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Review Article

Maize (*Zea mays* L.) Crop at Various Stages of Growth in Rabi Season as Influenced by Varieties, Plant Geometry and Nutrient Management

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A B S T R A C T

Maize is one of the most important cereal crops in the world agricultural economy both as food for man and feed for animals including poultry. It is also known as **"**queen of cereals'' because of very high yield potential, it is giving low yields because of lack of appropriate information about plant geometry and fertilizer management. Nitrogen, phosphorus and potassium are the major plant nutrients, which limit normal plant growth. Increasing productivity per unit area through agronomic management is one of the important strategies to increase the production of maize grain. Keeping this in view, various experiments were have been carried out on the effect of plant geometry and different dose of various inorganic fertilizers have seen very widely on hybrid and composite variety of maize in winter season. The information available on growth parameters *viz*, plant height, no of leaves/plant, LAI, dry weight/plant, CGR, RGR and NAR at various stages of crop growth as affected by varieties of maize and plant geometry and in conjunction with nitrogen, phosphorus, potash and zinc is also reviewed.

Keywords

Maize, hybrid, composite, plant geometry, growth, NPK and Zn and yield

Introduction

Maize (Z*ea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36 % (782 m t) in the global grain production. The United States of America (USA) is the largest producer of maize contributes nearly 35 % of the total production in the world and maize is the driver of the US economy. The USA has the highest productivity (> 9.6 t ha-1) which is double than the global average (4.92 t ha-1). Whereas, the average productivity in India is 2.43 t ha^{-1}.

It is also one of the most important cereal crops in the world agricultural economy both as food for man and feed for animals including poultry. Green cobs are roasted and consumed by people with great interest. The grains of special variety called the 'popcorn', are characterized by a hard corneous interior structure are converted into the 'popped' form, which is the favourite food for children in urban areas. Several food dishes including *chapatie*sare prepared out of maize flours and grains. It is

also a good food for poultry, piggery and other animals. A separate winter maize programme was started in 1975 realizing its potential in almost all non-temperate area of country, winter maize on an average yield 1.5 times higher than rainy season maize. The researches indicated that the winter maize raise favourable responds to better crop management (Singh, 1988).

Maize yield is closely related to plant population. More plants mean higher yield. However, there is limitation to increasing plant population under humid, tropical conditions. Maize becomes more susceptible to pests and diseases when temperature, rainfall, and humidity are high. The number of plants per unit area is influenced by the distance between row, the distance between plants in row and the number of plants in a hill. Select an optimum plant spacing that allows for ease of the field operations, such a fertilizer application and weeding, minimizes competition among plants for light, water and nutrients and creates a favourable micro-climate in the canopy that reduced the risk for pests and diseases. Narrow row width of about 50 to 70 cm is recommended to ensure that sunlight falls on the plants and not on bare soil. This reduced weed competition and loss of soil moisture from evaporation

Effect of Varieties

Growth parameters

Yu *et al.,* (1993) developed a hybrid by crossing two inbred lines *viz*., 'Duo-7' and 'WuDaiBai', which has good adaptability and recorded maximum height of 220 cm producing fine ears suitable for processing as baby corn. This hybrid matured in about 60 days during summer and 68 days in spring. They also recommended elite maize cultivar 'Lusan 1/U-1' for baby corn cultivation. In another trial, Kotch *et al.,* (1995) evaluated eleven maize cultivars for baby corn production in USA. They found that 'Robust 41-10' gave markedly higher cob yield with good organoleptic qualities such as colour, taste and appearance. While in another study, Thakur *et al.,* (1995) found that maize cultivar 'early composite' as the best variety for baby corn production. It recorded higher yield of 2032 kg/ha. Spaner *et al.,* (1996) studied the performance of three local cultivars *viz*., an improved land race 'ICTA farm corn', 'an open pollinated cross 7728' and the 'hybrid pioneer 3098' for baby corn production. The 'hybrid pioneer 3098' and 'ICTA farm corn' cultivars gave significantly higher number of marketable yield/ha and found to be superior to 'cross 7728'. However, sensory evaluations revealed that the three cultivars did not differ in overall quality with respect to ear appearance and kernel colour and even when boiled with Creole seasoning. Gollar (1996) comparing the performance of two genotypes narrated that Deccan-103 recorded 17 per cent higher yield than G-25 composite. The higher grain yield of Deccan-103 (6875 kg ha^{-1}) was attributed to higher values with respect to plant height, number of leaves, leaf area index, number of cobs $plant^{-1}$, number of grains cob^{-1}, grain weight and grain yield $plant^{-1}$ than composite G-25. Kumar *et al.,* (2002) reported that the three hybrid varieties ('KH 517', 'KH 101' and 'PSCL 3436') with 1 check ('Early Composite') were tested at 4 levels of fertility. 'Early Composite' produced significantly taller plants compared to hybrids which were statistically at par with one another. Numbers of days taken for silking were the lowest in composite, followed by 'KH 101. Rahman *et al.,* (2007) reported that tallest plant were those of Sarad yellow (176.75 cm) which were 11.87% taller than those of Dehqan (158 cm). Kaliq*et al.,* (2010) result revealed

that the hybrid maize 30Y47 significantly not only maximum leaf area index but also exceeded in crop growth rate and plant height under reduced row spacing of 60 and 45 cm compared with conventional row of 75 cm. Pal and Bhatnagar (2012) observed the application of nitrogen 80 kg ha^{-1} than 60 and 40 kg ha^{-1} significantly increased plant growth among the maize cultivars, HIM-129 (hybrid) proved more productive and profitable than popcorn 'VL Amar' and composite ' Pragati' and Vevak-11. Iptas and Acar (2006) evaluated the effect of row spacing (40, 60 and 80 cm) on dry matter yield and quality of four hybrids grown in the year 2001 and 2002. The highest dry matter yield was obtained from Arifiye (24.1 and 22.4 t/ha), while the lowest DM yield was obtained from pioneer 3163 (19.9 and 19.8 t/ha).

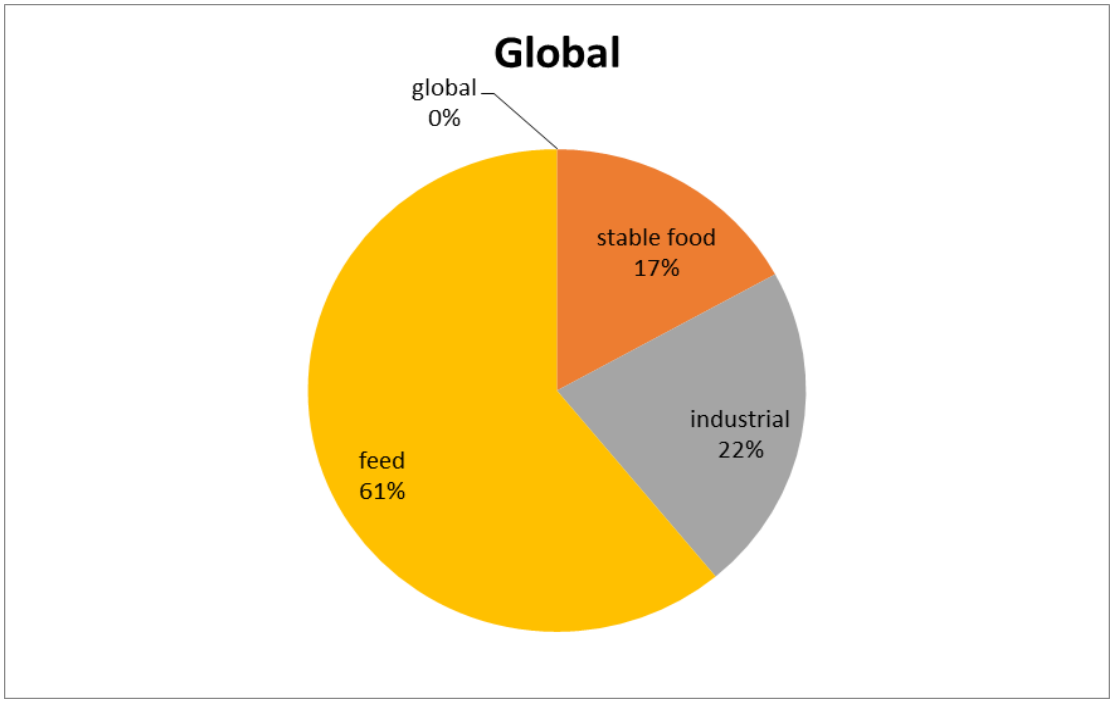
Effect of plant geometry

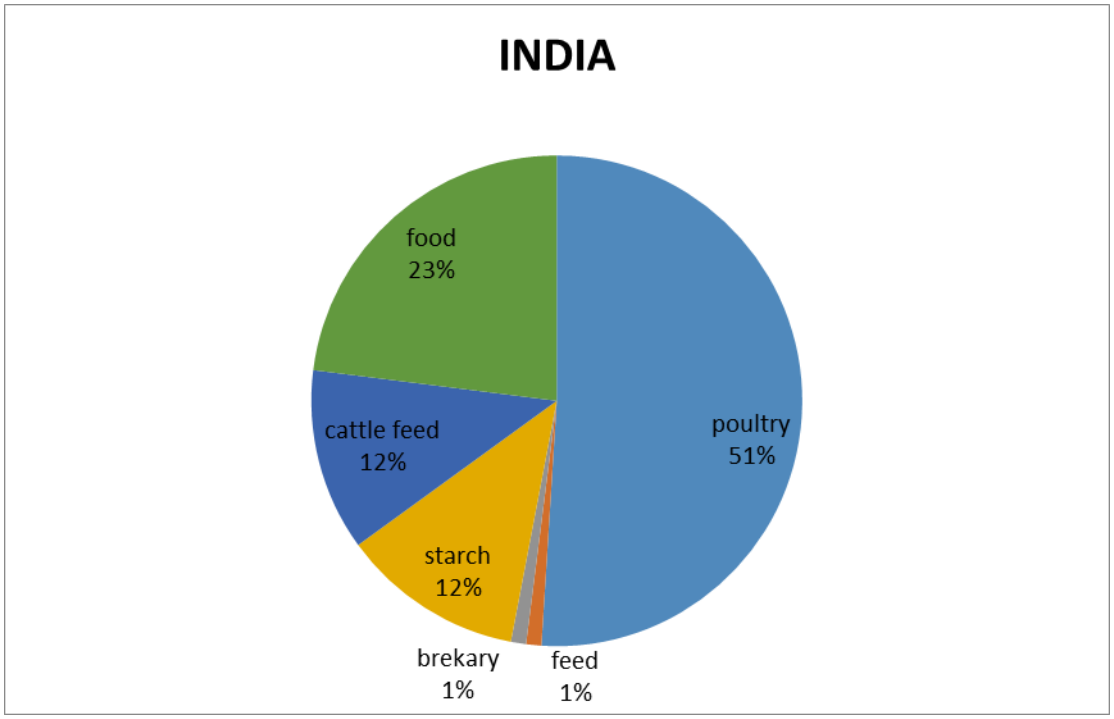
Growth parameters

At Dapoli (Maharashtra), Dalvi (1984) conducted a field experiment during *rabi* season and reported that number of functional leaves and dry matter accumulation were significantly higher at 60 cm x 30 cm spacings during all the growth stages as compared to 30 cm x 30 cm and 45 cm x 30 cm spacings. The effect of spacing on growth, development and yield of baby corn varieties at Bangalore during summer season under irrigated condition was studied.

It was found that the spacings of 45 cm x 15 cm recorded the maximum plant height of 181.8 cm, which was significantly superior to wider row spacings of 60 cm x 15 cm. Further, it was observed that the spacings of 45 x 30 cm recorded the maximum leaf area of 4826.42 cm^2 $plant^{-1}$ which was significantly superior over 60 cm x 15 cm and 45 cm x 15 cm spacing. Similarly, the 45 cm x 30 cm spacings produced significantly higher dry matter of 223.25 g $plant^{-1}$ over other spacings. The lowest dry matter of 166.47 g palnt-1 was recorded in 60 cm x 15 cm spacings (Sukanya *et al.*, 2000). A field trial was conducted by Thakur *et al.*, (2000) to study effect of planting geometry on baby corn during 1995-1996 at Bajaura. They reported maximum plant height with wider spacings (60 cm x 30 cm) than closer spacing (40 cm x 40 cm, 50 cm x 30 cm, 40 cm x 35 cm, 50 cm x 25 cm and 45 cm x 25 cm). Sahoo and Panda (1999) reported that the plant spacing of 40 cm x 20 cm was optimum to get high yield and higher net profit. The green fodder yield also followed similar trend.

No significant difference could be observed in different spacing treatments on various yield attributing parameters. Thakur and Sharma (2000) at Bajaura reported that reduced spacing accommodating from 1.25 to 1.78 lakh plants/ha with two plants/hill remained statistically at par with each other in influencing the baby corn yield and were found significantly superior to increased spacing of 60 cm x 30 cm, accommodating 1.11 plants/ha. He also reported that with an increase in plant density, an increase in green fodder yield, discarded baby corn and barrenness was observed, whereas decrease was observed in cobs/plant and husk: baby corn. Sukanya *et al.*, (2000) studied the influence of varieties and spacing on growth parameters and yield of baby corn at Bangalore and revealed that closer row spacing of 30 cm recorded significantly higher yield as compared to other wider row spacings. Sahoo and Mahapatra (2004) conducted a field trial on sweet corn at Jashipur (Orissa) revealed that higher plant population (83,333 plants/ha) with spacing of 60 cm x 20 cm produced maximum number of ears.





But green cob weight and length of dehusked cob were maximum under lower plant population (55,555 plants/ha) which was at par with 66,666 plants/ha. Chougule (2003) conducted a field experiment on sweet corn at Rahuri and reported that plant height, number of functional leaves, leaf area and total dry matter production per plant were significantly higher with 60 cm x 20 cm spacings than the closer spacing *viz*., 45 cm x 15 cm, 45 cm x 20 cm and 60 cm x 15 cm. The effect of spacings on baby corn

revealed that plant height was significantly higher under the closer spacings of 30 cm x 20 cm than other spacing (40 cm x 20 cm and 60 cm x 20 cm). Thavaprakaash *et al.*, (2005) revealed the growth characters such as plant height, LAI and DMP; yield attributes *viz*., length of cob and corn, diameter of cob and corn and weight of cob and corn; green cob yield and fodder yield were significantly higher at 60 cm wider row spacing than 45 cm spacing level. Kunjir *et al.,* (2007) stated that the spacings of 45 cm x 20 cm produced significantly higher plant height of maize (sweet corn) than 60 cm x 20 cm and 75 cm x 20 cm spacings. Rao (2010) reported that the spacing of 45 cm × 10 cm recorded significantly more plant height at harvest stage (190 cm) compared to 45 cm × 20 cm (173.1cm).But higher value of leaf area per plant recorded with a spacing of 45 cm × 20 cm (12500.43 cm^2) over 45 cm × 10 cm spacing (9261.00 cm^2) during the crop growth stages. He also reported that spacing of 45 cm × 10 cm recorded 53.6 days whereas; 45 cm × 20 cm recorded 53.4 days for 50 per cent flowering. Khaliq *et al.*, (2010) reported that the early (DK-919) and late (Pioneer – 30Y87) maize hybrid performance best at 45 cm row spacing, while mid-season hybrid (DK - 5219) did best at 60 cm row spacing. Laskari *et al.*, (2011) revealed that the three maize hybrids (KSC-206, KSC- 30 and KSC- 500) and three level of plant density (7, 9 and 13 plant/m2). The plant height significantly increased at the level of density (13 plants/m^2).

Effect of nutrient management

Growth characters

Sharma (1983) found that there was significant increase in plant height and number of leaves per plant with each successive increase in the level of fertilizers. Addition of 12t FYM per ha along with fertilizer levels up to 60 kg N, 30 kg P_2O_5 and 30 kg K_2O per ha significantly improved the growth characters. Prasad *et al.,* (1985) found that plant height and leaf area index in winter maize increased with increasing levels of nitrogen application up to 100 $kgha^{-1}$. Whereas, Prasad *et al.,* (1987) reported higher plant height, dry matter accumulation and leaf area index with increase in nitrogen application up to 150 kg per ha. Application of 180 kg N per ha recorded maximum values of growth characters of maize *viz*., leaf area index and dry matter per plant. An increase in the nitrogen level increased its availability in the soil, resulting in higher uptake by plants and production of larger leaves more photosynthates and dry matter accumulation which ultimately gave higher yield and its attributes (Bangarwa *et al.,* 1988). Ogunela *et al.,* (1988) observed increased plant height and dry matter production as nitrogen fertilization increased upto 100 or 150 kg per ha. Ahmed (1989) also reported increased plant height, number of leaves per plant, plant dry weight and leaf area index with an increase in nitrogen rate, but did not increase in NAR, CGR or leaf area ratio.

Fertilizer management plays an important role in baby corn cultivation. Hybrid varieties exhibit their full growth and yield potential only when supplied with adequate quantities of nutrients at proper time. In a study in Himachal Pradesh, significant enhancement in growth parameters of baby corn *viz.*, plant height and functional leaves was noticed with up to 200 kg N/ha (Thakur *et al.,* 1995). Similar improvement in plant height and dry matter accumulation and leaf area index with each successive increase in N level up to 120 kg/ha was also reported by Shivay and Singh (2000) and up to 150 kg N/ha by Singh (2001). In another study on

winter maize, Singh *et al.,* (2003) found an improvement in green leaves/plant up to a nitrogen application rate of 240 kg/ha and dry matter accumulation up to 180 kg/ha. However, Chaudhary *et al.,* (2002) working on maize with different levels of N (0, 40, 80, 120 kg/ha) advocated that 80 kg N/ha is sufficient to get higher plant height, dry matter accumulation and leaf area index. Number of green leaves per plant and plant height of maize differed significantly due to organic manures at 60 days after sowing (DAS). Compost @ 10 t/ha along with recommended dose of N, P and K (150: 75: 40) at 60 DAS recorded maximum number of green leaves per plant (10.73) and maximum plant height (171.1 cm) Mirza *et al.,* (2001)

Purushotham *et al.,* (2002) applied different level of NPK 100, 75 and 50% recommended dose of fertilizer (RDF) and sulfur (0, 20, 40 and 60 kg S/ha). He reported the growth parameters, except leaf area and maize yield were not significant increased by different fertility level and sulphur nutrition. Luikham *et al.,* (2003) reported the maximum dry matter production by maize plants with the application of 135 kg N/ha and 10 t/ha FYM. In other study significantly higher leaf area index was recorded with the application of 120 kg N, 26.2 kg P and 45.5 kg K/ha (Kumar *et al.,* 2003). Application of 120 kg N/ha resulted in the tallest plant with maximum dry matter yield and leaf area index which were significantly higher than 40 and 80 kg N/ha (Bindhani, 2007). In a study, maximum plant height of 120 cm and minimum plant height of 97 cm were found with 120 and 100 kg N/ha, respectively (Dass *et al.,* 2009). Application of 120 kg N + 26.4 kg P + 41.7 kg K/ha through chemical fertilizers recorded lower root dry weight and root volume of baby corn compared to 120 kg N applied through vermicompost, 120 kg N through FYM and 120 kg N through leaf compost (Barod, 2010). He also reported that the application of 120 kg N + 26.4 kg P + 41.7 kg K/ha through fertilizers crop took 54 days to cob initiation which were earlier than the organic sources. Sadiq *et al.,* (2005) concluded that the application of highest NP levels significantly increased plant height (176.8 cm), cob per plant (1.50), 1000 grain weight (281.0 g) and grain yield (4272 kg/ha). The tallest plants with largest LAI and greater dry matter were produced with foliar application of Zn and Fe which were, however, comparable with soil application of Zn and Fe and foliar application of Zn. Reddi and Reddy (2007). Mahesh *et al.,* (2010) have suggested that the application of recommended dose of NPK (150:75:40 kg/ha) + FYM 10 t/ha recorded higher plant height (213.6 cm), total dry matter production (368.5 g/plant), number of grains per cob (438.5), grain weight per cob (166.9 g), test weight (38.9 g) and grain yield (65.9 q/ha). Paramasivan *et al.,* (2011) recorded the maximum maize plant height (149.1, 225.0 and 249.6 cm), higher dry matter production 4319 and 10962 kg/ha were noted with application of 250:70:150:9.6 kg of NPK and Zn ha^{-1}.

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