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Review on Growth, Yield and Quality of Rice as Influenced by Genotypes (*Oryza sativa* L.)

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A B S T R A C T

Rice is the major food of more than 3 billion people representing the major carbohydrate and even protein source not only in South East Asia but also in some part of Africa .During the thousands of years since its domestication, Asia rice has been cultivated under significantly diverse agro-ecosystems to meet different human demands. As a consequence, many rice varieties with different characteristics have arisen under natural and human selection. In bastar plateau regions several land races of red rice are available which is having good yield potential.

Introduction

Rice is cultivated on all the continents except Antarctica, over an area of more than 161 million ha (production of about 680 million metric tonnes), but most rice production takes place in Asia (Fageria, 2014). It occupies about 23% of the total area under cereal production in the world (Jagadish *et al.*, 2010). The historical importance of rice in Asia is so significant that it supported many civilizations in the river deltas of India, China, and Southeast Asia and has become deeply intertwined with the cultures in these regions (Krisahnan *et al.*, 2011). More than 90% of rice is produced and consumed in Asia (Grewal *et al.*, 2011). During the thousands of years since its domestication, Asia rice has been cultivated under significantly diverse agro-ecosystems to meet different human demands (Xiong *et al.*, 2011). This has resulted in tremendous genetic diversity in rice around the world, as shown by different molecular tools such as the analysis of restriction fragment length polymorphism and simple sequence repeats (Zhang *et al.*, 1992). As a consequence, many rice varieties with different characteristics have arisen under natural and human selection (Vaughan *et al.*, 2007).Zhang *et al.*, (2010) studied genetics diversity in the USDA rice world collection and concluded that germplasm accessions obtained from the Southern Asia, Southeast Asia, and Africa were highly diversified, while those from North America and Western and Eastern Europe had the lowest diversity. The diversity are due to variation in environmental conditions. The main environmental conditions considered in classifying rice ecosystems are soil moisture regime, soil drainage, land topography and temperature (IRRI, 1984). Rice is the major food of more than 3 billion people representing the major carbohydrate and even protein source not only in South East Asia but also in some part of Africa. Deficiencies of from (Fe) and Zinc (Zn) results in impaired mental development, anaemia, reduced immunity, poor appetite and stunting. Micronutrient malnutrition is caused by poor quality diets. Increasing the Fe and Zn concentration of staple foods, such as rice could solve Fe and Zn deficiencies.

Enhancement of cereals grains with micronutrients is a high priority area of research and will contribute to minimizing micronutrients deficiency related health problems in humans (Prasad *et al.,* 2013).The pertinent literature is cited here how genotype influenced the productivity and quality of rice.

Effect of genotype on growth

Taniyama *et al.,* (1988) reported that the difference in the crop growth rate and CO_2 uptake in different rice genotypes was due to the variation in the amount of chlorophyll in the leaves and that CO_2 uptake and yield are positively correlated with each other. The genotype with higher DM accumulation and partitioning greater amounts into reproductive parts (panicles) at PDM had significantly higher productivity and profitability (Pukhraj > F-Malakand > Bamati-385). Mae (1997) described that the HI of old rice genotypes is about 30% and 50% for improved and semi-dwarf ones. The genotypes with higher HI produced higher grain yield. The increase in HI of coarse genotypes was attributed to higher DM accumulation and partitioning greater amounts into panicles. Fageria (1998) reported adequate N concentrations for maximum yield about 8.7 g kg^1 in the shoot of upland rice under field condition at harvest. Peng *et al.,* (2000) determined the trend in the yield of rice cultivars/lines developed since 1966 at the International Rice Research Institute (IRRI), Philippines. These authors concluded that the increasing trend in yield of cultivars released before 1980 was mainly due to the improvement in grain harvest index (GHI), while an increase in total biomass was associated with yield trends for cultivars/lines developed after 1980. They also suggested that further increases in rice yield potential will likely occur through increasing biomass production rather than increasing GHI. Wiangsamut *et al.,* (2013) reported that hybrid rice has higher DM partitioning efficiency and consequently has higher grain yield than inbred.

Effect of genotype on yield attributes and yield

Chandler, 1969) reported that the review on the breeding progress for high yields indicates that the improvement of the harvest index has made substantial contributions to achieve high yields of rice. Fageria (1984) reported that upland rice genotypes grain yield increased with the application of calcium carbonate but increase varied with genotype to genotype. Song *et al.,* (1990) and Yamauchi (1994) stated that hybrid rice had a 15% greater yield than inbred rice, mainly because of an increase in biological yield rather than HI. Amano *et al.,* (1993) noted that the HI of 67% for japonica F1 hybrid rice in South China. Ishii (1995) mentioned that grain harvest index is an important parameter in determining distribution of photosynthetic product between shoot and grain and consequently grain yield. Rice hybrids have a mean yield advantage of 10-15% over varieties since they possess a more vigorous and extensive root system and increased growth rate during vegetative period when grown under normal transplanting condition (Yamauchi, 1994 and Yang *et al.,* 1999). Rice genotypes differ significantly in N uptake and utilization efficiency. Ahmed *et al.,* (2008) studied that the yield potential of wild relatives of rice, which involves the improvement of seed protein content. A significant increase in seed protein content was observed in an interspecific hybrid between *Oryza sativa ssp. indica* and the wild species *Oryza nivara.* Lafarge and Bueno (2009) reported that the yield advantage of hybrid rice over old rice cultivars in tropical environments is up to 15%. This increase in grain yield is because of higher dry matter production due to higher seedling vigor leading to quicker growth rate and higher HI. Islam *et al.,* (2010) noticed that hybrid rice give higher yield over conventional rice. Kumar *et al.,* (2017) reported that the land races of red rice that different genotypes gave yield from 5 to 6 t ha^{-1}.

Effect of genotype on quality of rice

Qui *et al.,* (1995) reported a higher variability in mineral contents in some rice cultivars and the 6 level of iron content varied from 15.41 mg kg^{-1} to 162.37 mg kg^{-1} and zinc content ranged from 23.92 mg kg^{-1} to 145.78 mg kg^{-1}. Wang *et al.,* (1997) reported that zinc content in grains of rice ranged from 0.79 - 5.89 mg 100^{-1} g with an average of 3.34 mg 100^{-1} g in a study done among 57 rice varieties. The largest zinc value was found in Ganjay Roozy, a variety grown at IRRI while the lowest zinc value recorded was in long grain fragrant rice. Peng *et al.,* (2000) reported that high yielding rice cultivars/lines developed at the IRRI from 1985 to 1995 were intermediate in canopy height, tillering capacity, and leaf area index. Cultivars in this group were able to maintain relatively high grain harvest index. Kiniry *et al.,* (2001) reported that the GHI varied greatly among cultivars, locations, seasons, and ecosystems, ranging from 0.35 to 0.62, indicating the importance of this variable for yield stimulation. Nitrogen concentration was higher in grain compared to shoot. Nitrogen concentration in the grain of rice is always higher than the Stover. The yield variability among rice cultivars is highly dependent on grain harvest index.

Uphoff (2002) reported that drought resistance genotypes have thick voluminous and deep root system compared to other genotypes. Cassman *et al.,* (2002) reported that N concentration of 12 g kg^{-1} is desired in the grain of rice for optimal cooking and eating quality. Besides, rice hybrids exhibited highest yield potential even under SRI method, due to profuse tillering capacity, lodging tolerance, greater stress resistance and wide ecological adaptability (Yan, 2002). The largest germplasm collections of rice is available in the world. This accessible collection of diverse varieties, landraces and related wild species has made great contributions to rice breeding. Landraces harbor a great deal of useful traits with genetic potential for rice improvement and they played a very important role in the local food security and sustainable development of agriculture, in addition to their significance as genetic resource for rice genetic improvement (Tang *et al.,* 2002). Welch and Graham (2004) found 4-fold differences in mineral levels of iron and zinc concentration among rice genotypes, which suggests that there is a potential to increase the concentration of these micronutrients in rice grain with genetic technology. Bhattacharjee (2006) observed 0.136 to 11.4 per cent of amylase content in glutinous rice cultivars of Assam. Nine genotypes of rice were evaluated for iron and zinc content in rice grain at IRRI by found a range of 8.8 to 21.0 ppm, 14.0 to 40.0 ppm for iron, and zinc, respectively (Martinez *et al.*, 2006). Zozali *et al.*, (2006) reported grain of Zn concentration is substantially higher in certain landraces of Southeast Asia than in commonly grown high yielding rice varieties. Devi *et al.*, (2008) reported significant variation among cultivars for total starch content from 73.77% to 85.33% of carbohydrate content while studying fifteen indigenous rice and 100 upland rice cultivars respectively. The hybrid showed a protein content of 12.4%, which was 28 and 18.2% higher than those of the parents *O. nivara* and IR 64, respectively. Chakraborty *et al.*, (2009) noticed bold grained rice genotypes had starch content varied from 65.60 to 79.88 per cent.

Mallikarjuna *et al.*, (2011) studied 126 accessions/varieties of rice germplasm including wild relatives *O. rufipogon* and *O. nivara*. The Fe concentration in brown rice ranged from 6 ppm (Athira) to 72 ppm (O. *nivara*). Zn concentration ranged from 27 ppm (Jyothi) to 67 ppm (O.*rufipogon*). Iron and zinc concentration varies between brown rice and polished rice. Also, when whole rice grains and broken rice grains were compared, there was variation in iron concentration but not in zinc concentration.

Anuradha *et al.*, (2012) analyzed 126 accessions of brown rice genotype including 7 accessions of two wild species for Fe and Zn concentration and reported that iron concentration ranged from 6.2 ppm to 71.6 ppm and zinc from 26.2 ppm to 67.3 ppm. Zn concentration and grain elongation (-0.25) were significantly correlated. The wild accessions had the highest Fe and Zn. Yadi *et al.*, (2012) described significant effect of Zn fertilizer on HI of rice. More over, the coarse rice genotypes (Pukhraj and F-Malakand) had higher HI than fine genotype (Bamati-385). Differences in the HI of rice genotypes have been reported by many researchers. Devi *et al.*, (2012) observed a range of 70% to 89.25% of total carbohydrate content studying eighteen indigenous cultivars of North-Eastern hill regions of India. 79% carbohydrate content is recommended by USDA Nutritional database, U.S. Kumar *et al.*, (2017) reported that the land races of red rice having high in zinc content under ecological condition of Bastar plateau. Further**,** significantly highest zinc content (ppm) was registered under the treatment of N_{120}:P_{80}:K_{60} during both the years and on mean basis, but it was at par with the treatments $N_{120}P_{80}K_{60}$ $FYM_{5t,}$ $N_{80}P_{60}K_{40}$+Zn, $N_{80}P_{60}K_{40}$+S and $N_{80}P_{60}K_{40}$ +B during 2014 and treatment of $N_{80}P_{60}K_{40}$) + B (T_7) on mean basis. While, significantly highest iron content was registered under the treatment of $N_{80}P_{60}K_{40}$+Zn during 2013 and on mean basis, but it was at par with the treatment N_{120}:P_{80}:K_{60}. During 2014 significant difference among the treatment was not observed for iron content in grain (Kumar *et al.*, (2017).

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