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# Response of different date of transplanting, spacing and number of seedlings on growth and yield of hybrid rice

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## Abstract
An experiment was conducted at Crop Research Farm, Department of Agronomy, Maya College of Agriculture and Technology, Selaqui, Dehradun (Uttrakhand) during *kharif* of 2016. The experiment comprised of eighteen treatment combinations *i.e.* three date of transplanting (15 July, 27 July and 09 August), two seedlings rate (1 seedling hill$^{-1}$ and 2 seedling hill$^{-1}$) with three spacing (20 x 10 cm, 20 x 15 cm and 20 x 20 cm). The experiment was laid out in randomized block design and replicated three times. Rice 'Arize 6444 variety' used as test crop. The treatment $T_6$ (15 July + 20 cm x 20 cm + 2 seedlings hill$^{-1}$) were found most effective on plant height, dry matter relative growth rate and grain yield of rice over all the other treatments. However, treatment $T_2$ (15 July + 20 cm x 10 cm + 2 seedlings hill$^{-1}$) gave the maximum crop growth rate at 60-90 DAT and 90 DAT-at harvest.

**Keywords:** Date of transplanting, growth, hybrid rice, spacing and yield

## 1. Introduction
Rice belongs to the genus *Oryza*, family Poaceae (Gramineae), tribe: Oryzeae. The genus *Oryza* is distributed throughout the tropics and subtropics of the world. It has 25 species out of which 23 species are wild and only two species *viz. Oryza sativa* and *Oryza glaberrima* are cultivated species. *Oryza sativa* is mainly cultivated in the Asiatic region where as *O. glaberrima* in Africa. The primary centre of origin of the cultivated rice according to archaeological and historical evidence is South-East Asia for *O. sativa* and Africa for *O. glaberrima*. Rice (*Oryza sativa*) is the major food crop in the world. Nearly 40% of the world population consumes rice as the major staple food and 90% of the rice is grown and consumed in Asia. There are 42 rice producing countries throughout the world but China and India are major rice production centers. The rice crop occupies largest area in India followed by China and Indonesia, whereas China has the highest production. It is one of the most important staple food crops of India in terms of area, production and consumer preference. Rice is grown on about 164.19 million ha around the world, with annual productivity and production 3105 kgha$^{-1}$, 509.87 million tones, respectively. In India, Rice is grown on about 45 million ha with annual production and productivity is 118.87 million tonnes and 2641.5 kg ha$^{-1}$, respectively. The major rice producing state in India is West Bengal, Bihar, Maharashtra, Uttar Pradesh, Panjab, Haryana *etc.* (FAO STAT 2020) [3].
Rice is an excellent food and is a good source of carbohydrates and energy. On the basis of mean grain yield, rice crops produce more food energy and protein supply per hectare than wheat and maize. Hence, it can support more people per unit of land (Lu and Chang, 1980) [12]. Rice is unquestionably a superior source of energy among the cereals. The protein quality of rice (66%) ranks only below that of oats (68%) and surpasses that of whole wheat (53%) and of corn (49%). Rice, which is low in sodium and fat and is free of cholesterol, serves as an aid in preventing hypertension. It is also free from allergens and now widely used in baby foods (James and McCaskill, 1983) [8]. Because rice flour is nearly pure starch and free from allergens, it is the main component of face powders and infant formulas. Its low fibre content has led to an increased use of rice powder in polishing camera lenses and expensive jeweller. Rice starch can also serve as a substitute for glucose in oral rehydration solution for infants suffering from diarrhoea. The coarse and silica-rich rice hull is finding new use in construction materials. Rice straw is used less in rope and paper making industries than before, but except for modern varieties, it still serves as an important cattle feed throughout Asia.

In industrial usage, rice is also gaining importance in the making of infant foods, snack foods, breakfast cereals, beer, fermented products, and rice bran oil, and rice wine remains a major alcoholic beverage in East Asia (Juliano, 1985) [9].

Rice is normally sown at the end of May and transplanted during the 1st week of July. Transplanting is a traditional method which gives high and stable yield but at the same time it is a laborious and expensive job. Now-a-days farmers are switching towards some other methods like direct seeding of rice to minimize these expenses and difficulties (Mehmood *et al*., 2002) [16]. The exact sowing date for direct seeding of rice also play a vital role in improving its growth and increasing the yield. The sowing time of the rice crop is important for three major reasons. Firstly, it ensures that vegetative growth occurs during a period of satisfactory temperatures and high levels of solar radiation. Secondly, the optimum sowing time for each cultivar ensures the cold sensitive stage occurs when the minimum night temperatures are historically the warmest. Thirdly, sowing on time guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved (Farrell *et al*., 2003) [4]. Sowing date also has a direct impact on the rate of establishment of rice seedling (Tashiro *et al*., 1999) [25].

Beside nutritional factor, transplanting date is an important factor which affects tremendously the grain yield of transplanted rice. Late planting exposes the reproductive phase as well as phenological events of the crop to an unfavorable temperature regime, thereby causing high spikelet sterility and poor plant growth. However, optimum rice planting dates are regional and vary with location and genotypes (Bruns and Abbas, 2006) [1]. Adjustment in the time of transplanting, therefore, enables the plants to take advantage of natural conditions favourable for growth. Time of transplanting was found to have a great influence on the growth, yield and yield-contributing characters of rice (Islam *et al*., 1999).

Spacing is also one of the important parameter, which ultimately affected nutrients uptake, growth and yield of plant. Increase in spacing, the total population decrease, but with more nutrition the individual plant grows better and get more yield and vice-versa. The increase or decrease of row spacing's and plant population has definite pattern in relation to the yield. In these simultaneous opposing effects of the two components there should be a point where maximum yield is expected and that should be at the optimum spacing (Tan *et al*., 2000) [24].

Plant spacing and Number of seedling hill$^{-1}$ is another important factor which can play an important role in the boosting yield of rice. Many studies reveal that closer spacing may cause mutual shading, lodging, insect pest infestation due to more intra-specific competition. Optimum plant density ensures the plant to grow properly by utilizing more solar radiation and soil nutrients (Mondal *et al*., 2013) [17]. Also, Number of seedling hill$^{-1}$ influences the tiller formation, solar radiation interception, nutrient uptake, rate of photosynthesis and other physiological phenomena which ultimately affect the growth and development of rice plant (Khan *et al*., 2013) [10]. The lesser number of seedlings hill$^{-1}$ may cause insufficient tiller number, thus keeping space and nutrients underutilized and total number of panicles unit$^{-1}$ area may be reduced resulting in poor gain yield.

**2. Material and Methods:** An investigation was carried out at plot number 16 B of the crop research farm at the Maya College of Agriculture and Technology in Selaqui, Dehradun (Uttarakhand), during the 2016 *kharif* season. Selaqui receives 1040.0 mm of rainfall on average throughout the course of the experimental period. Selaqui is located at 25.28° N Latitude, 81.54° E Longitude, and 410 m above mean sea level. The average temperature for the maximum and minimum is 35.34 °C and 12.94 °C, respectively. The experimental site's soil had a sandy-loam with adequate drainage qualities and a reaction pH of 7.93. The soil had low organic carbon (0.336%) and available nitrogen (278.09 kg ha$^{-1}$) and medium in available phosphorus (18.25 kg ha$^{-1}$) as well as potassium (150.34 kg ha$^{-1}$). The experiment included eighteen treatment combinations, of three factors, including three transplantation dates (15 July, 27 July, and 09 August), two seedling rates (1 seedling hill$^{-1}$ and 2 seedling hill$^{-1}$), and three spacing (20 X 10 cm, 20 X 15 cm, and 20 X 20 cm). These three replications were used to ensure that the results were consistent.

Rice 'Arize 6444 variety' was transplanting in three date of transplanting (15 July, 27 July and 09 August), two seedlings rate (1 seedling hill$^{-1}$ and 2 seedling hill$^{-1}$) with three spacing (20 X 10 cm, 20 X 15 cm and 20 X 20 cm) with seed rate of 8 kg ha$^{-1}$. Transplanting was done with puddling. The recommended dose of fertilizer given to the crop was N, P, K and Zn through urea, SSP, MOP and zinc sulphate, respectively. The field was maintained in a moist condition and provides eight irrigations as per recommendation during the crop growing period. Weed management was done by manually and weeding was done three times @ 20, 30 and 47 DAT. The crop was harvested separately from each plot according to transplanting date. The produce from net plot was tied in bundles separately and then tagged.

The tagged bundles were allowed for sun drying in field and after drying on the threshing floor. Threshing of rice was done manually by beating panicles on the sheaf with wooden baton and then seeds were separated by winnowing and recorded grain yield as treatments wise and expressed as q ha$^{-1}$.

Mean crop growth rate (CGR) of a plant for a time (t) is defined as the increase in dry weight of plant material from a unit area per unit of time. It was calculated with the following formula (Radford, 1967) [22] from periodic dry matter recorded at different stages:

$$CGR\ (g/m^2/day) = \frac{W_2 - W_1}{t_2 - t_1}$$

Where

$W_1$ = Total dry weight of plant at time $t_1$

$W_2$ = Total dry weight of plant at time $t_2$

$t_1$ = Time at first observation

$t_2$ = Time at second observation

The relative growth rate (RGR) of a plant at an instant in time (t) is defined as the increase in dry weight of plant material per unit of material present per unit of time. The mean relative growth rate (RGR) of the crop was calculated by the following formula (Radford, 1967) [22].

$$RGR\ (g\ g^{-1}day^{-1}) = \frac{\log_e w_2 - \log_e w_1}{t_2 - t_1}$$

Where

$W_1$ = Total dry weight of plant at time $t_1$

$W_2$ = Total dry weight of plant at time $t_2$
$Log_e$ = Natural logarithm
$t_1$ = Time at first observation
$t_2$ = Time at second observation

Plant height was measured from the ground level up to the tip of growing point at 30 and 90 DAS in tagged plants and the mean was expressed in cm. Number of tillers hill$^{-1}$ was counted from five tagged plants in each plot at 30, 60, 90 DAS and harvest. Five plants were selected at random from border rows in each plot for dry matter analysis. The plants cut, air dried initially and then oven dried at 65 $\pm$ 5 $^0$C for till constant weight was obtained and their weights were recorded. Dry mater accumulation was recorded at 30 and 90 DAS and expressed as g per plant.
Data was statistically analyzed by following the method of analysis of variance as suggested by Gomez and Gomez (1976). Critical difference was calculated wherever "F test„ was found significant at 5 percent probability level and the values were furnished.

## 3. Results and Discussion

### Plant height and dry matter

The growth parameters were significantly influenced by the different planting date and spacing. Among treatments, treatment T6 (15 July + 20 x 20 cm + 2 seedling hill$^{-1}$) significantly highest plant height and dry matter at 90 DAT over rest of the treatment combinations (Table 1). This might be due to more duration and higher heat accumulation, have favoured most of the growth parameters *viz*. plant height and dry matter in July 15 planting as compared to 27 July and 09 August planting. This is probably due to timely sowing which might have enjoyed favourable climatic conditions in terms of temperature and other parameters during crop growth and also on account of better availability of mineral nitrogen to the plants due to favourable soil temperature which have resulted in better utilization of carbohydrates to form more protoplasm resulting in more cell division and enlargement.). Similar results were also reported by Nayak *et al*. (2003) [19], Yadav and Tripathi (2006) [26], Ganvit *et al*. (2019) [5].
The maximum plant height of rice was recorded at all growth stages at a spacing of 20 x 20 cm over 20 x 15 cm and 20 x 10 cm spacing (Table 1). Tallest plants of rice were found in 2 seedlings hill$^{-1}$ as compared to 1 seedlings hill$^{-1}$ during investigation. This might be due to exposure of larger number of plant and leaf area to sunlight during the growth period resulting higher photosynthesis and consequently higher plant height. The increased in vigour due to wider spacing of the plant which help in effective absorption of nutrients at critical stage enhanced the physiological activity and increase the dry matter production (Kumari *et al*., 2000) [11]. The results of investigation are in line with those of Shrivastava *et al.* (1997) [23].

### Total numbers of tillers

The higher total number of tillers hill$^{-1}$ observed in 15 July transplanted rice crop (Table 1). This might be due to favorable weather during entire crop period coupled with nutrient absorption at appropriate time. In the early transplanting improve the canopy's photosynthesis and increase number of tillers. The higher total number of tillers hill$^{-1}$ in 15 July transplanted crop might be due to availability of more time for the growth period optimum photoperiod as well as optimum temperature for the growth of the crop plant which may result in more nitrogen absorption by the roots for the synthesis of protoplasm responsible for rapid cell division which may increase plant shape and size, ultimately the production of tillers may be more. The findings have also been supported by Patel (1999) [20]. Mandal *et al.* (1984) [14] reported that number of tillers declined with delay in transplanting and increased with early transplanting. The number of tillers hill$^{-1}$ was highest for 20 cm x 20 cm and 2 seedlings hill$^{-1}$ at 90 DAT and at harvest (Table 1). Such improvement in tillering may be attributed to the fact that early transplanting helps in greater translocation of photosynthates to the different parts of the plant. Kumari *et al*. (2000) [11] also reported that number of tillers was significantly increased with increasing plant densities. Similar findings were also corroborated by Devi and Singh (2000) [2]. Early stages growth did not vary number of tillers hill$^{-1}$ due to date of transplanting, spacing and number of seedlings in rice.

### Crop growth rate and relative growth rate

The treatment T2 (15 July + 20 cm x 10 cm + 2 seedlings hill$^{-1}$) gave the maximum crop growth rate at 60-90 DAT and 90 DAT-at harvest (Table 2). This might be due to prevalence of low temperature coupled with less humidity at the reproductive stage or at flag leaf stage might have reduced the yield as compared to late planting and wider spacing. These results confirm the findings of Yadav and tripathi (2006) [26].
At 60-90 DAT and 90 DAT-at harvest the significantly higher relative growth rate was recorded in treatment T6 (15 July + 20 cm x 20 cm + 2 seedlings hill$^{-1}$) (Table 2). This might be due to prevalence of low temperature coupled with less humidity at the reproductive stage or at flag leaf stage might have reduced the yield as compared to planting late planting and closer spacing (Yadav and tripathi 2006) [26].

### Yield

The grain yield was significantly influenced by the different planting date and spacing (Table 2). The maximum grain yield was recorded with 15 July transplanted rice with wider spacing 20 cm x 25 cm sown rice crop. This might be due to early transplanting which helped to absorb nutrients and translocate the photosynthates from source to sink. Similar findings were also corroborated by Mukesh *et al.* (2013) [18], Manoj *et al*. (2013) [15] and Islam *et al*. (2014) [7]. Wider spacing and more seedlings hill$^{-1}$ help increased the nutrient uptake efficiently which results in better translocation of photosynthates to the reproductive part and improved the yield and yield attributing characters. This result is supported with the findings given by Patra and Nayak (2001) [21] and Mahato *et al*. (2007) [3].

**Table 1:** Effect of sowing date, spacing and number of seedlings on plant height, dry matter of hybrid rice at different stages

| Treatments | Plant height | | Dry matter | | Number of tillers hill$^{-1}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAT | 90 DAT | 30 DAT | 90 DAT | 30 DAT | 60 DAT | 90 DAT | At harvest |
| $T_1$ - 15 July + 20 x 10 cm + 1 seedling hill$^{-1}$ | 46.71 | 71.89 | 1.0 | 13.88 | 4.73 | 14.60 | 16.00 | 20.44 |
| $T_2$ - 15 July + 20 x 10 cm + 2 seedling hill$^{-1}$ | 50.30 | 71.97 | 1.55 | 14.00 | 7.07 | 12.33 | 16.33 | 20.88 |
| $T_3$ - 15 July + 20 x 15 cm + 1 seedling hill$^{-1}$ | 47.27 | 78.69 | 0.79 | 15.07 | 7.00 | 15.73 | 17.87 | 23.55 |
| $T_4$ - 15 July + 20 x 15 cm + 2 seedling hill$^{-1}$ | 49.64 | 80.09 | 1.39 | 15.33 | 7.13 | 14.87 | 18.07 | 23.88 |
| $T_5$ - 15 July + 20 x 20 cm + 1 seedling hill$^{-1}$ | 47.55 | 90.22 | 0.82 | 16.67 | 4.67 | 15.87 | 21.73 | 32.27 |
| $T_6$ - 15 July + 20 x 20 cm + 2 seedling hill$^{-1}$ | 47.83 | 92.24 | 1.37 | 17.33 | 9.40 | 19.60 | 27.73 | 36.33 |
| $T_7$ - 27 July + 20 x 10 cm + 1 seedling hill$^{-1}$ | 43.51 | 70.55 | 0.89 | 13.44 | 8.13 | 14.27 | 15.40 | 19.67 |
| $T_8$ - 27 July + 20 x 10 cm + 2 seedling hill$^{-1}$ | 44.26 | 70.61 | 1.18 | 13.67 | 7.80 | 14.60 | 15.80 | 20.07 |
| $T_9$ - 27 July + 20 x 15 cm + 1 seedling hill$^{-1}$ | 42.49 | 73.28 | 0.83 | 14.67 | 6.60 | 14.73 | 17.20 | 22.07 |
| $T_{10}$ - 27 July + 20 x 15 cm + 2 seedling hill$^{-1}$ | 42.67 | 75.01 | 1.18 | 14.88 | 7.73 | 15.40 | 17.67 | 23.17 |
| $T_{11}$ - 27 July + 20 x 20 cm + 1 seedling hill$^{-1}$ | 45.00 | 89.83 | 1.72 | 16.17 | 6.27 | 15.27 | 19.67 | 27.67 |
| $T_{12}$ - 15 July + 20 x 20 cm + 2 seedling hill$^{-1}$ | 42.59 | 89.83 | 1.18 | 16.44 | 7.4 | 14.73 | 20.40 | 29.55 |
| $T_{13}$ - 09 August + 20 x 10 cm + 1 seedling hill$^{-1}$ | 38.05 | 68.67 | 1.50 | 11.88 | 6.10 | 17.33 | 14.87 | 18.67 |
| $T_{14}$ - 09 August + 20 x 10 cm + 2 seedling hill$^{-1}$ | 35.89 | 69.77 | 1.30 | 12.77 | 7.40 | 18.93 | 15.33 | 19.27 |
| $T_{15}$ - 09 August + 20 x 15 cm + 1 seedling hill$^{-1}$ | 40.52 | 72.15 | 0.98 | 14.17 | 7.40 | 21.33 | 16.60 | 21.33 |
| $T_{16}$ - 09 August + 20 x 15 cm + 2 seedling hill$^{-1}$ | 38.10 | 72.78 | 1.18 | 14.33 | 8.80 | 19.13 | 17.13 | 21.67 |
| $T_{17}$ - 09 August + 20 x 20 cm + 1 seedling hill$^{-1}$ | 40.83 | 84.86 | 1.08 | 15.55 | 8.20 | 20.00 | 18.93 | 24.77 |
| $T_{18}$ - 09 August + 20 x 20 cm + 2 seedling hill$^{-1}$ | 39.39 | 85.64 | 0.97 | 15.77 | 8.33 | 19.13 | 19.07 | 25.89 |
| S.Ed. | 2.64 | 0.25 | 0.38 | 0.05 | 1.58 | 2.26 | 0.10 | 0.13 |
| CD (P=0.05) | - | 0.50 | - | 0.09 | - | - | 0.20 | 0.26 |

**Table 2:** Effect of sowing date, spacing and number of seedling on crop growth rate and relative growth rate of hybrid rice at different stages

| Treatments | Crop growth rate | | | | Relative growth rate | | | Grain yield |
|---|---|---|---|---|---|---|---|---|
| | 0-30 DAT | 30-60 DAT | 60-90 DAT | 90 DAT- At harvest | 30-60 DAT | 60-90 DAT | 90 DAT- At harvest | |
| $T_1$ - 15 July + 20 x 10 cm + 1 seedling hill$^{-1}$ | 1.67 | 4.50 | 16.96 | 15.65 | 0.0504 | 0.0445 | 0.0171 | 35.33 |
| $T_2$ - 15 July + 20 x 10 cm + 2 seedling hill$^{-1}$ | 2.59 | 2.18 | 18.57 | 15.74 | 0.0210 | 0.0533 | 0.0172 | 37.00 |
| $T_3$ - 15 July + 20 x 15 cm + 1 seedling hill$^{-1}$ | 0.87 | 2.63 | 13.09 | 11.22 | 0.0476 | 0.0520 | 0.0172 | 48.33 |
| $T_4$ - 15 July + 20 x 15 cm + 2 seedling hill$^{-1}$ | 1.53 | 2.23 | 13.10 | 11.37 | 0.0313 | 0.0502 | 0.0172 | 50.67 |
| $T_5$ - 15 July + 20 x 20 cm + 1 seedling hill$^{-1}$ | 0.68 | 2.19 | 11.02 | 9.38 | 0.0537 | 0.0529 | 0.0172 | 60.27 |
| $T_6$ - 15 July + 20 x 20 cm + 2 seedling hill$^{-1}$ | 1.14 | 1.46 | 11.84 | 9.95 | 0.0287 | 0.0578 | 0.0175 | 64.33 |
| $T_7$ - 27 July + 20 x 10 cm + 1 seedling hill$^{-1}$ | 1.48 | 2.97 | 17.95 | 15.18 | 0.0372 | 0.0539 | 0.0173 | 32.67 |
| $T_8$ - 27 July + 20 x 10 cm + 2 seedling hill$^{-1}$ | 1.96 | 3.83 | 16.99 | 15.43 | 0.0377 | 0.0457 | 0.0172 | 34.00 |
| $T_9$ - 27 July + 20 x 15 cm + 1 seedling hill$^{-1}$ | 0.90 | 2.77 | 12.46 | 11.00 | 0.0470 | 0.0497 | 0.0173 | 43.67 |
| $T_{10}$ - 27 July + 20 x 15 cm + 2 seedling hill$^{-1}$ | 1.30 | 2.21 | 12.86 | 11.06 | 0.0330 | 0.0519 | 0.0172 | 46.17 |
| $T_{11}$ - 27 July + 20 x 20 cm + 1 seedling hill$^{-1}$ | 1.44 | 1.26 | 10.78 | 9.17 | 0.0208 | 0.0539 | 0.0173 | 56.17 |
| $T_{12}$ - 15 July + 20 x 20 cm + 2 seedling hill$^{-1}$ | 0.98 | 1.62 | 11.09 | 9.26 | 0.0327 | 0.0557 | 0.0172 | 58.33 |
| $T_{13}$ - 09 August + 20 x 10 cm + 1 seedling hill$^{-1}$ | 2.50 | 3.04 | 14.26 | 13.42 | 0.0293 | 0.0427 | 0.0172 | 28.55 |
| $T_{14}$ - 09 August + 20 x 10 cm + 2 seedling hill$^{-1}$ | 2.16 | 2.89 | 16.24 | 14.17 | 0.0286 | 0.0480 | 0.0170 | 30.27 |
| $T_{15}$ - 09 August + 20 x 15 cm + 1 seedling hill$^{-1}$ | 1.08 | 2.28 | 12.22 | 10.56 | 0.0414 | 0.0518 | 0.0172 | 38.67 |
| $T_{16}$ - 09 August + 20 x 15 cm + 2 seedling hill$^{-1}$ | 1.30 | 2.45 | 12.01 | 10.71 | 0.0350 | 0.0485 | 0.0173 | 41.77 |
| $T_{17}$ - 09 August + 20 x 20 cm + 1 seedling hill$^{-1}$ | 0.90 | 1.80 | 10.26 | 8.77 | 0.0392 | 0.0526 | 0.0172 | 52.27 |
| $T_{18}$ - 09 August + 20 x 20 cm + 2 seedling hill$^{-1}$ | 0.81 | 1.90 | 10.43 | 8.89 | 0.0450 | 0.0537 | 0.0172 | 54.67 |
| S.Ed. | 0.48 | 0.76 | 0.54 | 0.04 | 0.0145 | 0.0049 | 0.00006 | 0.32 |
| CD (P=0.05) | - | - | 1.11 | 0.08 | - | - | 0.00011 | 0.64 |

## 4. Conclusion

Based on the results from the experiment it can be concluded that the effect of planting date, spacing and number of seedlings on growth and yield of hybrid rice (*Oryza sativa* L.) The treatment T6 (15 July + 20 cm x 20 cm + 2 seedlings hill$^{-1}$) were found most effective from all the other treatment. From this research outputs we can conclude that the transplanting date *i.e.* 15 July, spacing 20 cm x 20 cm and 2 seedlings hill$^{-1}$ may be helpful for farmers in Selaqui, Dehradun and other area in the near future making hybrid rice.

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