International Journal of Agricultural Sciences ☞DOI:10.15740/HAS/IJAS/18.2/881-887
Volume 18 | Issue 2 | June, 2022 | 881-887 ■ ISSN : 0973-130X Visit us : *www.researchjournal.co.in*

A REVIEW

Effect of planting methods on growth, yield, quality and economics of maize (*Zea mays* L.)

Amandeep Kaur* **and** Ramandeep Kaur
Department of Agronomy, Lovely Professional University, Phagwara (Punjab) India
(Email: amugorsian@gmail.com, ramandeepkaur201533@gmail.com)

Abstract : The optimum time for sowing of *Kharif* maize in northern India is from last week of May to end of June. This period is characterized by a high evaporative demand due to high temperature and low relative humidity. The planting of maize during *Kharif* season experiences high rainfall in monsoon season which often causes temporary flooding in flat method of sowing. Planting methods in maize play a prominent role for reducing its water requirement when sown during *Kharif* season and also to save it from temporary flooding damage due to excessive rainfall during monsoon period. Excess water during the heavy rains especially on poorly drained soils also creates a great problem for maize cultivation as the crop is quite sensitive towards water stagnation. Best method of sowing is necessary to obtain maximum yield and higher net returns from maize cultivation. The findings of the various research scientists and eminent investigators will help in understanding effect of planting methods on growth, yield parameters, yield, quality and economics of maize. Among different planting methods, bed planting is found significant better in improving the growth, yield attributes, yield (grain and stover yield), quality and net returns in *Kharif* maize as compared to flat sowing method and it is followed by ridge sowing method. Bed and ridge planting methods give higher grain yield than the flat sowing method due to better crop growth and nutrient absorption. Water use efficiency and nutrient uptake was higher in bed planting as compared to flat and ridge planting methods.

Key Words : Economics, Growth, *Kharif maize*, Planting methods, Quality, Yield

View Point Article : Kaur, Amandeep and Kaur, Ramandeep (2022). Effect of planting methods on growth, yield, quality and economics of maize (*Zea mays* L.). *Internat. J. agric. Sci.*, **18** (2) : 881-887, **DOI:10.15740/HAS/IJAS/18.2/881-887.** Copyright@ 2022: Hind Agri-Horticultural Society.

Article History : Received : 11.04.2022**; Accepted :** 28.04.2022

INTRODUCTION

Maize is one of the most important cereal crops next to wheat and rice in the world. Globally, it is known as queen of cereals because it has the highest genetic yield potential among the cereals. Maize being a C_4 plant, is considered to be an energy efficient and has high yield potential which also adds towards its importance in agriculture. Because of its expanded use in the agro-industries, it is recognized as a leading commercial crop of great agro-economic value. Maize is grown throughout the world in a wide range of agro-ecological environment. Being a rich source of carbohydrates, it is cultivated as an important staple food crop of the world. There is a continuous increase in the demand for maize grain all over the world due to its varied usage such as food for

***Author for correspondence : (Present Address)**
University of Nebraska, Lincoln, U.S.A.

human beings, feed for animals and raw material for many industrial products. It is also known as emerging industrial crop because its utilization in the manufacturing of many products like ethanol, starch, dextrose, corn syrup, alcohol, corn oil, acetic acid, glucose, lactic acid, plastic, rayon, paper, textile, dye, synthetic rubber, soaps, resin and varnishes. It can also be used as green fodder at early stages, baby corn at very early cob stage, green cob at late milk to dough stage, maize grains as pop corn and maize flour for chapatti making. This crop also provides a good quality feed for poultry, piggery and milch animals.

The continuous adoption of rice-wheat cropping system has led to a number of problems such as severe depletion of underground water, deterioration of soil health, increased environment pollution and emergence of new insect-pests, diseases and resistant weeds. The above mentioned factors have led to the need for replacing high water requiring rice crop with comparatively low water demanding maize crop. So, it is an attractive alternative to rice for diversification by farmers of the state. Jalota and Arora (2002) suggested that maize-wheat cropping system have low water requirement and this can be an appropriate alternative to rice-wheat cropping system for maintaining soil health and balanced hydrology in the Punjab state. Thus, there is a great need to replace the rice crop from the rice-wheat cropping system and maize may be the best alternative because it has high production potential and easily fits in various intensive cropping systems. This crop is well adapted to the divergent climatic conditions prevailing in the tropical to temperate regions throughout the country especially during *Kharif*, *Rabi* and spring seasons in Peninsular India, *Kharif* and spring seasons of Indo-Gangetic plains and *Kharif* season in the hilly areas. The most suitable temperature for the maximum productivity of the crop is 21-32^{0}C but it can also be grown at low temperature of 10^{0}C with a frost free season.

There is a scope to increase the maize productivity through various agronomic manipulations. Planting methods can improve the drainage to a quite good extent. There is a risk of lodging in *Kharif* maize due to adverse weather conditions particularly at later stages of the crop. Water lodging at flowering can reduce grain yield by about 50%. A method of planting which can reduce the effect of flooding during irrigation and in the event of rainfall is there by also very desirable. Sowing on ridges and bed planting can meet this purpose. These methods may resist lodging and will produce higher grain yield than flat sowing. Bed planting is a method of planting a crop on the top of raised bed with a definite number of rows often one or two per bed. Sayer (2003) reported that raised bed planting has traditionally been associated with water management as it reduces the impact of excess water in high production irrigated systems. Mehta *et al.* (2010) observed significant increase in total grain yield, harvest index and shelling percentage in bed planted crop supplied with higher nitrogen dose. The conventional flat planting is the common practice of raising crops in India but this practice caused the degradation and inefficient use of basic resources and various inputs. Planting of maize on raised beds and ridges provide a better option for managing water, nutrients and weeds as observed by Freeman *et al.* (2007). So, the raised bed planting method in maize may help to achieve good plant establishment, increase nutrient use efficiency, better irrigation management, better weed management through inter bed cultivation, increase aeration in root zone, increase the grain yield and lead to increase in productivity. On the other hand, saving in irrigation water is the need of hour to sustain the underground water resources which can be met through raised bed planting method.

Effect of planting methods on growth parameters of maize :

Planting method is a major factor which may mitigate the vagaries of climate and also responsible for soil moisture storage, judicious use of water, good crop stand, better crop growth and higher grain yield. A field experiment on spring maize was conducted by Singh (2005) at Punjab Agricultural University, Ludhiana and he observed higher emergence count, plant height, leaf area index, dry matter accumulation and stover yield in ridge planted crop as compared to flat sown crop. He further reported that bed planting method has many advantages like better irrigation management and increased availability of nutrients to crop roots. Kaur and Mahey (2005) observed that bed planting method helped to increase aeration in the root zone and resulted in better plant stand by increasing emergence. Ramakrichenin *et al.* (2002) conducted a field experiment at Coimbatore and compared the performance of maize crop in terms of growth and yield characters under five planting methods which were compartmental bunding, broad beds

and furrows, ridges and furrows and flat sowing under rainfed conditions in clay loam soil. They reported that ridge and furrow planting method gave the higher values of growth characters like plant height, LAI, dry matter production, cob length and number of grains per cob which lead to significantly higher grain yield in ridge-furrow planting (34.6 q ha^{-1}) over flat planting (30.2 q ha^{-1}). The superior performance under ridges and furrows planting technique may be due to better infiltration of rain water collected in furrows which improves the soil moisture storage and its availability to crop plants. Ram (2006) observed that with bed planting method, there was better light penetration within the crop canopy, improved water and fertilizer use efficiency and there was reduction in the crop lodging. However, the conventional flat planting is common practice of raising crops in India. This practice has promoted the degradation and inefficient use of basic resources and various inputs. Mehta *et al* (2010) reported that plant height, leaf area, dry matter accumulation, crop growth rate, relative growth rate were maximum of winter maize under the bed planted crop. Tanveer *et al* (2014) reported that maximum crop growth rate (17.39 g/m^2/day) and net assimilation rate (6.27 g/m^2/day) were recorded in bed sowing method, while lower values were observed in ridge sowing and flat sowing methods. Similarly, bed sowing and ridge sowing methods took less number of days to 50% silking (74.8 and 75.0 days). Leaf area index was substantially improved in bed sowing (4.94) and ridge sowing (4.66) methods as compared to flat sowing. Maximum grain yield was obtained in bed sowing followed by ridge sowing and flat sowing methods. They concluded that maize sown on beds performed better as compared to other sowing methods. Gul *et al.* (2015) conducted a field experiment at Sher-e-Kashmir University of Agricultural Sciences and Technology, Budgam to investigate the response of *Kharif* maize to sowing methods for two years. Various growth characters, namely, plant height, leaf area index, dry matter accumulation, number of days to different phenological stages, grain yield and yield contributing characters namely, cob length, number of grains per cob, cob diameter and 1000-grain weight were significantly higher under ridge sowing method over the flat sowing during both the years. Kashif *et al.* (2018) reported that ridge planting method had a significant effect on all the growth parameters. Ridge planting method performed better in all the studied parameters and grain yield of maize. They suggested that maize should be grown on ridges in the agro-ecological condition of Peshawar. Kaur and Kumar (2018) reported that bed and ridge planting methods recorded statistically similar and significantly better plant growth and yield parameters like plant height, leaves per plants, cob length, grain weight and number of grains per cob, compared to maize sown by flat method (Table 1). Better aeration in the root zone and efficient water and nutrient absorption may have encouraged the large sink size under bed and ridge methods. The increase in grains per cob under bed and ridge planting methods was supported by significantly large source size as indicated by higher number of leaves per plant. This better growth of the plants helped the plant to develop

Table 1: Effect of planting methods and nitrogen levels on growth and yield of *Kharif* maize

Treatments	Plant height (cm)	Leavesplant^{-1}	Cobsplant^{-1}	1000-grain weight (g)	Grainsco b^{-1}	Stover yield (tha^{-1})	Grain yield (tha^{-1})	Shelling (%)
Planting method								
Flat	190	14.7	0.96	274	333.6	11.5	5.26	75.7
Ridge	205	15.3	0.97	281	360.5	12.3	5.73	77.1
Bed	206	15.6	0.98	284	361.9	12.56	5.85	78.0
C.D. (p=0.05)	7.0	0.4	NS	NS	16.7	0.6	0.42	NS
Nitrogen (kgha^{-1})								
0	169	12.7	0.88	249	283.7	10.1	3.42	68.5
90	192	15.0	0.97	266	335.7	11.6	5.45	75.3
120	208	15.3	0.99	288	362.2	12.4	6.04	77.6
150	215	16.0	1.00	297	388.2	12.9	6.53	81.3
180	218	17.2	1.01	299.5	390.2	13.2	6.62	81.9
C.D. (p=0.05)	7.0	0.9	0.06	15.8	24.3	0.9	0.48	3.5

Source: Kaur and Kumar (2018) NS= Non-significant

better sink size as supported by significantly longer cobs and ultimately produced more grains per cob. The maize sown on beds produced highest grain and stover yields which was at par with ridge method but significantly higher than maize planted on flat beds. This may be attributed to the fact that the initial crop growth was better in bed and ridge planting as is evident from significantly higher plant height and leaves per plant.

Effect of planting methods on yield attributes, yield, economics and quality of maize:

Aggarwal and Goswami (2002) reported that significantly higher grain yield and water use efficiency in maize was obtained under raised bed planting as compared to flat method of sowing. Similarly, Torbert *et al.* (2001) observed that corn yield in Texas responded positively to planting corn on raised beds. The planting of different crops on raised bed system facilitates mechanical weed control, increases water and fertilizer use efficiency and reduces crop lodging as reported by Limon *et al.* (2000); Sharma and Singh (2002) and Sayre (2004). Kaur (2002) conducted a field experiment at Ludhiana and reported that maize growth, yield attributes and yield were influenced significantly by different methods of planting *viz.,* ridge, trench (furrow), bed and flat. It was observed that planting one row per bed or one row per trench at 67.5 cm apart, one row per trench or ridge 60 cm apart increased grain yield of *Kharif* maize by 33.0, 27.2, 33.0 and 19%, respectively and water use efficiency by 44.5, 31.8, 36.3 and 25.5%, respectively as compared to flat sowing method. Randhawa (2004) observed that winter maize sown by bed planting method produced 5.2 and 6.8% higher grain yield and stover yield, respectively as compared to the flat sown crop. Similarly, the results from a study conducted in Department of Plant Breeding, Punjab Agricultural University, Ludhiana, revealed that planting one row per bed (67.5 cm x 15 cm) of variety Buland (winter maize) produced significantly higher grain yield (55.82 q ha^{-1}) as compared to flat sown crop (67.5 cm x 15 cm) followed by earthing up in February (52.33 q ha^{-1}) which in turn gave better grain yield over ridge (50.53 q ha^{-1}) sown crop (Anonymous, 2004). However, Jat *et al.* (2005) from Rajasthan observed significantly lower grain yield of *Kharif* maize sown on ridges (14.5 q ha^{-1}) as compared to crop sown by flat sowing method or when the ridges were formed after first interculture (15.3 q ha^{-1}). Whereas, Kumar (2008) conducted a research experiment at New Delhi and reported that *Kharif* maize sown on ridges recorded significantly higher plant height, number of rows per cob, number of grains per row, 1000-grain weight and grain yield as compared to flat sowing method. He also observed that irrespective of planting methods, application of 175 kg N ha^{-1} produced significantly higher grain yield (50.8 q ha^{-1}) than other nitrogen levels except 150 kg N ha^{-1} which produced the grain yield of 49.6 q ha^{-1} but 150 and 125 kg N ha^{-1} were also at par. Bhagwandin and Bhatia (1990) conducted a field experiment at Kanpur and also reported that grain and stover yield was higher under ridge and furrow method than that of flat sowing in *Kharif* maize. Similarly, a field experiment on winter maize was conducted by Mehta (2009) who found that bed planting method produced higher grain yield than the ridge and flat methods of planting. Therefore, cultivation of winter maize on raised beds may be adopted for better resource conservation and getting higher productivity. Mehta *et al* (2010) observed that yield attributes namely, bundle weight, straw yield, shelling percentage, harvest index, total grain yield, 1000-grain weight, were significantly higher in bed planted crop as compared to flat method of sowing. Kaur (2011) conducted a field experiment at Ludhiana on August sown maize and observed higher grain yield under bed planting method (78.2 q ha^{-1}) which was significantly higher than ridge (74.8 q ha^{-1}) and flat method of sowing (70.6 q ha^{-1}). The water use efficiency was also higher in bed planting method as compared to ridge and flat sowing method. Crop took less number of days to attain dough stage and physiological maturity under bed planting (108.0 and 119.8 days) in comparison to ridge (111.1 and 122.0 days) and flat (114.3 and 125.7 days) planting methods. The results showed that bed planting method proved to be better for obtaining higher grain yield with higher water use efficiency in comparison to flat and ridge planting method, the later further proved its superiority to the former. Various growth parameters and nutrient uptake was higher in bed planting as compared to flat and ridge planting methods. Singh (2011) reported that in spring maize, ridge and bed planting methods of sowing were at par with each other and recorded significantly higher grain yield by a margin of 16.4 to 24.4 and 17.0 to 24.5%, respectively over flat planting during both the years. The WUE in ridge and bed planting methods was also significantly higher than flat planting method. The net returns were 32 to 61 and 29 to 59% higher in ridge and

bed planting methods, respectively, over the flat sowing method during both the years. Bakht *et al.* (2006) conducted an experiment on spring maize with two methods of sowing *viz.,* ridge and flat.They also observed that ridge planting method was more economical than flat sowing method. Jassal (2013) reported that grain yield showed non-significant effect with different planting methods on maize (variety J-1006). This is due to same plant height, leaves per plant, dry matter accumulation, leaf area index and also same yield attributing characters such as number of cobs per plant, cob length, cob girth, number of grains per cob and 1000-grain weight. The grain yield was maximum under bed planted crop when 100 kg N ha^{-1} was applied and it was at par with 125 but significantly higher than control and 150 kg N ha^{-1}. However, in case of conventional flat sowing method, grain yield was maximum and significantly higher at 150 kg N ha^{-1} as compared to 0, 100 and 125 kg N ha^{-1}. Brar (2013) reported that various planting methods did not differ significantly with respect to growth parameters, yield, quality and nitrogen uptake in spring maize. Kaur (2013) reported that the grain yield, yield attributes and stover yield of spring maize were statistically at par under bed and ridge planting methods. Kumar and Chawla (2015) conducted a field experiment at Ludhiana and observed that the plant height was significantly more under ridge sowing method as compared to trench and flat sowing methods. Days taken to 50% silking under ridge sowing were significantly less than trench and flat sowing. The grain yield was significantly higher in ridge and trench sowing methods as compared to flat sowing. The ridge and trench method of sowing gave 10.2 and 8.0% higher grain yield as compared to flat sowing. Higher yield in ridge and trench planted crop may be attributed to access of roots to nutrients and water resulting in good plant growth. Singh and Vashist (2015) observed that growth parameters like plant height, number of leaves per plant, leaf area index and dry matter accumulation were significantly higher under ridge sowing method as compared to flat sowing and with mulch application as compared to no mulch. The grain yield of ridge sowing method (47.5 q ha^{-1}) was 13.2% higher than flat sowing. Kaur and Kumar (2018) conducted a field experiment at Punjab Agricultural University, Ludhiana, to study the effect of planting methods (flat, ridge and bed) on the quality of maize. Among different planting methods, bed planting produced significantly higher grain yield of *Kharif* maize as compared to flat sowing method. Maximum grain yield of 58.5 q ha^{-1} was recorded in bed planting method which was statistically at par with ridge sowing method (57.3 q ha^{-1}) but was significantly higher than that recorded under flat sowing (52.6 qha^{-1}). Similar trend was recorded in stover yield. Different planting methods did not significantly influence the protein content, total sugars, starch content, oil content, beta- carotene, total carotenoids and total minerals in maize grains. Kumar *et al.* (2020) conducted a field experiment at Yamunanagar, Haryana to study the performance of maize hybrids under different planting techniques. The 5 maize hybrids *viz.,* HM-4, HM-9, HM-10, HM-11, and HQPM-5 were tested under three planting techniques: ridge, flat and furrow methods. The growth parameters like plant stand per hectare, plant height and dry matter accumulation were recorded higher under ridge method of planting followed by flat and furrow but had no significant effect on the quality parameters such as tryptophan, lysine, protein, zinc, iron and nitrogen content in maize grains. The periodic growth parameters such as plant stand per hectare, plant height and dry matter accumulation were significantly higher with hybrid HM-10 followed by the rest of maize hybrids whereas, zinc and iron content was not significantly affected in any of the maize hybrids. Tryptophan and lysine content was significantly higher in HQPM-5 hybrid but nitrogen and protein content were more in HM-4 hybrid.

REFERENCES

Aggarwal, P. and Goswami. B. (2002). Bed planting system for increasing water use efficiency of wheat (*Triticum aestivum* L.) grown in inceptisol. *Indian J. Agric. Sci.,* **73** : 422-425.

Anonymous (2004). *Annual Report,* Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana, Punjab (India).

Bakht, J., Ahmad, S., Tariq, M., Akber, H. and Shafi, M. (2006). Response of maize to planting methods and fertilizer nitrogen. *J. Agric. Biol. Sci.,* **1**: 8-14.

Bhagwandin, S. and Bhatia, K.S. (1990). Effect of sowing methods and mulching on the intercropping of black gram with maize under rainfed conditions. *Crop Res.,* **3**: 284-286.

Brar, H.S. (2013). *Performance of spring maize under different drip irrigation regimes, nitrogen levels and planting methods.*Ph.D. Thesis, Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab (India).

Freeman, K.W., Girma, K., Teal, D B., Klaat, A. and Raun,

W.R. (2007). Winter wheat grain yield and grain nitrogen influenced by bed and conventional planting systems. *J. Pl. Nutr.,* **30**: 611-622.

Gul, S., Khan, M.H., Khanday, B.A. and Nabi, S. (2015). Effect of sowing methods and NPK levels on growth and yield of rainfed maize (*Zea mays* L.) *Hindawi Pub. Corp. Scient*., Art. ID 198575: 1-6.

Jalota, S.K. and Arora, V.K. (2002). Model-based assessment of water balance components under different cropping systems in north-west India. *Agric. Water Manage.,* **57**: 75-87.

Jassal, R.K. (2013). *Effect of planting methods and nitrogen levels on the seed production of fodder maize.* M.Sc. Thesis, Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab (India).

Jat, M.L., Singh, P., Balyan, J.K., Gupta, A. and Jain, L.K. (2005). Energetics of different in-situ moisture conservation practices in maize (*Zea mays* L.). *Indian J. Agric. Sci.,* **75**: 414-416.

Kashif, M., Javed, M., Ullah, S., Ali, A., Khan, G.R., Rahman, A.U., Alam, J.E. and Siraj, S. (2018). Effect of planting methods and nitrogen sources on yield, yield components and N-uptake of spring maize. *Adv. Crop Sci. Tech.*, **6**: 373-374.

Kaur, A. and Kumar, M. (2017). Effect of different planting methods and nitrogen levels on the quality of *Kharif* maize (*Zea mays* L.). *Adv. Res. J. Crop Improv.,* **8**: 179-182.

Kaur, A. and Kumar, M. (2018). Effect of different planting methods and nitrogen levels on productivity o*f Kharif* maize. *Agric. Res. J.,* **55**: 154-155.

Kaur, J. (2013). *Spring maize* (*Zea mays* L.) *productivity as influenced by nitrogen in relation to irrigation regimes and planting methods.* M.Sc. Thesis, Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab (India).

Kaur, M. (2011). *Growth, quality and water productivity of August sown maize as affected by planting method, mulch and irrigation regimes.* M.Sc. Thesis, Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab (India).

Kaur, T. (2002). *Studies on irrigation requirement in relation to method of planting of maize.* M.Sc. Thesis, Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab (India).

Kaur, T. and Mahey, R.K. (2005). Effect of planting method and irrigation levels on water use of maize (*Zea mays* L.). *Indian J. Env. Ecoplan.,* **10**: 373-376.

Kumar, A. (2008). Growth, yield and water use efficiency of different maize (*Zea mays* L.) based cropping systems under varying planting methods and irrigation levels. *Indian J. Agric. Sci.,* **78**: 254-257.

Kumar, A., Kamboj, B.R., Thakral, S.K. and Malik, K. (2020). Impact of planting techniques on the growth and quality performance of maize hybrids in the spring season. *J. Nat. Res. Conserv. Manage.,* **1**: 112-118.

Kumar, M. and Chawla, J.S. (2015). Influence of methods of sowing on productivity of spring maize (*Zea mays* L.) hybrids. *J. Pl. Sci. Res.,* **31**: 97-99.

Limon, O. A., Sayre, K.D. and Francis, C.A. (2000). Wheat and maize yield in response to straw management and nitrogen under a bed planting system. *Agron. J.,* **92**: 295-302.

Mehta, S. (2009). *Physiological basis of yield behavior under different planting methods and nitrogen levels in winter maize.* Ph.D. Thesis, Department of Botany, Punjab Agricultural University, Ludhiana, Punjab (India).

Mehta, S., Bedi, S. and Vashist, K.K. (2010). Performance of winter maize (*Zea mays* L.) hybrid to planting methods and nitrogen levels. *Indian J. Agric. Sci.,* **81**: 50-54.

Ram, H. (2006). *Micro-environment and productivity of maize-wheat and soybean-wheat sequences in relation to tillage and planting system*. Ph.D. Thesis, Department of Agronomy and Agrometeorology, Punjab Agricultural University, Ludhiana, Punjab (India).

Ramakrichenin, B., Sakthivel, N. and Balasubramanian, A. (2002). Effect of pre-monsoon sowing and land management practices on growth, yield parameters and yield of rainfed maize. *Madras Agric. J.,* **89**: 177-179.

Randhawa, J.S. (2004). *Integrated nutrient management in soybean (Glycine max)-winter maize (Zea mays* L.*) cropping system under flat and bed planting method of sowing*. Ph.D. Thesis, Punjab Agricultural University, Ludhiana, Punjab (India).

Sayer, K.D. (2003). Raised-bed cultivation. In: Rattan Lal (ed.) *Encyclopedia of Soil Sci*. pp 1-4. Taylor and Francis.

Sayre, K.D. (2004). Raised bed cultivation in maize. Encyclopedia of Soil Science. Marcel Dekker Inc. UAS.

Sharma, R.K. and Singh, R. (2002). Furrow irrigation raised bed-planting system an efficient input use production technology. *Indian Fmg.,* **52**: 25-32.

Singh, J. and Vashist, K.K. (2015). Effect of planting methods, mulching and irrigation regimes on maize productivity. *Agric. Res. J.,* **52**: 23-27.

Singh, K. (2005). *Performance of spring planted maize in relation to planting dates, methods of sowing and nitrogen levels.* M.Sc. Thesis, Department of Agronomy, Punjab Agricultural University, Ludhaina, Punjab (India).

Singh, M. (2011). *Growth, yield and water productivity of spring planted hybrid maize (Zea mays* L.) *cultivars as influenced by method and time of planting and irrigation regimes.* Ph.D. Thesis, Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab (India).

Tanveer, M., Ehsanullah., Anjum, S.A., Zahid, H., Rehman, A. and Sajjad. (2014). Growth and development of maize (*Zea mays* L.) in response to different planting methods. *J. Agric. Res.,* **52**: 511-522.

Torbert, H.A., Poter, K.N. and Morrison, J.E. (2001). Tillage system, fertilizer nitrogen rate and timing effect on corn yield in the texas black and friarie. *Agron. J.,* **93**: 119-124.