Review Article

Sowing Dates and Maturity Classes' Cultivar Exaggerating the Direct Seeded Rice: A Review

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Abstract

To solve the problem of labour shortage and high production cost, cultivation of direct seeded rice in many parts of India has been increased. In Haryana, rice cultivation is mainly practiced through transplanting which is a cumbersome and labour intensive. Extension in the irrigated area, the introduction of early maturing rice cultivars, availability of selective herbicides for weed management together with increasing transplanting cost and declining profitability of transplanted rice production system have encouraged rice farmers to shift from transplanting to direct seeding [1]. One of the critical aspects of direct seeding of rice is a time of sowing. Lower production of direct seeded rice occurs when a crop is sown very early or delayed. Optimum sowing time thus needs to be standardized for every agro-ecological situation for the success of direct seeded rice. Rice cultivars differ in their seedling vigour, weed competitiveness, submergence and drought tolerance, maturity duration, lodging resistance, affecting the resource utilization and productivity.

Keywords: Direct seeded rice, optimum planting time, maturity classes' cultivar

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Introduction

Rice occupies a pivotal place in Indian agriculture and is the staple food for more than 70% of the population. In India, it is grown on an area of 42.41 mha with the total production of 104.40 mt, with the productivity of 2462 kg/ha [2]. The major contribution in the national food basket (10.5 mha) comes from the rice-wheat system [3]. The rice-wheat system contributes about 65% of food grain production [4]. In Haryana, rice was grown over an area of 1.21 mha with the total production of 3.97 mt and the productivity of 3272 kg/ha [5].Therefore, there is sufficient scope for direct seeding of rice in the state. Farmers in north-western India have been adopting direct-seeded rice (DSR) for benefits associated with reduced labour costs as well as savings in water and energy use [6].

In most of South Asia, puddling following by manual transplanting is the common practice for establishing rice in the rice-wheat system. Although puddling helps in reducing water losses through percolation and controlling weeds by submergence of rice field, but besides being costly, cumbersome and time-consuming. It results in degradation of soil and other natural resources and subsequently poses difficulties in seedbed preparation for succeeding wheat crop in the rotation. Impediment in root growth of succeeding wheat due to the formation of a hard pan in rice during pudding [7], labour scarcity and drudgery among women workers [8] are some of the other disadvantages associated with puddle transplant rice. Under such situations, involvement in the form of direct seeding of rice or mechanized transplanting is the only need of a time to avoid puddling or manual transplanting or both [9]. Direct seedling of basmati rice has already been recommended in Punjab during 2010 and also in Haryana in 2012 [3], [10], [11].

Planting rice in the optimum period of time is critical to achieving high grain yield. However, optimum rice planting dates vary with regional, location and genotypes [12].Rice plants require a particular temperature for its phenological affairs such as panicle initiation, flowering, panicle exertions from flag leaf sheath and maturity. Rice needed before the window of optimum dates usually has slow germination and emergence, poor crop stand establishment, increased soil borne, seedling diseases damage under cold conditions, and seeds lose by birds or mice. Seedling at the optimum time is an important factor of transplanting for uniform stand establishment of rice. On the other hand, seedling sown with the delay of sowing more than optimum produces fewer tillers due to the reduction of the vegetative period and hence results in poor yield. Among the crop production tools, optimum time and method of sowing are the important agronomic tools that allow the crop to complete its growth timely and successfully under specific agro-ecology zone [13], [12]. [14] concluded that early date of sowing results in the maximum tillers, a number of tillers per m-2, plant height, 1000 grain weight and grain yield. The number of kernel per panicle show, a better response with early sowing because of late sowing, growth period is very short for the plant and therefore the reduction in the leaf area, the length of panicle and number of kernels per panicle has been there. [15] and [12] reported that with the delay in planting time a thousand grain weight decreased gradually. Grain yield was significantly influenced by sowing time. Therefore, to evaluate the impact of different sowing dates and cultivars of direct-seeded rice on crop phenology, productivity, and profitability, these practices should also be tested.

Effect of Sowing Dates

Growth parameters

Physiological phenomenon of plant life is the growth and development. The rate and amount of growth have a substantial influence on the ultimate yield of crop. Dry matter accumulation is one of the most important parameters for growth, which is cumulative product of plant height, tillers and leaf area index.

Reddy and Reddy (1992) [16] found that productive tillers per m^2 and productive tillers per hill were significantly more when the crop was transplanted on 29 August than 14 August and 30 July.

Reddy and Reddy (1994) [17] reported that maximum dry matter accumulation per m^2 and per hill was recorded when planting was done on 29 August which was significantly higher than that of the crop transplanted on 30 July and 14 August.

Dhiman *et al.* (1995) [18] observed that higher plant height and dry matter accumulation per plant in an earlier planting of 15 July than delayed planting on 25 July and 5 August.

Parihar (1995) [19] conducted a field experiment at Bilaspur revealed that higher plant height 84.6 cm and 83.75 cm in 1991 and 1992, respectively and significantly highest number of effective tillers of 15 July planting as compared to both early planting of 30 June and late planting of 30 July.

Samdhia (1996) [20] found from an experiment conducted at Bhubaneshwar taking rice hybrid PA 6201 and *cv.* Lalit that LAI declined gradually as the planting was delayed beyond 15 July and maximum LAI of 4.64 was recorded at 60 DAP.

Singh *et al.* (1996) [21] reported that total tillers per plant of the crop transplanted on 25 June followed by 5 July, 15 July and 25 July.

Singh *et al.* (1997) [22] conducted a field experiment at Kanpur found that plant height, total tillers and dry matter accumulation of the crop transplanted on 5 July was more than that of 20 July and 4 August.

Pandey *et al.* (2001) [23] noted that PA6201 gave significantly higher productive tillers per hill and dry matter accumulation per plant of the crop transplanted on 20 July and 4 August than that of the crop transplanted on 20 August.

Nayak *et al.* (2003) [24] conducted the field experiment on hybrid rice cultivar PA 6201, reported that early planting of 16 July exhibited the maximum total and effective tillers per clump, LAI and biomass accumulation than that sowing on 31 July and 16 August. One month delay in planting from 16 July reduced total tillers number, LAI and dry matter accumulation by 38, 13 and 18 percent, respectively.

Dixit *et al.* (2004) [25] observed that rice crop planting on 25 June showed significantly high number of leaves at 60 DAS than that crop planting on 5, 10 and 15 June.

Yield and yield attributes

Gangwar and Ahamedi (1990) [26] recommended planting of rice within June or latest by the first week of July when yield attributes and grain yield increased and delay in planting after the first week of July decreased drastically the number of grains per panicle, 1000 grain weight, and grain yield.

An experiment conducted at DRR, Hyderabad on traditional scented rice varieties in different dates of planting showed that time of planting significantly influenced the grain yield, 2 July planting produced significantly higher grain yield of 3.30 t/ha. The reduction in grain yield of 16.0, 22.2 and 34.5 per cent was recorded under 16 July, 31 July and 5 August planting as compared to the yield levels reported under 2 July planting (AICRP, 1991) [27].

Bali and Uppal (1995) [28] conducted a field experiment with a cultivar of basmati rice, reported earlier transplanting on 10 July gave higher grain yield of 5 and 8.6 percent in 1990 and 1991, respectively as compared to 30 July transplanting. This results of experiments conducted at DRR, Hyderabad during *Kharif* 1995 indicated that planting on 25 July registered significantly higher grain yield (5510 kg/ha) than the crop sown on 5 August and 15 August (DRR, 1995a) [29]. A similar study conducted at Pantnagar showed higher grain yield (6230 kg/ha) of rice hybrids (DRRH 1, ARHR 2, PA 103 and CRH1) with 15 July planting.

Paliwal *et al.* (1996) [30] in his field experiment at Waraseoni (M.P.) found that significant reduction in panicle length and grain yield due to delay in transplanting beyond 25 July.

Singh *et al.* (1997) [23] observed that rice planted on 15 June gave 20.5% higher grain yield than planted on 29 June (27.37 q/ha) owing to 17.8 % more productive tillers per m^2, 20% filled grain per panicle and 29 % grain weight per panicle.

Kumar *et al.* (1998) [31] from a 2-year field study with rice hybrids' PA 103, APHR 2, DRRH1 reported a significantly higher grain yield (5.1 t/ha) due to early planting on 25 July as compared to planting on 5 and 15 August during both the experimental years of study.

Nayak *et al.* (2003) [24] conducted a field experiment at Bhubaneshwar during wet season of 1999 and 2000 to find out the response of hybrid rice cultivar PA 6201 to dates of planting (16, 31 July and 16 August) and reported that a fortnight delay in planting from 16 July reduced the grain yield by 7.6 and 4.5% during first year and second year, respectively. One month delay in planting from 16 July reduced the grain yield by 24.3%. The result confirms the findings of Gohain and Saikia (1996) [32] and Kumar *et al.* (1998) [31].

Singh *et al.* (2004) [4] carried out a field experiment on hybrid rice PRH 10 at New Delhi and reported that significant reduction in yield and yield attributes was observed with the delay on transplanting, timely transplanting on 3 July led to 8.4 and 19.1% higher grain yield than transplanting on 10 and 17 July, respectively.

Verma *et al.* (2004) [33] studied the response of hybrid rice cultivar named under Pa 6201 to date of planting and found that early planting on 20 July showed significantly higher grain yield than late planting on 5 and 20 August.

Dongarwar *et al.* (2005) [34] reported that early transplanting on 15 July and 30 July resulted in significantly higher grain yield 31.29 and 32.61 q/ha, respectively than late transplanting on 15 August (28.40 q/ha).

Sreenivas *et al.* (2004) [35] reported the effect of different sowing dates (16 and 26 June, 7 and 18 July) and cultivars (Varaalu, Erramallelu, Jagtiala Sannalu and Polasa Prabha) on grain yield of aerobic rice. Significantly higher grain yield was observed for the crop sown on 16 June than 18 July in 2003 and 7 July in 2004.

Vange and Obi (2006) [13] reported the effect of sowing dates significantly on grain yield and some agronomic characters by early seeding (June 15 and June 30) and late seeding (15 June and 30 June) and late seeding (15 and 30 July).

Gill *et al.* (2009) [36] reported that significantly higher yield (38.5 q/ha) was recorded with all the basmati cultivars when transplanted on 20 July, as there was a linear decrease in yield when transplanting was delayed up to 5 August (22.9 q/ha) irrespective of cultivars. Whereas, all basmati rice cultivars differed significantly in their yield attributes and yield as Pusa Basmati-1 gave grain yield followed by Super Basmati, Basmati- 370 and Basmati-386.The findings thus showed that timely planting (around 20 July) of short stature basmati rice cultivars gave better yields on loamy soils of Punjab.

Hussain *et al.* (2009) [37] discovered that with the delay in the transplanting after the last week of May resulted in significant reduction of grain yield of Basmati rice. The magnitude of reduction of grain yield observed with the week delay in planting beyond 25 May observed was 5.2, 9.9 and 12.3 q/ha respectively. The corresponding figures for 2007 were 4.7, 9.9 and 21.9 q/ha respectively. Earlier planting dates of 25 May and 2 June produced higher straw yield and higher harvest index than the delayed planting of 9 and 16 June.

Nawlakhe *et al.* (2009) [38] studied to decide the optimum time of transplanting for three basmati types of rice *viz.*, Pusa Basmati, Kasturi and Haryana Basmati. The rice crop transplanted on 15 July gave the highest grain yield (3043 kg/ha) and was significantly more than that given by the crop transplanted on 30 July and 15 August. In interaction Pusa Basmati planted on 15 July gave significantly higher yield and was on par with other two varieties planted on same date.

Osman *et al.* (2015) [39] the highest range of a number of tillers/plant (from 4.3 to 4.8.) were exhibited for the planting dates 1st July, 15th July, 1st August, 15th August, 1st and September 1st. On the other side, the lowest range of a number of tillers/plant (from 3.0 to 3.7) were exhibited for planting dates 1 October, 1 November, 15 November, 1 December and 15 December.

Crop Phenology

Khalifa (2009) [12] reported that early sowing is the best time of sowing which resulted in maximum tillering, panicle initiation, heading date, number of tillers per m^2, plant height and root length at panicle initiation and heading stage, chlorophyll content, number of days to panicle initiation and heading date, leaf area index, sink capacity, spikelet's/leaf area ratio, number of grains per panicle, panicle length (cm), 1000-grain weight (g), number of panicles per m^2,grain yield (t/ha).

Osman *et al.* (2015) [39] found in the experiment that for days to flowering, the earliest flowering (67.8 days) and the latest (81.7 days) were obtained from the sowing dates 15th July and 1st December, respectively. Generally, it seems that early flowering dates up to September 15th produce early flowering days and maturity. Whereas, late sowing dates produce late flowering and maturity. These results replicate the effect of temperature from high to low on delaying flowering and maturity in rice, therefore this character can be considered as an indicator for the heat stress (effect) in rice flowering and maturity. Similar results were also reported by Bashier *et al*. (2010) [12] in his experiment that the plant height was affected significantly by the different sowing dates and decreased significantly when sowing days were delayed. It is obvious from the study that grain yield (t.ha-1) was affected significantly by different sowing dates. The grain yield (t.ha-1) decreased when the sowing date delayed after 1st August.

Profitability

Singh *et al.* (1997) [22] reported that planted on 5 July gave higher net profit (15,157.34 Rs/ha) than the crop planted on 20 July (13,639.75 Rs/ha) and 4 August (10,305.48 Rs/ha). However, return per rupee was decreased from 2.17 to 1.80 with a subsequent delay in planting time from 5 July to 4 August.

Osman *et al.* (2015) [39] maximum net income of SDG 4910 was recorded for when rice was sown on 1st July and minimum net income of SDG 2071 was observed when rice was sown on 15th September. However, a loss of SDG 113 was observed when the rice was sown on 15th December. This showed that the net benefit gradually decreased as sowing was done after 1st September and later on.

Effect of Different Maturity Classes Variety

The exact sowing date for direct seeding of rice plays a vital role in improving the growth yield and other parameters including water productivity. Further, the most important factor left beside optimum sowing date is cultivar whereas our most of the cultivar are developed for puddle transplanted conditions. In the absence of the strong rice improvement program, we need to work over the best varieties we can adopt for direct-seeded or aerobic rice. So, here are some reviews on different varieties worked by various researchers across the globe and enlisted below a few:

Growth parameters

Om *et al.* (1997) [40] at Kaul in *Kharif* season 1993 and 1994 with hybrids'ORI 16 (PHB 71), 'PMS 2A/IR 31802' and PMS 10 A/PR 106' revealed that panicle weight and grain yield were recorded on 25 June transplanting. They were reported that 10, 3 and 43%, and 11, 5 and 78 % increased in grain yield with 25 June transplanting over 15 June, 5 July and 25 July in 1993 and 1994, respectively.

Kumar *et al.* (1998) [31] from a 2-year field study with rice hybrids' PA 103, APHR 2, DRRH1 reported significantly higher grain yield (5.1 t/ha) due to early planting on 25 July than the delayed planting on 5 August and 15 August during both the year of experimental study.

Sreenivas *et al.* (2004) [35] indicated the effect of different sowing dates such as 16 and 26 June, 7 and 18 July and cultivars such as Varaalu, Erramallelu, Jagtiala Sannalu and Polasa Prabha on grain yield of aerobic rice. Significantly higher grain yield was observed when crop sown on 16 June than 18 July in 2003 and 7 July in 2004. Higher water productivity was observed when crop was sown on 26 June during both years. Among the cultivars, highest grain yield and water productivity were obtained with short duration cv. Erramallelu.

Singh *et al.* (2005) [41] examined in his experiment that the performance of six different maturing rice cultivars *viz.* HKR 126, HKR 46, Govind, HKR 95-222, HKR 47 UP and 1230-9-2 under three sowing dates of transplanting. A significant interaction between the transplanting time and cultivars revealed that cv.HKR-126 could be grown both under early transplanting of 15 June and mid transplanting of 5 July whereas under late transplanting of 25 July, the short duration were also as good as the medium duration ones.

Arumugam *et al.* (2007 [42]) study also indicated that sowing of long duration cultivars could be extended up to 1st fortnight and that of medium duration varieties up to 2nd fortnight of July instead of June 2nd fortnight and July 1st fortnight, respectively without significant reduction in grain yield.

Gill *et al.* (2009) [36] reported that all basmati cultivars gave significantly higher yield (38.5 q/ha) when transplanted on 20 July, as there was linear decrease in yield when transplanting was delayed up to 5 August (22.9 q/ha) irrespective of cultivars. Whereas, all the basmati rice cultivars differed significantly in their yield attributes and yield as Pusa Basmati -1 gave grain yield followed by Super Basmati, Basmati- 370 and Basmati-386.

Saad *et al.* (2014) [43] at Egypt during the experiment of two successive summer seasons of 2012 and 2013 to study the effect of planting methods (Transplanting and drill) and sowing dates of April 15,May 1 and May 15 on growth, yield and its attributing characters of GZ 7112,GZ 9057 and Sakha 105 rice varieties under D.U.S. experiments and the results showed that, GZ 7112 sown on April 15 using transplanting method significantly produced higher number of tillers/m^2, panicle weight (g), number of grains/panicle. Late sowing (25 June) resulted in the lowest dry matter. Delayed sowing also resulted in higher yield compared to early sowing. There is no significant difference in yield performance between the cultivars.

Yield attributes and yield

Sreenivas *et al.* (2004) [36] reported the effect of different sowing dates (16 and 26 June, 7 and 18 July) and cultivars (Varaalu, Erramallelu, Jagtiala Sannalu and Polasa Prabha) on grain yield of aerobic rice. Significantly higher grain yield was produced where crop was sown on 16 June than 18 July in 2003 and 7 July in 2004. Higher water productivity was observed when crop was sown on 26 June during both years. Among the cultivars, highest grain yield and water productivity were obtained with short duration cv. Erramallelu.

Singh *et al.* (2005) [41] studied the performance of six different duration rice cultivars such as HKR 126, HKR 46, Govind, HKR 95-222, HKR 47 UP and 1230-9-2 under three dates of transplanting. The highest grain yield (73.2 q/ha) was obtained with the transplanting of rice on 15 June, followed by 5 and 25 July. The reductions in yield due to each succeeding delay in the planting were showed significant during both the years.

Arumugam *et al.* (2007) [42] study also indicated that sowing of long duration varieties could be extended up to a 1st fortnight and that of medium duration varieties up to a 2nd fortnight of July instead of June a 2nd fortnight and July a 1st fortnight, respectively without significant reduction in grain yield.

Gill *et al.* (2009) [36] reported that all basmati cultivars gave significantly higher yield (38.5 q/ha) when transplanted on 20 July, as there was a linear decrease in yield when transplanting was delayed up to 5 August (22.9 q/ha) irrespective of cultivars. Whereas, all basmati rice cultivars differed significantly in their yield attributes and yield as Pusa Basmati-1 gave grain yield followed by Super Basmati, Basmati- 370 and Basmati-386.The findings thus showed that timely planting (around 20 July) of short stature basmati rice cultivars gave better yields.

Crop Phenology

Ashrafuzzaman *et al.* (2009) [44] observed that a number of days required to 50% flowering differed significantly among the varieties.Kalizira required (86.67 days) a maximum number of days required to 50% flowering while lowest days Chinia top (81.33 days), which is statistically indifferent from Kataribhog (82.33 days).

Singh *et al.* (2012) [45] studied to know the response of prevailing environments and their interaction with photosensitive genotypes (mahsoori) and photo-insensitive (Ashwani and Pant-4). This study proved that the first year was more favorable for growth and development. The crop produced highest dry matter and grain yield probably due to the congenial environment conditions during reproductive phase. During first year maximum thermal temperature requirements were recorded in 1000-grain weight was not affected significantly by environment however it was recorded during first dates of planting (105.2 and 98.5 q/ha) and genotype mahsoori (106.4 and 97.9 q/ha)

Profitability

Dawadi et.al. (2013) [46] concluded from his research that when crop sown on 13th June showed higher gross return, net return and B:C ratio. Among varieties, Haridnath-1 revealed comparatively higher gross return, net return and benefit cost ratio and at the same time combination of late sown crop 13th July and variety Sabitri observed lower value of economic parameters.

Conclusion

Review of the results presented in therefore, going sections reveal that the effect of different sowing dates and maturity classes' cultivar showed significant results. Some of the workers showed the advantage of the direct seeded rice with short duration crop. When a crop is sown early it results in the better establishment and there is optimum time left to sow the next crop. Early sowing along with early maturing cultivar showed the maximum establishment of the crop along with yield and its other related parameters.

Future Line of Research

A suitable direct seeded plant type could include traits such as early vigour, optimal grain filling and high HI. Both agronomic management and a suitable variety with appropriate traits are needed to achieve maximum potential under DSR. The optimum sowing time and a number of cultivars should be investigated under different approaches to improving paddy yield and other related parameters for DSR.

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