogen and stress conditions. Therefore high score was indicated poor endosperm modification; this finding was applied by QPM cultivars in which lose kernel hardness due to low soil nitrogen stress. Endosperm modification of QPM hybrids has been recorded less widely in a stable across the environments (Pixley and Bjarnason, 2002).

Management of Stress Environment

Plant breeding is more important to raise crop yield potential and greater adoptive in the future agricultural system (Araus *et al*., 2002). Potentially climate change is lead to increase temperature and evapotranspiration losses and eventually decreased rain fall in the maize crop (The World Bank, 2007). Flowering period is the very sensitive time of maize crop. Most of the maize breeding activities are conducted under optimum growing conditions and do not take the other conditions of the smaller formers (Muza *et al*., 2004).

Table 3 : Amount of proteins and amino acids (tryptophan and lysine) in QPM and non QPM (Vivek *et al*., 2008).

Biochemical component	QPM (%)	Non-QPM (%)
Protein Lysine Tryptophan	≥ 8 4 ≥ 0.65	≥ 8 2 ≤ 0.60
	Whole grain	Endosperm
Tryptophan and Proteins	0.075 8*	0.07 8*
Quality	index	0.8 0.7

*Protein level higher than 8% is desirable; but ensure QI is minimum.

Maize is growing in tropical, marginal and rain-fed environments, during affection biotic and abiotic stress conditions. Mostly grain yield could be affected by drought stress condition in growth stages (Banziger *et al*., 2000), but silking is drought sensitive period during flowering after 2-22 days. Low-N fertility and droughts are performing major role for maize productivity constraints in the lowland tropics (Zaidi *et al*., 2008). Draught environments were achieved by stopping irrigation one week before flowering, when field received 64 Kg N ha^{-1} and 46 Kg P ha^{-1} during plantation, 46 kg N ha^{-1} after plantation in seven weeks under control of optimum environment. The growing world population together with lack of expansion, reduction and available arable lands needed to maintain agricultural sustainability (Cassaman, 2003). Thus, unpredictable nature of climate related stresses and recorded number of testing sites recommended for development and manage stress sites (Edmeades *et al*., 2006). Management of stress environments are targeted for selection of reduces abiotic stress conditions (Banziger and Cooper, 2001).

Drought conditions are managing stress crop in rain free natural environments, its equipment was managed with irrigation capacity and N stress crops conducted under uniform N depleted fields (Edmeades *et al*., 2006). QPM hybrid is an improved maize variety, these are tolerating to heat and low soil fertility in stress prone areas of maize farmers to obtain better harvest crop (CIMMYT, 2007). Bänziger *et al*. (2003) showed improve QPM hybrids for drought tolerance with low N condition. New QPM hybrids were performing under low nitrogen, stress and optimal conditions with desirable endosperm modification and protein quality. Protein concentrations

Table 4 : List of some genetic primers used in identification of QPM and non QPM inbred lines.

Name of Primer	Size(bp)	non QPM Inbred Lines						QPM Inbred Lines		
		CML145	V353	V358	V359	V3z69	V370	CML184	CML180	CML176
ZmHSDH5	280 – 290	+, -	+, -	+, -	+, -	+, -	+, -	-, +	-, +	-, +
ZmASK1	205 – 230	+, -	-,-	-,-	-,-	-,-	+, -	-, +	-, +	-, +
ZmOM5	190 – 200	-,-	-,-	-,-	-,-	-,-	+, -	-, +	-,-	-,-
ZmHSDH4	160 – 170	-,-	-,-	-,-	-,-	-,-	+, -	-, +	-,-	-,-
ZmHSDH2	90 – 100	+, -	-,-	-,-	-,-	-,-	+, -	-, +	-,-	-,-

Symbol + indicate presence of DNA band, - indicate absence of DNA band in gel.

Table 5 : Detection of QPM and non QPM by tow simple sequence repeat (SSR) markers (phi057 and phi112) in three QPM population (Pop61C1, Pop62C6, Pop65C6) and in two standard varieties of Opaque-2 (QPM) and Suwan-1 (non QPM).

Plant varieties	Maize types	Number of plants and percentage (%)	
		Phi057	Phi112
Pop61C1	QPM Non QPM	24(60%) 16(40)	34 (85%) 6(15%)
Pop62C6	QPM Non QPM	34(97%) 1(3%)	35(100%) 0(0%)
Pop65C6	QPM Non QPM	24(80%) 6(20%)	30(100%) 0(0%)
Opaque-2 Suwan1	QPM Non QPM	3(100%) 3(100%)	3(100%) 3(100%)

(Babu *et al*., 2005).

are also down under low N compared to optimum N (CIMMYT, 2003). CIMMYT (2003) reported tryptophan amount of QPM under both low N and optimum conditions.

Nitrogen initiation effects are determined to genetic parameters such as gene action and combining ability of protein quality of QPM hybrids, gene actions are governing protein concentration and nature of tryptophan concentration. Zaidy *et al*. (2003) also suggested the utilization of QPM hybrids tolerant to N efficient cultivars in maize production, to lead better stability of grain yield in different environments. The highest grain yielding genotypes tend to, delayed senescence, and grow highest number of ears per plant of maize crop under low N and drought (Diallo *et al*., 2004). However, the tryptophan amounts of QPM hybrids are more under low N and optimum conditions (Mosisa, 2005).

Detection of QPM Hybrid with Molecular Markers Analysis

Molecular maker is a powerful tool for analysis of genetic variation and elucidation of genetic relationships with the maize crop (Chakravarthi and Naravaneni, 2006). Molecular markers are determining DNA sequence that found at specific location of genome and associated with the inheritance of a trait or linked gene (FAO, 2004) (table 4). The development of molecular markers is irreversibly changes the plant genetics and breeding system (Collard and Mackill, 2006). Molecular markers increase the effectiveness and reduce time management; therefore plant geneticist considered MAS selection through powerful tool in breeding program of plant to make a variety selection (Bueren *et al*., 2010).

SSR analysis

The identified markers are introduced and used in plant breeding programs (Danson *et al*., 2006). The o2 alleles are identify maize populations and expressing homozygous recessive (o2o2) traits with hard endosperm quality. SSR markers identify availability of different traits in maize crop, therefore using phi57, phi112 and umc1066 primers during the analysis of maize crop (Danson *et al*., 2006). In maize crop, tryptophan and lysine associated genes were identified by Wang *et al*. (2007) and express that lys sensitive Asp kinase is better genes for the QTLs affecting through free amino acid content of maize grains (Wang and Larkins, 2001). Sharma and Chauhan (2008) identified candidate genes by SSR markers in maize. The SSR markers derived from target genes in the lysine metabolic pathways that useful to differentiation of QPM and non QPM crops.

The identified SSR markers repeated Fe and Zn genes transmissions with di, tri and tetra-nucleotide in maize crop. There SSR primers were selecting on the basis of distribution in the genome, as profile quality and polymorphism level. Babu et al (2005) define that phi112 was a dominant marker clearly distinguished the QPM inbred lines from the selected normal inbred lines by the absence of 150 bp from QPM plants. The phi057 marker detect amplified products of 160 bp in Suwan 1 (non QPM), 170 bp fragments in opaque-2 variety, QPM lines and express fragments (160 bp and 170 bp) for non-QPM

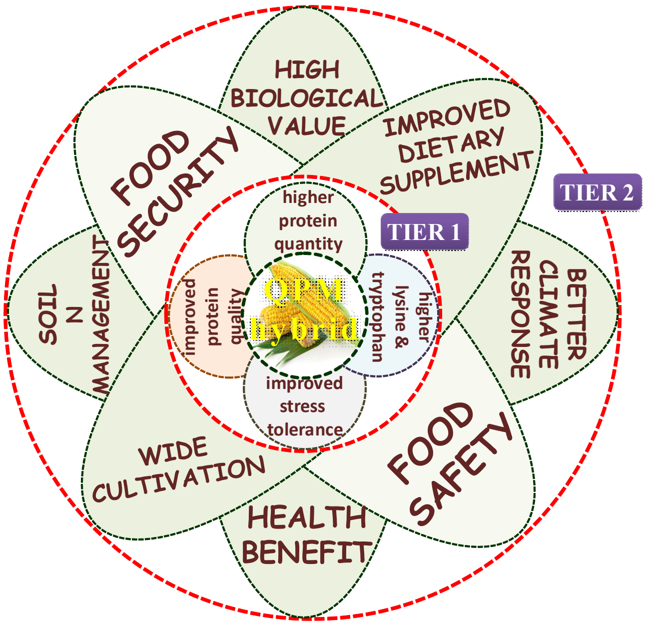

Fig. 3 : Multi-level impact of QPM hybrids in agricultural and social sphere. In figure, the 'Tier 1' shows the important improved qualities of QPM hybrid, and in 'Tier 2' impact of QPM on agricultural and social sphere. The Tier 1 and Tier 2 are inter-related but not inter-changeable; as, Tier 2 always depends on Tier 1 only for its complete execution.

lines as shown in the plant varieties (table 3). The phi 057 show amplification 160 bp fragments in normal maize inbred lines and 170 bp fragment in QPM inbred lines (Babu *et al*., 2005). With the help of above marker QPM and non-QPM populations were detected by phi057 and determine tryptophan level in hybrids (table 5).

Biological Value of QPM Hybrids

Biological value is closely related to protein quality, which is limited in maize by low concentrations of the amino acids such as, lysine and tryptophan. Animal protein has higher biological value than cereal protein but limited in nature, such as, 60-70% protein in wealthy countries comes from animals and less than 20% from cereals (Pellet and Ghosh, 2004). The biological value was estimated on the average proportions of absorbed amino acid determination. The biological value of a maize variety is 45% whereas that of QPM is about 80%.

The utilization of QPM and its products for use as infant food, health food mixes, convenience foods, and emergency ration in different environmental condition (Vasal, 2000; Prasanna *et al*., 2001). In developing countries, about 32% preschool children are stunted, 20% are under weight due to protein malnutrition (Black *et al*., 2008). QPM is a nutritive value for human, especially for women and children and also used as animal feeding for pigs (Upadhyay *et al*., 2009). The determination of QPM yield and nutritional values will enhance the production of protein from affordable source in plant population especially in the rural communities and particularly for milk feeding mothers, babies, adults and livestock in order to improve nutrition's (Krivanek *et al*., 2007). It enhances reduction prevalence and persistence of malnutrition and improves food safety system in India. QPM hybrids were potentially contributed especially in poor countries where maize has been potentially contribute a staple food and documented in different environmental conditions (Akuamoa-Boateng, 2002).

Conclusion and Future Prospect

Maize is an important crop in Asia, and it is used as live stock, resulting, rapid increase economic growth and poultry products. The basic component of QPM cultivars is the opaque-2 (o2) which transfers during conventional breeding program. QPM can be evaluated under optimum, low N and drought environments for protein and tryptophan determination in grains. Different field conditions are changes the ratio of maize genetic effects and suppress genetic effects for protein concentration. Low nitrogen decreases the proportion of additive effects and creates genetic differences of protein composition and also it decrease non-additive effects of tryptophan amount. The above determination of QPM will providing nutritional benefits by addition to opaque 2 as modifier gene. This study extends the knowledge of QPM hybrids and normal maize crop in N application rate those effects on grain quality to the wide diversity of maize genotypes and different doses of N in different environments of India. The kernels hardness is increased through nitrogen application in minor extent, while genotypes had larger influence on grain quality parameters. The limited correlation of grain yield and breakage susceptibility with hardness parameters of high yield maize production is feasible (fig. 3).

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