



## Performance of transplanted maize (*Zea mays*) under varying age of seedling and method of nursery raising in the midlands of eastern region

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### ABSTRACT

Field experiments were conducted at ICAR Research Complex for Eastern Region Farm, Patna during winter (*rabi*) season of 2008-09, 2009-10 and 2010-11 to study the performance of maize (*Zea mays* L.) crop under transplanted condition as affected by different age of seedlings and methods of nursery raising. Transplantation of five weeks old seedlings and nursery raised on sand culture as well as on raised bed recorded more plant height, leaf length, dry matter accumulation/plant and yield attributes over other methods of raising seedlings and varying age group. After transplantation mortality of seedlings in the main field was minimum reported with 5 week old seedlings (5.8%) as well as seedlings raised under sand culture and raised bed method (5.2% and 5.8%, respectively) during the years of experimentation. Transplanting of five weeks old seedlings raised either in sand culture or on raised beds produced significantly higher grain yield (6.71 and 6.36 tonnes/ha, respectively) over other treatments. Root volume and leaf area index (LAI) at 90 days after transplanting (DAT) were also higher in seedlings raised under sand culture (1.03 and 72.2 cm<sup>3</sup>) and raised bed conditions (0.99 and 69.8 cm<sup>3</sup>) in nurseries. However, 5 week old seedlings grown either on sand culture or on raised bed resulted higher net income (₹ 23 074 and 22 334/ha respectively). It was also observed that transplanted crop matured 10-12 days earlier than direct seeded maize.

**Key words:** Age of seedling, Economics, Maize, Method of raising seedling, Productivity, Seedlings, Transplanting

Maize (*Zea mays* L.) is an important cereal crop which holds prominent position in the Indian agriculture after rice and wheat. It 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 2011). Ever growing cereals demand due to increasing population and the rising incomes with the consequent growth in meat and poultry consumption has necessitated for increasing area under maize cultivation. Maize is predominately a *kharif* crop but it is grown throughout the year in many parts of the country like Bihar, West Bengal, Asom and Sikkim. The productivity of *rabi* maize is highest of all. In Bihar *rabi* maize occupied 0.412 million hectare area with a production of 1.02 million tonnes during 2010-11. Its productivity in Bihar is 25.41 q/ha, which is far greater than the all-India average productivity of 19.07 q/ha (Singh *et al.* 2012).

Rice-wheat cropping system is a predominant cropping system in Bihar. Due to erratic behaviour of monsoon, farmers transplant and harvest rice late up to mid December

which leads to delayed sowing of wheat. The optimum sowing time for wheat is up to second fortnight of November. Due to delay in sowing of wheat, it faces terminal heat stress at the time of reproductive phase and switched to forced maturity resulting in shriveled grains and poor yield. So, farmers are switching over to *rabi* maize for getting a better yield and economy. Ideal sowing time of *rabi* maize also lies in last week of October to mid November in the Eastern region. Here again, sowing of maize gets delayed due to late harvesting of rice (last week of November to mid December). Late sowing delays germination and plant growth receives a major setback. Hence, grain yield reduces due to late planting as the crop experiences high temperature with the advancement of growth which reduces the duration for grain filling and dry matter accumulation resulting in small grain size (Biswas *et al.* 2009, Porwal and Jain 1999).

Reduction in grain yield of maize from 3.9 to 66.4% due to early and delayed plantings. The extent of reduction in yield due to delayed sowing however varies with the location. Also, in late sown crops, the occurrence of common rust and post flowering stalk rot is more prevalent as compared to timely sown crop. Reduction in the yield of maize can be compensated by transplantation technique. Badran (2001) stated that under late planting conditions, transplanting of maize may be a viable alternative to direct

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sowing. Sowing of maize is a traditional practice whereas transplantation of maize is a recent technique. A transplanted maize crop can be harvested in just 60-90 days during *kharif* and 110-130 days 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. Transplantation technique in maize helps farmers to harvest a third crop in areas where none would have been possible because of late harvest of *rabi* maize; as maize transplantation shortened the crop period (Basu *et al.* 2003). If maize seedlings are raised in nursery in the month of November and transplanted after harvesting of rice, the adverse effect of low temperature (delayed sowing) can be minimized. So, the development of an appropriate early plant establishment technique through proper agronomic management is essential for maize cultivation under such situations. Therefore, transplanting of seedling may be an important area of study for maize cultivation considering the field duration and early plant establishment in Bihar. Unfortunately, sizeable amount of works have not been reported on transplanted maize in India. Keeping all these facts in view the present field experiment had been carried out to evaluate the performance of transplanted maize under midlands and to standardize an optimum age of seedling and method of nursery (seedling) raising along with economics.

#### MATERIALS AND METHODS

Field experiments were conducted during *rabi* season of 2008-09, 2009-10 and 2010-11 at the Main Research Farm of ICAR Research Complex for Eastern Region, Patna situated between 25°37' N latitude and 85°12' E longitude. The soil of the experimental site was clay loam in texture, well drained, having pH 6.6, electrical conductivity 0.44 ds/m, organic carbon 0.59%, low in available N (186.0 kg/ha), medium in available P (14.0 kg/ha) and exchangeable K (211.0 kg/ha). In general, weather conditions were favourable for plant growth and no severe pest and diseases were noticed during entire period of experimentation.

The treatments comprised four age of seedling, viz. (i) 4 weeks old, (ii) 5 weeks old, (iii) 6 weeks old, (iv) 7 weeks old and four methods of nursery raising (i) nursery raised on flat beds, (ii) on raised beds, (iii) on sand culture (3: 1:: Sand: Soil) and (iv) on polythene sheets as dapog method in rice (plastic culture). The experiment was conducted in split plot design keeping age of seedlings in main plot and methods of nursery raising in sub plots with three replications. Maize variety Shaktiman 4 was sown in the nursery (starting from 1 November) and seedlings of different ages were transplanted in the main field on 20 December during all the years of experimentation. The experiment was conducted in the field which was kept vacant during the previous year and in *kharif* during current year to have uniform fertility and moisture gradients. In a strip of 5 m × 40 m, maize seeds of same variety were sown manually on 1 November in the same field so that

comparison between the performance of transplanted maize and direct sown maize could be done. Maize seeds were treated with Thiram@ 3 g/kg of seeds and sown evenly. Both crops were fertilized with recommended dose of fertilizer (120:60:40:: N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O kg/ha). Similar agronomic practices were followed for both direct sown as well as transplanted maize.

One-twentieth area of the main field was utilized for nursery purpose. Seeds were sown in nursery at a spacing of 5 cm × 5 cm. 500 g of N, 300 g of P and 200 g of K and two light irrigations were provided to the nursery crops. After attaining the age of 4, 5, 6 and 7 weeks, seedlings were uprooted manually in form of plug and transplanted to the main field on the same day. Seedlings were carefully uprooted after irrigating the nursery six hours prior of uprooting to reduce root injury. The uprooted seedlings were kept under shade before transplanting. A row to row and plant to plant spacing of 60 cm × 45 cm were maintained in the main field during transplantation. The crop was raised as per the recommended package of practices for direct sown maize crop. Half dose of N and full dose of P and K were applied at the time of transplantation in the main field and at the time of sowing in case of direct sown crop. To ensure optimum moisture in the main field, one light irrigation was given to the crop just after transplanting. All growth and yield parameters were recorded by adopting standard procedures. The yield was calculated on the basis of net plot yield. The data collected were statistically analyzed in split-plot design as per the analysis of variance technique described by Panse and Sukhatme (1985).

#### RESULTS AND DISCUSSION

##### *Seedling mortality and growth attributes in transplanted crop*

Plant density is one of the most important agronomic attributes of maize (Fanadzo *et al.* 2009). Thus, transplanting is a strategy that can be used to achieve optimum plant densities and to optimize yield. Seedling raised by different methods has significant effect on mortality percentage at 15 days after transplanting (Table 1). Least mortality was recorded in sand culture method (5.2%) which was at par with raised method (5.8%) of raising seedling. Mortality percentage in plastic culture (10.8%) was significantly higher over all other methods and was nearly double than sand culture method of seedling raising. This may be due to the fact that seedlings grown on plastic did not get sufficient nutrients and moisture throughout the seedling growth period and produced weaker seedlings whereas, raising seedlings grown on soil substrate resulted in healthy seedlings. Fine tilth and better aeration in sand culture and raised bed might have caused lesser root penetration impedance and provided favourable condition for seedling growth and development. As a result it produced healthy seedlings which enabled these seedlings to bear more strength at the time of transplanting, i.e. these seedlings recovered sooner from transplantation shock and thus reduced the mortality

percentage. This confirms the findings of Basu *et al.* (2003). Transplanting of 7 weeks old maize seedlings showed significantly higher mortality percentage than 4, 5 and 6 weeks old seedlings (Table 1). Khera *et al.* (1990) also reported higher mortality in transplantation of 60-80 days old seedlings than 40 days old seedlings.

Growth parameters, i.e. plant height, leaf length and dry matter accumulation differed significantly due to different methods of seedling raising and age of seedling (Table 1). Seedlings which were grown on raised bed and sand culture attained more plant height (128.1 cm and 125.4 cm respectively) than those of flat bed and plastic culture at 30, 60 and 90 days after transplanting (DAT). Transplantation of 7 weeks old seedlings attained maximum plant height at 30 and 60 days after transplanting but 90 DAT the plant height of 5 weeks old transplanted seedlings was recorded maximum. The reason behind this may be that 7 weeks old seedlings approached towards senescence earlier than that of 6, 5 and 4 week older seedlings and resulted in lesser vegetative growth. These findings are in accordance to the results reported by Andreas and Ransom (2002) in winter transplanted maize.

Seedlings raised through sand culture and raised bed method produced plants with longer leaves and accumulated more dry matter per plant than rest of the methods at 30, 60 and 90 days after transplanting. Plants followed similar trend in accumulating dry matter even at maturity and produced 33.2% and 5.7% more dry matter over plastic cultured and flat bed transplanted seedlings, respectively as seedlings raised under sand culture and flat bed methods were healthier than seedlings raised by other methods and enabled these seedlings to show better growth performance than flat bed and plastic cultured seedlings (Table 1). Similarly, transplanting of 7 weeks old seedlings produced significantly longer leaves and higher dry matter accumulation per plant up to 90 days after transplanting

over lesser old seedlings but at maturity the plants transplanted with 5 weeks old seedlings produced 21.3, 28.7 and 61.1% more dry matter per plant over 4 week, 6 week and 7 week old seedlings. Dhillon *et al.* (1990) also reported greater dry matter accumulation in transplanted maize with 5 to 6 weeks old maize nurseries.

Leaf area index (LAI) and root volume at 90 days after transplanting were significantly higher due to methods of raising seedling and seedling age (Fig 1). Plants raised through sand culture method showed higher leaf area index and root volume at 90 days after transplanting over plastic cultured and flat bed method. Sepat *et al.* (2010) also reported positive correlation between root volume and leaf area index. Dense roots absorb more nutrients and water from the soil and translocates it into different plant parts due to which more photosynthates were produced and resulted in higher plant vigour. In case of varying seedling age, transplanting done with 5 weeks old seedlings showed higher leaf area index and root volume over plants transplanted with seedlings of different age group. Plants transplanted with lesser aged seedlings resulted in more LAI and root volume which contributed towards increased source-sink relationship within the plants with delayed maturity and resulted in more dry matter accumulation. Enhanced root volume and leaf area index was also reported by Kumar *et al.* (2012) and Town Phung (2004) under light soils at 60-90 days after transplanting.

#### *Yield attributes and yield*

Significant differences were observed in yield attributes 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 (Table 2). The enhanced vegetative growth in terms of leaf area index, dry matter

Table 1 Mortality percentage, plant height, leaf length and dry matter accumulation as affected by seedling age and method of raising seedlings (pooled data of three years, 2008-11)

Treatment	Mortality (%)	Plant height (cm)			Leaf length (cm)			Dry matter accumulation (g)			
		15 DAT	30	60	90	30	60	90	30	60	90
<i>Methods of raising seedling</i>											
Flat bed	6.9	52.6	98.7	121.2	49.1	51.6	53.8	25.2	70.2	160.2	390.2
Raised bed	5.8	60.1	113.6	128.1	55.8	58.7	62.2	32.4	76.3	180.3	412.2
Sand culture	5.2	58.6	104.8	125.4	58.2	60.2	63.6	33.1	75.2	182.2	412.6
Plastic culture	10.8	42.1	78.5	104.2	42.4	48.5	49.5	20.1	40.2	138.6	309.8
SEm.±	0.46	1.52	4.28	1.58	1.34	0.82	1.2	1.92	1.52	4.78	5.81
CD (P= 0.05)	1.58	5.24	14.8	5.18	4.62	2.82	4.14	6.62	5.24	16.5	20.04
<i>Seedling age</i>											
4 weeks	6.3	44.7	80.3	106.8	46.2	48.2	54.2	14.6	52.6	120.3	391.2
5 weeks	5.8	53.3	94.5	135.8	51.2	56.6	58.2	18.8	63.8	190.2	474.5
6 weeks	6.9	49.2	106.6	109.8	53.6	55.2	56.5	26.7	65.2	145.4	368.6
7 weeks	9.1	66.2	114.2	126.5	54.5	59.0	60.2	50.8	80.3	205.4	294.5
SEm.±	0.79	1.49	3.28	5.56	0.62	0.42	0.72	3.20	4.12	6.74	11.2
CD (P= 0.05)	2.30	4.35	9.57	16.22	1.80	1.22	2.10	9.34	12.02	19.6	32.6

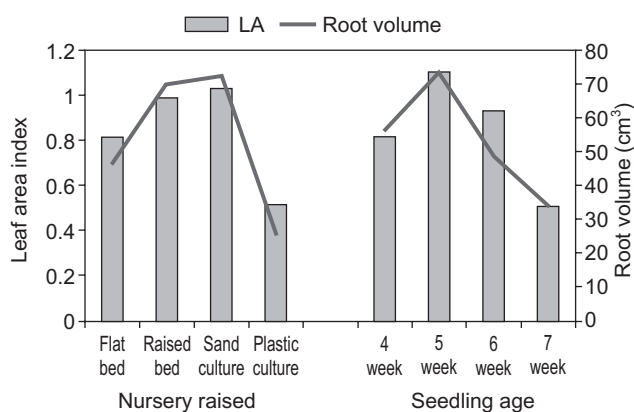


Fig 1 Leaf area index and root volume as affected by nursery raising methods and varying seedling age

accumulation and root volume resulted in more grains per cob and 100 grain weight which in turn increased the grain yield. In case of 100-grain weight, significant higher grain weight was recorded for plants raised with sand cultured seedling and was found again at par with plants transplanted with raised bed seedlings over all other methods. Higher values for yield attributes of sand cultured and raised bed method grown plants ascribed to higher LAI, dry matter production as well as translocation and conversion of photosynthesis into reproductive parts due to more root volume. Dhillon *et al.* (1990) also found more grains/cob and heavier grains in raised seedbed than flat seed bed.

Grain yield and stover yield were significantly affected by method of seedling raising and age of seedling at the time of transplanting (Table 2). The grain yield obtained through sand cultured plants was 61% and 10.2% higher than that of plastic cultured and flat bed, respectively but was at par with that of raised bed. Grain yield of plastic culture method of nursery raising was found significantly inferior than all other methods of raising seedlings. 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. This might be due to abrupt switch off from growth phase to reproductive phase and more reduction in crop duration as compared to others. 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 (Table 2). Dale and Drennan (1997b) also reported greater dry matter accumulation and harvest index in maize transplanted with 5 to 6 weeks old maize nurseries.

#### Days to 50% flowering and maturity

Days to 50% flowering and maturity differed significantly due to different methods of nursery raising and varying age of seedlings (Table 2). Plants raised with plastic cultured seedling took least number of days (50 days) to attain 50% flowering but completed its reproductive phase in maximum number of days thus having longer crop duration than maize plants of other methods of nursery raising. However, plants grown with plastic cultured seedlings could not perform better instead of getting longer reproductive periods over other treatments due to weaker seedlings and poor plant growth. Plants grown with sand culture and raised bed seedlings attained 50% flowering 8-10 days later but matured 10-12 days earlier than plastic culture raised seedling. Higher root volume at 90 days after transplanting from sand culture and raised bed methods of seedling raising might be one of the responsible factor in

Table 2 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/ cob	100-grain wt (g)	Grain yield (tonnes/ha)	Grain: stover	Days to 50% flowering	Maturity days	Gross income (₹)	Net return (₹)	B: C ratio
<i>Methods of raising seedling</i>									
Flat bed	237.2	32.5	4.7	0.58	56.0	124	42 480	19 654	1.86
Raised bed	292.5	34.6	5.1	0.62	58.2	126	45 810	22 334	1.95
Sand culture	286.5	35.0	5.2	0.62	59.8	129	46 800	23 074	1.97
Plastic culture	190.4	30.2	3.2	0.53	50.3	137	29 070	7 370	1.34
SEm	8.9	0.21	0.10	0.01	0.51	3.46	802	817	0.08
CD (P= 0.05)	30.7	0.72	0.34	0.03	1.75	11.9	2 762	2 819	0.28
<i>Seedling age</i>									
4 weeks	283.3	34.2	4.8	0.62	66.1	148	43 650	20 591	1.9
5 weeks	328.6	35.2	5.7	0.64	61.0	132	51 750	28 691	2.1
6 weeks	258.2	33.3	4.6	0.61	56.0	126	41 400	18 341	1.8
7 weeks	136.5	29.6	3.1	0.48	41.2	110	27 810	4 258	1.26
SEm	14.60	0.33	2.7	0.06	0.81	3.8	2 005	2 102	0.03
CD (P= 0.05)	42.61	0.9	0.8	0.17	2.36	11.1	5 852	6 136	0.08

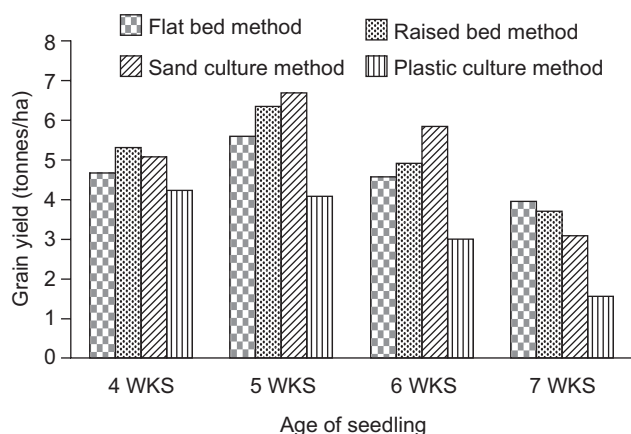


Fig 2 Grain yield (tonnes/ha) as influenced by interaction between nursery raising method and age of seedlings

producing taller plants with longer leaves and higher yield attributes over other methods of seedling raising. Direct seeded maize took 162 days to mature and produced 5.8 tonnes/ha grain yield. Biswas *et al.* (2009) also reported that the crops of different seedling raising methods availed more grain filling duration compared to direct planting.

Transplanting four weeks old seedlings took maximum number of days to mature followed by that of five weeks. Seedlings transplanted at 7 weeks age took 41 days to attain 50% flowering, i.e. 25, 20 and 15 days earlier than that of 4, 5 and 6 weeks old seedlings, respectively. Likewise 7 weeks aged transplantation attained maturity 38, 22, and 16 days earlier than 4, 5 and 6 weeks seedling age. Due to reduction in total crop period, crop could not get sufficient time to complete its vegetative as well as reproductive phase and forced maturity was reported. Consequently yield attributes were adversely affected and ultimately produced lesser crop yield over 4, 5 and 6 week transplanted maize. The results confirm the findings of Andreas and Ransom (2002) on winter transplanted maize.

#### Interaction effect

Grain yield of transplanted maize was significantly influenced by interaction between methods of nursery raising and age of seedlings (Fig 2). Significantly higher grain yield (6.71 tonnes/ha) was obtained by transplanting 5 weeks old seedlings which were raised in sand culture but at par with transplantation of 5 weeks old seedlings of raised bed nursery. This may be due to the fact that nursery raised in sand culture or raised bed might have got lesser root damage while uprooting and proper aeration and favourable condition for its growth which in turn converted into healthy crop and finally better yield over all other treatments. Dhillon *et al.* (1990) also reported similar findings from their experiments on transplanted maize.

#### Economics

The gross income, net return and B:C ratio significantly differed among different methods of nursery raising and seedling age (Table 2). The gross income, net return and

B:C ratio were maximum from sand cultured seedlings and were found at par with those of raised bed method. Seedlings raised on sand culture fetched 10% and 61% more net return over seedlings raised with flat bed and plastic culture method, respectively. The extra labour consumed during transplantation of seedlings were compensated over direct sown maize as seedlings were transplanted on ridges and no earthing up and weeding operations were required. Transplanting 5 weeks old seedling resulted in significantly higher net returns and B:C ratio over 4, 6 and 7 weeks old seedlings. This might be due to higher productivity from plants which were transplanted with 5 weeks older seedlings.

On the basis of plant growth, development, productivity and economics of three years pooled data (2008-11), it may be emphasized that five weeks old seedlings perform better if raised either through sand culture or raised bed up to last week of November with equal level of yield as that of direct sown maize. The findings advocates that transplanted maize can be grown successfully even after late harvest of rice without any yield loss. However, there is need for further researchable issues, viz. date of transplanting, fertilizer, irrigation optimization, intercropping etc. in transplanted maize.

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