An overview of *Zea mays* for the improvement of yield and quality traits through conventional breeding

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Abstract: *Zea mays* is an important cereal crop through out the world. The grain, fodder yield and quality traits are the most imperative traits to increase demand to improve its production to fulfill human and livestock requirements. Various breeding methods and techniques are used to get required results in maize under varying environmental conditions. The present review described different breeding aspects to explore the potential of *Zea mays* germplasm. Different agronomic, physiological and quality traits are described with findings of various researchers at seedling and maturity stage. Importance of different yielding and quality traits may be understand by knowing the type of gene action and transfer of trait becomes easy after studying mode of gene action and inheritance pattern. The information about heritability, genetic advance, general combining ability (GCA), specific combining ability (SCA), additive and dominance effects, epitasis, heterosis and heterobeltiosis provides the breeder a suitable breeding method to develop synthetic variety of hybrid. It was concluded that traits like fresh root length, fresh shoot length and biomass of seedling are the traits on the basis of which selection of stress tolerance genotypes may be effective to improve grain yield at seedling stage while 100-seed weight, cobs per plant, grain rows per cob, total dry matter, green fodder yield per plant, cob diameter and grains per ear row are important traits to improve grain and fodder yield per plant at maturity stage. The grain and fodder quality traits may also be improved on the basis of protein contents, oil contents, nutrient detergent fibre (NDF), acid detergent fibre (ADF), starch, fibre percentage and carbohydrate percentage.

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1. Introduction

Zea mays is an imperative vastly cultivated cereal crop of the grass family, it belongs to a small but highly specialized tribe *Maydeae*. Globally maize, wheat and rice are cultivated and produced in massive quantities as compare to other crop; however maize has the highest grain yield potential per hectare than other cereals. Maize has separate male and female inflorescences (monoecious) which produces grain on the lateral branches rather than the terminal branches. Maize is an Allogamous (cross-pollinated) species and therefore, natural populations of maize are generally heterogeneous. There has been an issue of controversy in the origin of maize. The most common opinion about the origin of maize is that maize was originated through the domestication of *Zea mexicana* (teosinte, a wild grass), which is native to Central America, Honduras, Mexico and Guatemala. An extensive cross-pollination under natural conditions has occurred and studied by scientists between *Zea mexicana* and maize during their evolution. However, there are differences between both species in general appearance due to which some research scientists suggested that maize must have been originated from wild pod corn species that has been extinct now. The 7000 years old maize cobs are still preserved which were found from the caves of Mexico (Doebely, 2004). *Zea mays* plant has a remarkable productive potential and world's leading cereal food crop with added importance for countries like Pakistan where quickly increasing population has already facing less availability of food supplies. Maize is the third important cereal crop in Pakistan than wheat and rice. Maize accounts for 5.67% of the value of agriculture output. It accounts for 1083 thousands hectares of total cropped area in Pakistan with annual production of 4271 thousand tons (Anonymous, 2011-12). Maize is the dual purpose cereal crop as used in human food, livestock feed and industrial raw material for the manufacturing of various by-products. It has highest crude protein 9.9% at early and at full bloom stages which decreases to 7% at milk stage and to 6% at maturity. Maize has highly nutritive value as it contains 72% starch, 10% protein, 4.80% oil, 9.50% fiber, 3.0% sugar, 1.70% ash, 82% endosperm, 12% embryo, 5% bran testa and 1% tip cap (Chaudhary, 1983; Bureau of Chemistry, U.S., 2010). Pakistan have livestock population of 154.7 million heads which produce about 43.562 million tons of milk, 1.601 million tons of beef and 0.590 million tons of mutton (Anonymous, 2009-10). The livestock sector of Pakistan contributes about 53.2% of the agriculture outputs and 11.4% to national GDP of Pakistan (Anonymous, 2009-10). Green fodder is the most cheapest and precious source for livestock food. It is rich an important source of 35-40% cellulose, 25.28% hemicelluloses, 0.30% fat, 28.70% crude fiber, 37.22% acid detergent fibre, 70.85% neutral detergent fibre, 40.6% dry matter, 4% ash, 48.86% carbohydrates, 9.22% moisture, 2.84% ether extract and 11% crude proteins (Chaudhary, 1983; Bureau of Chemistry, U.S., 2010). The milk production of livestock animals may be increased up to 100% by using good quality and highly nutritive fodder (Maurice *et al.,* 1985 and Dost, 1997). Around 80-90 % of nutrient requirements of livestock are met from the fodder crops but the present fodder supply is 1/3 times less than the actual needs and the majority of the animals remain under fed especially during June-July (extremly hot season) and December-January (extremly cold season). In Pakistan out of total cropped area of 23.51 million ha only 2.46 million ha was under fodder crops with total fodder production of 55.06 million tonns (Anonymous, 2009-10) that is not sufficient enough to fullfil the requirements of nutrition for the existing livestock. The livestock feed pool in Pakistan is deficient by 21 % of total dry matter (DM), and by 33 % of crude protein requirements (Dost, 1997). Maize is a cold-sensitive crop and must be grown during spring in the temperate zones. It has shallow type of root system, therefore the plant generally dependents on the soil moisture contents. Maize is a C4 crop plant (uses C4 carbon fixation cycle) therefore it is more water-efficient crop as compared with C3 crop plants (use C3 carbon fixation cycle) like alfalfa, soybeans and the small grains (Araus *et al*., 2002). Maize is drought sensitive crop and greatly affected by drought during anthesis, silk emergence and at pollination phase. Requirement of water for maize plant is 500-800mm of water for life cycle of 80 to 110 days (Critchely and Klaus, 1991).

Maize is an important high dry matter yielding crop while forage of maize is usually with low protein contents. The growth and milk production of livestock animals is greatly affected by protein contents of fodder and forage. Protein required by rumen bacteria that help to digest a large amount of feed for ruminant animals (Ghanbari-Bonjar, 2000). The maize hay is generally low in protein contents therefore the protein requirements of livestock animals remained unfulfilled. Therefore, it becomes compulsory to make available livestock with higher protein supplements due to low forage quality. Therefore, the purchasing of protein supplements is usually expensive that caused increase in higher livestock feed costs.

Maize production in Pakistan is low as compared to other maize growing countries due to non-availability of resources and improved germplasm. Grain yield is related to others various morphological, physiological and agronomic traits in maize. By improving these traits, production of maize genotypes may be increased. Combining ability analysis provides an opportunity to a plant breeder to select genotypes on the basis of strong correlations among grain yield contributing traits as reported by Grzesiak *et al*. (2007); Ali *et al*. (2011a, b); Ali *et al*. (2012) and Ali *et al*. (2013a,b,d). Grain and fodder yield and quality plays an important role in the improvement of demand and production of maize. Crop growth and yield is directly affected by the weather condition during crop growing season. It is a basic biological principle that the quantity and quality of growth of a plant are controlled by its genetic potentialities and the environment acting through its internal physiological and biochemical processes. The only way in which environmental factors such as moisture, temperature and mineral nutrients can affect growth is by affecting internal processes and conditions. The mineral nutrition of crop plants is the major factor which determines the crop growth. The improvement in crop yield and quality are main traits to increase production and demand of maize for human as well as livestock consumption (Ali *et al*. 2012a; Abbas *et al*. 2013; Amir *et al*. 2012 and Ali *et al*. 2014). The yield and quality of maize grain and fodder may also be effected by change in environmental condition, i.e., drought, heat, insect pest attack, alkalinity, salinity etc. that caused to reduce yield and production. The improvement in yield under stress conditions may be carried out by using proper breeding methods. Gene action provides plant breeder a plate form to select genotypes with better grain yield and quality (Ali *et al*. 2011a,d,e; Ali *et al*. 2012b; Ali *et al*. 2014; Bibi *et al*. 2012; Farooq *et al*. 2011a,b; Naveed *et al*. 2012; Saeed *et al*. 2012; Hussain *et al*. 2012 and Hussain *et al*. 2013).

2. Breeding of maize for various traits

2.1 Seedling Parameters

Several research workers used the fresh and dry seedlings weights as selection criteria for the development of high yielding maize genotypes (Aslam *et al*., 2006; Ali *et al*., 2010a,b,c; Ali *et al*., 2011a,b,c; Ali *et al*. 2012a,b; Ali *et al*. 2013a,c,d; Elahi *et al*. 2011a,b and Mustafa *et al*. 2013). Fresh and dry seedling weights are the factors that added to the vigour of seedling and crop yield by enhancing growth of barley seedling (Ali *et al*. 2013). Cross (1991) and Ajala (1992) suggested that SCA was found to be related with maternal effects for germination percentage, leaf emergence, seedling vigour, early maturity, higher standability and higher yielding traits related to grain yield can be used to select higher yielding maize genotypes. Higher SCA and GCA effects for grain yield per plant, germination percentage, root and shoot lengths, dry matter, root and shoot dry weights and vigour index were found. GCA effects were more important as compared to SCA effects for all grain yield related traits but for root length both SCA and GCA were important and equally significant (Juvik *et al*. (1993); Ajala (1992) and Dronavalli and Kang (1992)) and simple mass selection can improve the grain yield and field emergence in maize through which grain yield and quality can be improved by following simple mass selection. Dronavalli and Kang (1992); Camacho (1994) and Rehman *et al*. (1994) reported that leaf area, root volume, longest root length, seedling length, fresh root and shoot weights, root and shoot dry weights, root dry weight to shoot dry weight ratio and total biomass per seedlings may be used for the selection of higher yielding maize genotypes. Heterosis and broad sense heritability for adventitious roots and root dry weight was found to be 2.54%, 103.52%, 88% and 88% respectively.

Singh *et al*. (1997); Mehdi and Ahsan (1999) and Mehdi and Ahsan (2000a) estimated higher heritability values for grain related traits and vigour. Positive genotypic correlation was found to be significant for germination rate, seedling growth rate and 100-seed weight with field emergence. Germination rate also showed positive genotypic correlation with seedling growth rate and 100-seed weight. The higher estimates of coefficient of variation were found for shoot and root fresh weights. Shoot fresh weight was found to be significantly and positively correlated with shoot and root length, root fresh weight and dry root/shoot weight ratio. Bromely *et al*. (2000) reported genetic variability among maize genotypes at seedling stage for various seedling traits. It was concluded that the estimates of heterosis greatly effected on bulking the inbred lines heaving association with different heterotic groups. Mehdi and Ahsan (1999); Mehdi and Ahsan (2000a) and Mehdi and Ahsan (2000b) estimated higher values of coefficient of variation for fresh and dry root and shoot weights. Moderate broad-sense heritability was found shoot fresh weight, root dry weight and shoot length. All traits were positively and significantly correlated with each other. Juvik *et al*. (1993); Ajala (1992); Dronavalli and Kang (1992) and Akhtar (2002) determined heterosis, GCA, SCA, genetic advance and heterobeltiosis for root and shoot fresh and dry weights, root length, branches/root and root/shoot weight ratio. Higher genetic advance was found for germination percentage, shoot length and fresh root weight. Aslam *et al*. (2006); Ali *et al*. (2011a,b,c,); Ali *et al*. (2013a,b,d) reported that cell membrane stability, stomata conductance and survival rate of maize seedlings may be used to select drought resistant maize genotypes and Grzesiak *et al*. (2007) studied that direct effects of water stress on maize seedling caused the reduction in dry matter of seedlings, leaf water potential, chlorophyll contents and leaf injury index. The use of coronatine caused significant increase in stem diameter, shoot weight, root length, stomata conductance, transpiration rate and photosynthesis rate in maize genotypes (Wang *et al*. (2007); Ali *et al*. (2011a,b,c,); Ali *et al*. (2013a,b,d)).

Moulin *et al.* (2009) and Veronica *et al.* (2009) studied chlorophyll content on each leaf from a large number of plants throughout crop cycle and concluded that chlorophyll content were greater for middle leaves as compared to top and bottom leaves of maize plant. Relationships among chlorophyll contents in each maize leaf and total plant canopy chlorophyll contents were recorded and found that chlorophyll contents in ear leaves and collar leaves exhibited more than 87% and 80% of variation in total chlorophyll contents in a maize plant canopy, respectively. It was recommended that non-destructive technique of tea-reflectance and single leaf (ear or collar) may be used to estimate accurate total chlorophyll content in maize. Root and shoot fresh weights and stomata frequency were found as direct and indirect contributing traits in shoot fresh weight and also showed positive and significant correlation with shoot fresh weight. It was concluded that fresh root and shoot weights, root and shoot lengths, epidermal cell size, leaf venation and stomata frequency may be used as selection criteria for higher yielding maize genotypes (Ahsan *et al.* (2011); Ali *et al*. (2011a,b,c,); Ali *et al*. (2013a,d,e)). Ali *et al*. (2011a,b) and Ahsan *et al.* (2013) concluded that root length, root dry weight, leaf temperature, root density and shoot dry weight were significantly correlated with each other at genotypic and phenotypic levels and hence may be used as selection criteria for higher yielding maize genotypes. Hence the seedling traits of maize may be helpful to select maize genotypes for the development of maize varieties and hybrids heaving good yield potential under various adverse environmental conditions.

2.2. Maturity parameters

Farkorede and Ayoola (1981) and Javed (1987) reported a positive and significant genotypic and phenotypic correlation of grain yield with plant height, cobs per plant and 100-seed weight. Altaf (1990) concluded that cobs per plant, grain rows per cob, grain per cob, 100-seed weight and plant height had direct effect on grain yield. Debnath and Sarkar (1990); Reddy and Joshi (1990) and Beck *et al*. (1990) estimated higher GCA and SCA for grain yield per plant and grain per row. It was reported that positive and significant genotypic and phenotypic correlation were between grain yield per plant and cobs per plant, plant height, grain rows per cob, 100-seed weight, cob length and diameter. Nevado and Cross (1990) and Martinez *et al*. (1990) reported higher GCA and SCA effects number of grain rows per cob, 100-seed weight, grains per row and grain yield. Ivankhenko and Klimo (1991); Jadhav *et al*. (1991); Tarutina *et al*. (1991); Dash *et al*. (1992) and Rehman *et al*. (1992) estimated GCA and SCA effects for grain yield and its contributing traits in maize. SCA effects were found to be greater than the GCA effects which indicated additive type of gene action for all traits. Additive gene action was more dominant over the dominance gene action for grain yield per plant, 100-seed weight, grain rows per cob and grains per cob. SCA effects were significant for grain rows per cob, plant height, grains per cob, 100-seed weight and grain yield per plant (Sedhom (1994); Elhosary *et al*. (1994); Lee *et al*. (1995); Bolanos and Edmeades (1996); Flower *et al*. (1996); Singh and Mishra (1996); Balderrama *et al*. (1997) and Chapman *et al*. (1997a). Chapman *et al*. (1997b) and Tusuz and Balabanli (1997) reported that plant height and cob length showed low broad sense heritability while grain yield was positively and significantly correlated with plant height and cob length.

Kahkim *et al*. (1998); Mather *et al*. (1998); San-vicente *et al*. (1998); Singh *et al*. (1998); Almeia *et al*. (1999) and Nass *et al*. (2000) concluded that grain yield had a positive and significant genotypic correlation with cobs per plant, plant height, number of grain per cob, number of grain rows per cob, cob length, 100-seed weight and grain oil contents. Significant GCA effects were recorded for all traits while SCA effects were significant for plant height and grain yield per plant. concluded from an experiment that moderate estimates of heritability and genetic advance; positive and significant genotypic correlation was found for grain yield per plant with plant height, cob length, grains per cob, 100-seed weight and number of cobs per plant. Golob and Plestenjak (1999); Khatun *et al*. (1999) and Mehdi and Ahsan (1999) reported that a positive and significant correlation was shown by grain yield per plant with 100-seed weight, number of grain per cob and cob diameter. Green fodder yield was positive and significantly correlated with number of leaves per plant and plant height. Ravilla *et al*. (1999) and Torun *et al*. (1999) found significant GCA and SCA effects were found for plant height, days to silking, grains per cob, cobs per plant, cob length, and 100-seed weight had significant direct effects on grain yield. Arya, *at al*. (2000) reported that leaf area and number of leaves per plant of maize were increased by decreasing the plant population density. Borrell *et al*. (2000) found that the leaf area reduced up to 67% due to water stress. Pandey *et al.* (2000); Rameeh *et al*. (2000); Rocha *et al*. (2000); Umakanth *et al*. (2000) and Vaezi *et al*. (2000) concluded that increasing the moisture stress was major cause of decrease in crop growth rate, leaf area, shoot dry matter, plant height and harvesting index. Significant GCA and SCA effects for grains per row, grains per cob, 100-seed weight and grain yield per plant. Wenzel *et al*. (2000) and Zelleke (2000) concluded that the 44% grain yield was reduced and significant SCA effects were shown by plant height, days taken to tasseling, silking, grain rows per cob, cobs per plant and grain yield per plant.

Rocha *et al*. (2000); Umakanth *et al*. (2000); Desai and Singh (2001); Iqbal *et al*. (2001) and Khan *et al*. (2001a) found significant differences in GCA and SCA effects for plant height, days taken to 50% tasseling and 50% silking. Khan *et al*. (2001b); Nigussie and Zelleke (2001) and Vales *et al*. (2001) reported that stem diameter, plant height, leaf area, cobs per plant, cob diameter, grain rows per cob, 1000-seed weight and grain yield per plant decreased significantly under water stress conditions. The mid parent heterosis showed a range of -11.6-21.9% for grain yield per plant and significant GCA and SCA effects for cobs per plant, grain rows per cob, plant height, 100-seed weigh and grain yield per plant in three synthetic maize populations. Banziger *et al*. (2002) reported that the increase in the leaf length, increased nutrient and water uptake, greater reserve food materials during grain filling stage, cobs per plant and grain yield per plant was positively associated with each other and with water stress tolerance ability in maize. Additive gene action was found for relative transpiration arte, leaf water retention, grain yield and cobs per plant. studied that plant growth, photosynthetic rate, reproductive stage, grain filling and grain yield per plant were reduced due to water stress on maize (Bruce *et al*. (2002); Cordova and Burris (2002); Farshadfar *et al*. (2002) and Jeanneau *et al*. (2002) .

Alvi *et al*. (2003); Aguiar, *et al*. (2003); Gautam (2003) estimated heterosis for 8 F_1 hybrids of maize and evaluate on the basis of cob length, cob diameter, cobs per plant, plant height, grain rows per cob, 1000-seed weight and grain yield per plant. The higher SCA effects were found for grain yield, ear height, plant height, prolificacy and ear placement. GCA effects and genotype vs. environment interactions were significant for all traits. GCA and SCA effects were significant for all traits while highly significant for hybrid × year interactions for days taken to maturity and plant height. Mehmood *et al*. (2003); Bhatnagar *et al*. (2004); Malik *et al*. (2004) found that plant height, number of leaves per plant, days taken to pollen shedding, cobs per plant, grain rows per cob, cobs per plant, 100-seed weight, cob weight, grain moisture contents at harvesting, leaf area and grain yield per plant. Fan et *al*. (2004); Prakash *et al*., (2004) and Zhou *et al*. (2004) estimated GCA and SCA effects for days taken to 50% tasseling, plant height, cobs per plant, grain rows per cob, cob length, cobs per plant, 100-seed weight, cob weight, leaf area and grain yield per plant. Non-additive gene action was found for all traits except for cob length, days taken to 50% tasseling and grain rows per cob that showed additive type of gene action.

Zhen *et al*. (2005); Vafias *et al*. (2005); Welcker *et al*. (2005) estimated higher value of heterosis for 100-seed weight, cobs per plant, cob diameter and grain yield per plant. The interactions of genotype × soil conditions were significant for grain yield per plant. The mid parent heterosis was significantly greater in acidic soils as compared to non-acidic soils 32% and 20%, respectively. Muraya *et al*. (2006) estimated higher heterosis and signifiacnt SCA and GCA effects in S_1 maize lines for days taken to 50% tasseling, plant height, cobs per plant, grain rows per cob, cob length, 100-seed weight, cob weight, leaf area and grain yield per plant. Ojo *et al*. (2007) and Saleem *et al*. (2007) reported significant differences among maize genotypes for days taken to 50% tasseling and silking, cobs per plant, cob length, cob weight, grain rows per cob, plant height, flag leaf area, biomass per plant, total dry matter, 100-grain weight and grain yield per plant. Ahsan *et al*. (2008) found positive correlation for cell membrane thermostability, leaf area, stomata frequency with stomata size. Grain yield showed positive direct effect and significant positive correlation with stomata size and frequency. Akbar and Saleem (2008) and Akbar *et al*. (2008) reported that the SCA, GCA and reciprocal effects of grain yield and its contributing traits were highly significant at low and high temperatures except GCA effects for 100-seed weight that were non-significant. The F_1 hybrids showed higher SCA effects and also better performance for grain yield and its contributing traits under both high and low temperatures. Amler (2008) studied that ratio of dry matter contents of grain to dry matter contents of stover (silage maize ripeness index) is one of the most useful tool to determine the yield and silage quality and harvesting date of maize. Derera *et al*. (2008) found significant GCA effects for grain yield per plant in maize. Monneveux *et al*. (2008) studied that secondary morpho-physiological traits, cobs per plant, grains per cob, anthesis interval, leaf rolling, leaf senescence and grain yield per plant may be used as selection criteria for developing drought resistant maize genotypes. Akbar *et al*. (2009); Yousufzai *et al*. (2009) and Wali *et al*. (2010) found that grain yield per plant of male parent was higher than the female parent 78.01g and 70.66g respectively. The significant interactions of line x tester variance were estimated for all characters except shelling percentage, circumference, fodder yield and ear length and significant interactions were also found for grain rows per cob, grains per row, 100-seed weight and grain yield.

2.3. Quality Parameters

Halim *et al*. (1990) found that the in vitro digestible total dry matter of stem was increased up to 9% while crude protein concentration was also increased by 11%. The maturity and total dry matter yield per plant were decreased due to increase in water stress while leaf/stem ration was increased. Sa (1990) reported that crude protein contents was found to be greater in maize as compared to sorghum. Viana *et al*. (1990) reported that dry matter yield, crude proteins and crude fiber were not generally affected due to increase in plant height while the concentration was increased. Bruno *et al*. (1992) concluded that the nutritional value was higher in leaves as compared to the stem of maize plant. Li and Liu (1994) reported bt2, sh2, wx, O2 and su1 mutant genes for maize endosperm that all of theses genes caused to increase the soluble sugars, sucrose, proteins and reducing sugar contents. Positive and significant correlation was found between grain yield per plant, 100-seed weight, zein and starch contents. Zein and starch contents were the major factors that greatly influence the quality of maize seeds. Due to reducing in the zein and starch contents the grain and 100-seed weight decreased that leads towards yield losses. Bertolini *et al*. (1995) concluded from an experiment that the maize hybrids were high in starch and protein contents. Dunlap *et al*. (1995) concluded that corn oil contains 6.7-16.5% palmitic acid, 0.7-6.6% stearic acid, 0.0-1.2% palmitoleic acid, 16.2-43.8% oleic acid, 39.5-69.5% linoleic acid, 0.0-3.7% linolenic acid and 0.0-2.0% arachidic acid. A small amount of margaric acid, myristic acid and gadoleic acid were also reported in corn oil. Significant correlation was found among fatty acids, protein, oil contents and starch. Hussain *et al*. (1995) conducted an experiment and concluded that crude fiber were in range of 30-31% while crude proteins 6-8%. Alika and Ojomo (1996) studied gene action for gel spread, starch, gelatinization and temperature in maize genotypes. Additive gene action was found for gel spread and starch contents while non-additive gene for gelatinization time. Torres Capeda *et al*. (1996) estimated significant differences for 3-4% lipids, 60-65% raw fiber, 9-11% proteins, 78-83% N-free extract, 61-64% starch 3-10mg/g tannins and 380-4000kcal energy for maize. Protein digestibility and ash contents 24-39% and 1-2% were non-significant, respectively. Yung *et al*. (1996) concluded from an experiment that maize endosperm hardness was significant but negatively correlated with cob per plant, 100-seed weight and protein contents. It was also found that plant height had a negative indirect effect for grain yield per plant. Motto *et al*. (1996) evaluated maize genotypes for grain protein quality. The genes for endosperm protein and zein wee also identified and concluded that the genes belong to a multigene family. The zein gene was found to be regulated in relation to the opaque loci.

Cheesbrough *et al*. (1997) found that the range of stearic acid from low 1.7% to higher palmitic acid 1.7%. Oleic acid was negatively correlated with linoleic acid and linolenic acid. It was concluded that the fatty acid composition and endosperm type may be used for QTL mapping. Li (1997) reported from an experiment on 210 maize genotypes that an average crude oil, crude protein and starch contents were 5.0, 12.5 and 67.45 respectively. Kovacs *et al*. (1998) concluded that scutellum size and quality may be used for the selection of high yielding and good quality maize genotypes. Pastzor *et al*. (1998) concluded that crude protein contents showed a positive and significant correlation with starch contents, ash percentage, fibre contents and fatty acid composition in hybrid maize. It was found that DeSC351 hybrid showed higher protein contents, starch contents, ash percentage and fibre contents. Seo *et al*. (1998) studied that the major fatty acids of corn oil were oleic acid, linoleic acid, palmitic acid, stearic acid and arachidic acid. Campbell *et al*. (2000) identified single and double mutant genes for endosperm due to induced mutation. Mutations were studied in amylase-extender, dull, sugary-2, waxy, ae wx ae du, du wx, du su2 and ae su2 genotypes. It was concluded that the mutations caused useful as well as adversive affects on maize grain and quality yielding traits. Geetha (2000) found that grain yield per plant, grain rows per cob, cob weight, plant height and starch contents showed significant increase. Khalil *et al*. (2000) reported that major saturated fatty acids were found to be palmitic acid and stearic acid while minor and unsaturated oleic acid and linoleic acid. Mazur *et al*. (2001) developed transgenic maize genotypes for improved proteins, oil and carbohydrates. The higher oil contents caused increase in the amino acid composition which enhanced the protein quality and concentration. Dubey *et al*. (2001) estimated higher heterosis for oil contents while with low GCA effects. The highest SCA effects for oil contents while the additive effects for days taken to silking, starch contents, 100-seed weight, harvest index and grain yield per plant. Madibela (2002) reported from the sweet sorghum chemical composition analysis that the crude protein contents are usually different among the parts of plant body. Kolomiets and Lyashov (2003) determined 9-10% proteins and 13-14% sugar contents in fodder maize.

Rai *et al*. (2004) reported that pearl millet and sorghum generally produced better quality fodder with 9% crude proteins in millet and 6% in maize under water stress conditions. Tomich *et al*. (2004) reported that leaf/stem ratio of sorghum sudan grass exhibited great variability. Iptasi and Yavuz (2007) reported that plant height and stem diameter was not affected due to late or early pollination treatment; while showed different affects for hybrids. Stalk and leaf contents were significantly but negatively correlated with actual grain filling. Cob content was positively and significantly correlated with dry matter yield while negatively correlated with acid detergent fibers and neutral detergent fibers. The highest dry matter yield at 100% pollination level was 17.8 kg ha^{-1}. Total dry matter contents were increased (19 %) from 0 % to 100 % change in pollination level. Neutral detergent fibers (NDF) and acid detergent fibers (ADF) were negatively but significantly correlated with pollination levels. Grzesiak *et al*. (2007) reported that there are direct and indirect effects of soil drought for 7 and 14 days on seedling dry matter, leaf water potential, leaf injury index and chlorophyll content of drought resistant and sensitive triticale and maize genotypes. Khani and Heidari (2008) concluded that by decreasing water potentials in the roots and leaves of both cultivars, total soluble protein content first increased but decreased after stress. Under low water potential the root and shoot fresh weights were decreased. Xiang *et al*. (2010) reported that cob height, plant height, cob length, leaves per plant, barren-tip length, grain rows per cob, grains per row, cob weight, grain depth, oil composition, grain yield, starch content and protein. The higher GCA and SCA effects for grain yield were estimated that were highly significant among the maize landraces and their hybrids. Ali *et al*. (2011a,b,c) reported highest genotypic coefficient of variation for fats while highest heritability for 100-seed weight. Significant and positive genotypic correlation of grain yield was found with proteins, carbohydrates, moisture contents, 100-seed weight, pods per plant and seeds per pod. Significant genotypic and phenotypic correlations were found for 100-seed weight, pods per plant, leaflets per leaf, chlorophyll contents, leaf area, biomass per plant, grains per plant and protein percentage (Ali *et al*. 2012a,b).

3. Conclusions

It was concluded from present study that *Zea mays* is very important cereal crop which is consumed as feed for animals and food as human. The traits like fresh root length, fresh shoot length and biomass of seedling are the traits on the basis of which selection of stress tolerance genotypes may be effective to improve grain yield at seedling stage while 100-seed weight, cobs per plant, grain rows per cob, total dry matter, green fodder yield per plant, cob diameter and grains per ear row are important traits to improve grain and fodder yield per plant at maturity stage. The grain and fodder quality traits may also be improved on the basis of protein contents, oil contents, NDF, ADF, starch, fibre percentage and carbohydrate percentage. By under taking these traits good maize synthetic varieties and hybrids may be developed under various environmental conditions.

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