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An overview on problems and prospects of transplanted maize with special reference to India

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Abstract
Transplanting is the technique of moving of a plant from one location to another. This strategy is commonly practiced to establish crops when conditions are less favourable for direct seeding. Birds and squirrels damage to seedlings of maize is a serious problem resulting in poor crop stand and low yield. Delayed germination and plant growth receives a major setback due to late sowing of maize which reduces grain yield; however, reduction of yield can be compensated by transplantation technique. Transplanting of maize is a strategy that can be used to achieve optimum plant densities, better crop stand and obviously to get optimum yield. It reduces the nutrient requirement and also shortens the growth period of crop that helps farmers to harvest a third crop in intensive cropping system. Transplanted crop produces about 15.44% higher grain yield and can be harvested 10-12 days earlier that of direct seeding crop, so, late maturity high yielding cultivars can be fitted in to available growing season. Though, there are several advantages of transplanted maize, it is not popular in India due to lack of awareness, lacking in proper rational scientific technology and very little information about age of seedling and optimum dose of nutrient. Farmers can be benefitted if proper technology regarding age of seedling, process of transplanting and other cultivation techniques of raising transplanted maize is supplied to them.

Keywords: Farmers, Maize, Transplanting, Problem, Prospect

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INTRODUCTION

Corn (*Zea mays L.*) holds third position with respect to total production following wheat and rice in the world and ranks as the top most cereal in terms of grain yield. Maize, a 'miracle crop' due to high genetic yield potential and 'queen of cereals' due to its very high yield potentiality as well as colourful silk holds prominent position in Indian agriculture after rice and wheat and not only contributes in the national food basket but also generates more than 100 million man-days employment at the farm and downstream agricultural and industrial sectors (Anonymous, 2013). Out of total produced maize, about 48% is used for poultry feed 28% as food purpose, 12% for wet milling industry (starch and oil production), 11% as livestock feed and 1% as seed purpose in India (AICRP on Maize, 2007). Saikumar *et al*. (2012) reported that 61% of maize produced in the world is utilized for feed purpose and 17% is used as food, however, in India, 44% is used as poultry feed, 16% as livestock feed and 24% as food (Fig. 1). It contains about 70% carbohydrate, 10% protein, 4% oil, 2.3% crude fibre, 10.4% albuminoides and 1.4% ash (Singh *et al.*, 2012). It is rich in vitamin-A, nicotinic acid, riboflavin and vitamin-E, however, deficient in two essential amino acids namely lysine and tryptophan, low in calcium, fairly high in phosphorus. Maize is used as a staple human food, livestock and poultry feed and for fermentation and many industrial purposes. Maize crop is utilized in many ways like several food dishes including 'chapattis', roasted green cobs', 'popcorn' etc. Importance of maize is increasing day by day due to establishment of maize-based

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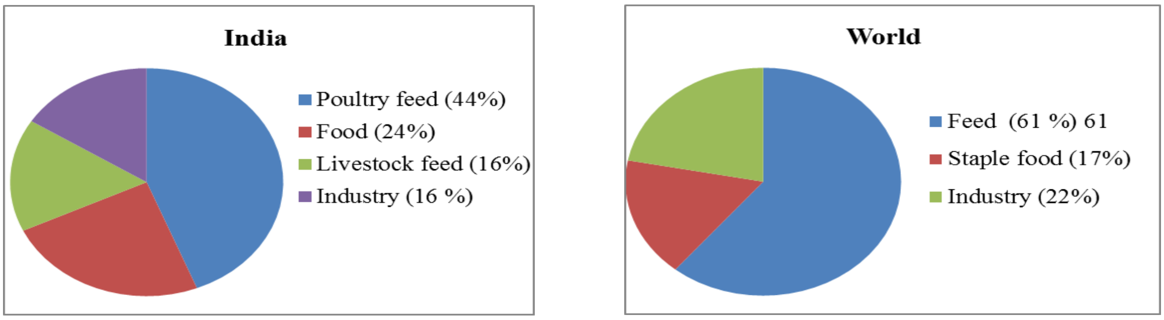

Fig. 1. *Maize utilization pattern in India and World.* (Source: Saikumar *et al*., 2012)

food industries and feed for poultry, dairy and fish farms. Ethanol is prepared from fermented maize starch, used to produce bio-fuel "gasohol" (10% ethanol+ 90% gasoline). In India, 85% of the maize produced is consumed as human food and animal feed including poultry. Industrial use of maize is limited at present. However, there exists a huge scope for using maize as raw material for several industries such as alcoholic beverages, sweeteners, pharmaceuticals, textile, starch, oil, protein, cosmetics, film, gum, paper and packaging. Due to burgeoning population explosion the demand of maize is increasing day by day in India and even worldwide. Globally, corn is grown on more than 175 million ha across 166 countries with a production of around 880 million tons (Anonymous, 2013). Prasad (2016) indicated that more than 40% of the total world maize grain production is recorded in USA followed by China (20%), Brazil (6.3%), Mexico (2.5%), Indonesia (2.2%) and India (2.0%). USA ranks first position with the production capacity of 377.50 million metric tons per annum, however, India is occupying fourth position in the list of leading maize producing countries (Table 1) in the world (Anonymous, 2019). In India, maize is cultivated in 86.91 lakh hectare area with the production of 21817 thousand tonnes with the productivity of 2509 kg ha^{-1} (Anonymous, 2015-16). It is also reported by Prasad (2016) that major maize growing states (contributing >85% of the total maize production) in India are Karnataka (20.5%), Andhra Pradesh (19.6%), Maharashtra (10.7%), Rajasthan (9.5%), Bihar (6.7%), Uttar Pradesh (5.1%), Madhya Pradesh (5.1%), Tamil Nadu (5.1%), and Himachal Pradesh (3.2%).

Transplanting strategy is commonly practiced to establish crops when conditions are less favourable for direct seeding, however, reduction in the yield of maize due to delayed sowing can be compensated by transplantation technique. This study is therefore aimed at assessing the responses of maize to transplanting strategy in India.

Transplanting of maize: Transplanting is the technique of moving of a plant from one location to another. It is a strategy that is commonly used to establish crops when conditions are less favourable for direct seeding. Transplanting is related mainly common for rice, chilli, brinjal, tomato etc. but not familiar with maize crop. Maize transplanting was first tried by agricultural scientists of the Punjab but scheme fell through due to lack of rational scientific approach. First successful blueprint of transplanted maize was developed in the mid-eighties by the scientist of North Korea where 80% land area is covered by transplanting maize. China and Vietnam also adopted this technique later on. Transplanting of maize is most common in Korea but this practice is followed in various parts of the world such as North Vietnam (CIMMYT, 1989) and Northern India (Khehra *et al*., 1990; Sharma *et al*., 1989). North Korea has already doubled its maize crop area from 3.5 lakh ha to 7 lakh ha with the new transplantation technique. Vietnam is also applying the similar technique for the first time in tropical areas. In the Red River delta of Vietnam the area under transplanted maize has been increased five-fold from 50,000 ha/year in 1983-86 to almost 2.5 lakh ha in 1990 (Anonymous, 2015).

Advantages of transplanted maize: There are so many advantages of transplanted maize cultivation such as follows:

- In direct seeding of maize, reduction in plant density occurred due to crows (*Corvus corax*) which fed on the emerging seedlings. One of the most important agronomic attributes of maize is plant density (Sangoi, 2000). So transplanting technique may be used for optimum crop stand to achieve maximum yield.
- Transplanting resulted in a significantly higher crop stand of 96% as compared to direct seeding which achieved 78% (Fanadzo *et al*., 2009).
- Transplanted maize can be harvested in just 60-90 days during *kharif* and 110-130 day during winter depending on prevailing temperature and the variety while direct sown maize is generally harvested at 100-110 days during *kharif* and 170-190 days during *rabi* season (Kumar *et al*., 2014).
- Transplanted maize can be harvested 8-10 days earlier in the main field than the direct seeded crop (Basu *et al*., 2003). Waters *et al*. (1990) also reported that duration of maize crop was reduced by one to three weeks in the USA and 10 to 12 days in France depending upon the seedling age.

Table 1. List of leading maize producing countries in the world.

Rank	Country	Production capacity per annum (million metric tons)
1	United States of America	377.50
2	China	224.90
3	Brazil	83.00
4	India	42.30
5	Argentina	40.00
6	Ukraine	39.20
7	Mexico	32.60
8	Indonesia	20.80
9	France	17.10
10	South Africa	15.50
11	Philippines	8.30
12	Serbia	7.00

(Anonymous, 2019)

Table 2. Effect of variety and seedlings age on plant stand, growth parameters, yield, harvest index and B: C of transplanted maize.

Treatment	Plant Stand% (20 DAT)	Plant height at harvest (cm)	DMA (30 DAT)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index (%)	B:C
Variety							
GM3	89.38	106.14	21.65	1844	2778	37.34	1.03
HQPM	96.38	111.20	30.59	2447	3728	36.80	1.32
SEm.(±)	0.78	1.52	0.72	42	63	0.22	-
CD (0.05)	2.25	4.42	2.08	121	183	NS	-
Age of Seedling							
2 Week	95.94	112.39	16.29	2402	3573	37.62	1.38
3 Week	96.88	127.79	24.73	2963	4210	38.47	1.69
4 Week	95.00	116.95	28.33	2129	3268	36.91	1.23
5 Week	93.44	99.76	30.01	1766	2822	36.35	1.03
6 Week	83.13	86.46	31.25	1468	2391	36.01	0.85
SEm.(±)	1.23	2.41	1.13	67	99	0.35	-
CD(0.05)	3.56	6.98	3.28	191	284	1.01	-
Interaction (V×A)	S	NS	NS	S	S	NS	S

(Source: Nagbha, 2017)

Table 3. Plant height, dry matter accumulation (DMA), yield, harvest index (HI) and B: C of transplanted maize as affected by sowing date, method of planting and nitrogen levels**.**

Treatments	Plant Height (cm)	DMA (60 DAS)	Grain Yield (q/ha)	Stover Yield (q/ha)	Harvest Index (%)	B:C
Sowing Date						
June, 25	131.00	52.39	45.69	64.14	0.41	1.04
July, 10	126.26	50.45	42.22	60.22	0.40	0.88
July, 25	122.24	46.74	34.96	55.74	0.38	0.58
SEm.(±)	0.75	1.00	0.48	0.30	0.006	-
CD (0.05)	2.39	2.97	1.43	0.91	0.021	-
Method of Planting						
Direct	124.34	48.72	37.79	58.18	0.39	0.73
Transplanting	128.67	51.00	42.31	61.89	0.40	0.79
SEm.(±)	0.62	0.72	0.40	0.25	0.02	-
CD (0.05)	1.95	2.18	1.17	0.74	NS	-
Nitrogen Levels (kg/ha)						
0	121.69	47.98	32.22	56.78	0.36	0.60
75	125.77	50.16	40.90	60.02	0.41	0.85
150	132.05	51.44	47.03	63.30	0.43	1.01
SEm.(±)	1.23	0.62	0.71	0.41	0.02	-
CD (0.05)	3.58	1.72	2.06	1.19	0.06	

(Source: Sobarad, 1997)

Table 4. Effect of transplanting date, age of nursery and transplanting method on growth parameters, yield and harvest index of transplanted maize.

Treatment	Plant Height (cm)	LAI	DMA (g/plant)	Grain Yield (q/ha)	Stover Yield (q/ha)	Harvest Index
Date of Transplanting						
Dec,21	190.1	4.63	259.5	76.6	129.1	0.42
Jan,5	187.0	4.43	206.5	65.0	124.8	0.40
Jan, 20	146.8	3.87	164.7	56.4	116.1	0.39
CD (0.05)	13.3	0.49	24.8	9.1	9.7	NS
Age of Nursery						
40 DAS	171.4	3.95	206.6	62.3	124.0	0.39
55 DAS	177.8	4.67	214.0	69.6	123.0	0.42
CD (0.05)	NS	NS	NS	6.2	NS	NS
Method of Transplanting						
Flat beds	168.3	3.95	202.2	64.1	68.0	0.40
Raised beds	171.5	4.26	199.8	58.1	61.0	0.39
Ridges	184.1	4.72	228.7	75.7	87.0	0.42
CD (0.05)	6.1	0.46	14.2	6.2	7.2	NS

(Source: Singh, 2005)

Table 5. Yield attributes, yield, days taken to 50% flowering, days taken to maturity and economics as affected by seedling age and method of seedling raising (pooled data of three years, 2008-11).

Treatment	Grains per Cob	100-grain Weight (g)	Grain yield (t/ha)	Grain: Stover	Days to 50% flowering	Maturi-ty days	Gross Income (Rs.)	Net return (Rs.)	B:C
Methods of raising seedling									
Flat bed	237.2	32.5	4.7	0.58	56.0	124	42480	19654	1.86
Raised bed	292.5	34.6	5.1	0.62	58.2	126	45810	22334	1.95
Sand culture	286.5	35.0	5.2	0.62	59.8	129	46800	23074	1.97
Plastic culture	190.4	30.2	3.2	0.53	50.3	137	29070	7370	1.34
SEm.(±)	8.90	0.21	0.10	0.01	0.51	3.46	802	817	0.08
CD (P=0.05)	30.70	0.72	0.34	0.03	1.75	11.90	2762	2819	0.28
Seedling age									
4 Weeks	283.3	34.2	4.8	0.62	66.1	148	43650	20591	1.90
5 Weeks	328.6	35.2	5.7	0.64	61.0	132	51750	28691	2.10
6 Weeks	258.2	33.3	4.6	0.61	56.0	126	41400	18341	1.80
7 Weeks	136.5	29.6	3.1	0.48	41.2	110	27810	4258	1.26
SEm.(±)	14.60	0.33	2.70	0.06	0.81	3.80	2005	2102	0.03
CD (P=0.05)	42.61	0.90	8.00	0.17	2.36	11.10	5852	6136	0.08

(Source: Kumar *et al*., 2014)

Table 6. Effect of seedling raising methods and age of seedling on growth, yield, harvest index and B: C of transplanted maize.

Treatment	Plant Stand (%)	Plant Height (cm)	DMA at Harvest (g/plant)	Grain yield (kg /ha)	Stover Yield (kg/ha)	Harvest Index (%)	B:C
Seedling raising method							
Flat bed	97	177.62	201.92	5443	5680	48.94	1.94
Raised bed	97	179.22	205.46	5494	5691	49.12	1.93
Poly Bag	98	190.22	216.96	6177	6441	48.93	1.99
Poly cup	97	186.18	208.90	6010	6278	48.84	1.94
SEm. (±)	-	1.16	2.10	14.2	17.1	0.25	-
CD (0.05)	-	4.04	7.30	49.2	59.3	NS	-
Seedling age							
7 days	97	184.92	215.45	6219	6292	49.73	2.10
14 Days	97	181.94	206.89	5870	6093	49.09	1.98
21 Days	97	176.76	203.63	5354	5784	48.07	1.81
Direct Seeded	98	189.63	207.26	5681	5922	48.95	1.92
SEm.(±)	-	0.76	2.23	6.8	7.9	0.24	-
CD (0.05)	-	2.24	6.51	19.9	23.0	0.71	-
Interaction (M×S)							
CD (0.05)	-	NS	NS	Sig	Sig	NS	-
General Mean	97	183.31	208.31	5781	6022	48.96	1.95

(Source: Hajong, 2017)

Maize seedlings could be transplanted on the mud just after recession of flood water and the crop might be established earlier in the season in *diara* regions (Biswas, 2008 and Biswas, 2015).

Maize also needs far less water than rice for an equivalent yield.

Lodging of maize crop can be reduced due to transplanting.

Transplanted crop produced about 15.44% higher grain yield than that of direct seeding (Badran, 2001) and also compensate the yield losses due to delayed sowing (Hajong, 2017). Rattin *et al*., (2006) also suggested that similar or highest yield from sweet maize mutant plant can be obtained using a transplanting technique with respect to direct seeded method under optimal environmental conditions. Sánchez *et al*., (2014) opined that there was no significant yield difference between direct seeded and transplanted maize. Ibrahim and Gopalasamy (1989) registered 14.7 and 11.5% higher grain yields in transplanted maize in *kharif* and *rabi* seasons respectively as compared to direct seeding.

Unfortunately sizeable amount of works have not been reported on transplanted maize in India though there are several advantages of transplanted maize as because direct sowing of maize is a traditional practice whereas transplantation of maize is a recent technique.

Constraints of maize transplanting: Transplanting of maize is not popular in India because of several constraints such as follows

- Lack of proper technology - there is lack of scientific, rational, appropriate approach for raising transplanted maize that means in which method (such as flatbed, raised bed, ridges etc.) transplanted maize should be cultivated, is not standardized till date.
- A little information is available about optimum dose of nutrient (N, P, K) for the transplanted maize
- More labour is required than the direct sowing
- Age of seedling is not standardized for transplanting technique
- Lack of awareness - most of the farmers doesn't know about the transplanted technique. Some of the farmers heard about the term "transplanted maize" but they don't adopt this technique from fear of loss.

Prospects of maize transplanting: Food and Agriculture Organisation (FAO) scientists believe that countries ranging from Bangladesh and Indonesia in Asia to Haiti in Latin America can be benefited from maize transplantation (Nagbha, 2017). Prospects of transplanted maize are as follows.

- Damage of emerging maize seedling by bird and squirrel is a serious problem that results in poor crop stand and low yield (Van *et al*. 1998).
- Transplanting provides maximum stand establishment, early flowering, maximum biomass and more grain yield as compared to direct seeding (Nagbha, 2017).
- Delayed germination and plant growth receives a major setback due to late sowing of maize reduced grain yield (Biswas *et al*. 2009; Porwal and Jain,1999), however, reduction of yield can be compensated by transplantation technique (Nagbha, 2017). Under late sowing condition transplantation technique may be viable alternative to direct sowing (Badran, 2001).
- Farmers can harvest a third crop due to transplanting of maize in areas where none would have been possible because of late harvest of *rabi* maize (Basu and Sharma, 2003).
- Maize transplantation shortens the crop period for 8-10 days (Basu and Sharma, 2003). It is observed that transplanted crop matures 10-12 days earlier than direct seeded maize (Kumar *et al.,* 2014). Late maturating high yielding cultivars could be fitted into available growing season (Dale and Drennan, 1997).
- Transplanting crop reduced the nutrient requirement than the direct seeded maize and at low N rates; transplants produced higher green cob weight, grain yield and longer cobs than direct seeded one (Fanadzo *et al*., 2009). The findings suggested that transplantation is a better option to achieve similar yield potential than direct seeded maize at lower N rates.

Research work at University level: Few research works on transplanted maize have been reported from different State Agricultural Universities as well as from different research stations such as follows.

Nagbha (2017) reported from a field experiment conducted during *Rabi* season of 2015-2016 at B. A. College of Agriculture, Anand Agricultural University that higher grain yield and benefit cost ratio of *Rabi* maize might be achieved due to transplanting of maize varieties with 3 weeks old seedling under middle Gujrat conditions (Table 2)

Sobarad (1997) opined from a field experiment conducted during *kharif* seasons of 1995 and 1996 at Indian Agricultural Research Institute, New Delhi that transplanted maize performed better in terms of net returns and benefit-cost ratio as compared to direct sowing under delayed conditions (Table 3).

Singh (2005) reported that winter maize yielded highest when 40 days aged old seedling transplanted on 21 December, after that delay in transplanting to January 5 declining the yield from the experiment "Agronomic management of transplanted winter maize (*Zea mays* L.) for higher productivity" which was carried out during the *rabi* seasons of 2002-03 and 2003-04 at Students' Research Farm, Department of Agronomy and Agro meteorology, Punjab Agricultural University, Ludhiana. He also opined that transplanting made on southern slope of E-W oriented ridges was more yielder than other two planted method i.e. flat and raised beds. He registered yield increase up to 175 kg N/ha, however, it was statistically at par with 150 kg N/ha (Table 4).

Kumar *et al.,* (2014) recorded that transplantation of five weeks old seedlings and nursery raised on sand culture as well as on raised bed proved to be superior with respect to yield attributing characters like grains/cob, 100 grain weight due to variation in age of seedlings and methods of nursery raising. Number of grains per cob were significantly higher in plants from raised bed method over other methods but was at par with plants raised with sand cultured seedlings. Significantly higher 100-grain weight was recorded in plants raised with sand cultured seedling and was found to be at par with plants transplanted with raised bed seedlings over all other methods. The enhanced vegetative growth resulted in more grains per cob and 100 grain weight which in turn increased the grain yield. It was also registered that transplanting of five weeks old seedlings raised either on raised beds or in sand culture recorded significantly higher grain yield with respect to other methods of raising seedlings and varying age group. Five weeks old seedlings grown either on sand culture or on raised bed resulted in higher net income and transplanted crop matured 10-12 days earlier than direct seeded maize (Table 5).

Dhillon *et al.* (1990) also found more grains/cob and heavier grains in raised seedbed than flat seed bed. Grain and stover yield were significantly affected by method of seedling raising and age of seedling for transplanting. Transplanting of 5 weeks old seedling produced highest grain as well as stover yield. The increase in grain yield could be attributed to higher yield attributes and increase in biological yield might be due to higher dry matter accumulation. Grain yield obtained from 7 weeks old transplanted seedlings reduced by 36.3, 45.8 and 32.8% from 4 week, 5 week and 6 week transplantation age, respectively.

Basu *et al.* (2003) opined that transplanting of four to five weeks old seedlings gave identical grain yields with direct sown crop and matured 8-10 days earlier than direct sown crop. Grain: Stover ratio was also found highest in raised bed and sand cultured transplanted seedlings. Transplanting of 5 weeks old maize seedlings recorded significantly higher grain: stover ratio over 4, 6 and 7 weeks maize seedlings. Dale and Drennan (1997) also reported greater dry matter accumulation and harvest index in maize transplanted with 5 to 6 weeks old maize nurseries.

A field experiment on “Effect of seedling raising methods and age on growth, yield and quality of transplanted maize” conducted at Post Graduate Institute Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharastra during *Kharif*, 2016 (Table 6) revealed that transplanting of one week old seedlings of maize raised in poly bag obtained significantly maximum monetary return and net monetary return than transplanting of two week and three week old seedlings as well as direct seeded maize (Hajong, 2017).

Conclusion

Farmers can be benefitted if transplanted maize is grown on commercial scale and proper technology regarding age of seedling, method of transplanting and cultivation process of raising it is supplied to them. It will also become helpful and beneficial for farming community if transplanting technique becomes an alternative of direct seeded maize in excess moisture condition. It is assumed that the practice of transplanting in maize will be popular in India in near future.

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