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# CONTENTS

# Weed management and crop geometry effect on nutrient uptake and yield in aerobic rice

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**ABSTRACT:** A field experiment was conducted at Norman E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, laid out in split plot design (SPD) with four replications during *Kharif* season of 2017 to assess the effect of weed management practices and row spacing on growth and yield attributes of aerobic rice as well as density, dry matter accumulation and nutrient uptake by weeds. Among row spacing, the lowest total weed density, total dry matter accumulation and nutrient uptake was recorded under 25 cm row spacing. The highest weed control efficiency (73.9%) at 60 DAS, grain yield (4.2 t/ha) and B: C ratio (2.0) was achieved at row spacing of 25 cm with application of Pendimethalin 1.0 kg/ha (PEm) *fb* Penoxsulam 22.5 g/ha (PoEm). While, 20 cm and 30 cm row spacing were significantly at par to row spacing of 25 cm, in terms of weed control efficiency, yield and B:C ratio. Row spacing of 25 cm recorded the highest number of shoots per square metre at 60 DAS and at maturity. However, among weed management practices, Pendimethalin 1.0 kg/ha (PEm) *fb* Penoxsulam 22.5 g/ha (PoEm) recorded lowest removal of nutrients (N, P and K) by weeds, highest plant height, number of shoots per square meter and grain yield (4.4 t/ha) than other weed management treatments after weed free.

**Key words:** Growth, herbicides, Pendimethalin, Penoxsulam, Post-emergence (PoEm), Pre-emergence (PEm), rice, row spacing, weeds

"Aerobic" rice grows well under dry conditions in the absence of flooding, offers a promising means to combat the looming water crisis. Farmers can use 30 to 40% less irrigation water by growing aerobic rice; however, this savings typically comes with a yield penalty of 10 to 25%, which discourages many rice growers in the tropics from adopting the new technology (Ghosh *et al*., 2012). Aerobic rice is a resource conservation practice which has got high water use efficiency by cutting down the water losses caused due to the seepage and percolation. Weed management is one of the most important aspects which affect the growth and productivity of aerobic rice (Joshi *et al*., 2016). Taking the advantages of saving water and labour and increasing system productivity, aerobic rice has been believed to be an optimal option for rice production (Kumar and Ladha, 2011). Aerobic rice are subjected to much higher weed pressure than puddled transplanted rice system (Rao *et al.,* 2008), in which weeds are suppressed by standing water and transplanted rice seedlings, which provide 'head start' over germinating weed seedlings. In aerobic rice, weeds emerge simultaneously with crop seedlings and grow more quickly in moist soil than in puddled transplanted rice resulting in severe competition for resources to the crop. Therefore, weeds present the main biological constraint to the success of aerobic rice (Chauhan, 2012) and failure to control weeds result in yield losses ranging from 50 to 90% (Chauhan and Johnson, 2011; Chauhan and Opena, 2012). Hence, proper management of weeds is the need of the hour to sustain the productivity of aerobic rice. On the other hand, row spacing also plays a significant role for adopting the weed management practices and also decides the plant population which in turn affects the final grain yield (Sirazuddin *et al*., 2015). Herbicides with different crop geometries may show different effect on crop, hence, standardization of herbicides and their application time with different row spacing is essential for the efficient weed management and crop growth and development.

## MATERIALS AND METHODS

A field experiment was conducted during *Kharif* season of 2017 at Norman E. Borlaug Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar, with a view to find out the efficacy of different pre and post emergence herbicides for controlling the weeds and also their effect on aerobic rice in three planting geometries. Three planting geometries ($S_1$-20 cm, $S_2$-25 cm and $S_3$-30 cm) in main plots and four weed management practices ($W_1$- Weedy check, $W_2$- Pendimethalin 1.0 kg/ha *fb* Penoxsulam 22.5 g/ha, $W_3$- Cyhalofop-butyl + Penoxsulam 150 g/ha, $W_4$- Weed free) in sub plots were studied in a split plot design (SPD), with four replications.

Seeds of "*Pant dhan* 18" were seeded manually in lines at seed rate of 40 kg/ha with different row spacing of 20cm , 25cm and 30cm apart in all plots. Pendimethalin on the next day of sowing and post emergence herbicides penoxsulam and cyhalofop-butyl were applied at 20 DAS using 500 litre of water by knapsack sprayer fitted with flat fan nozzle. Plant height, expressed in cm, was recorded from randomly selected 5 tagged plants from one meter row length marked in each plot at 60 DAS and maturity of the crop. Total number of shoots was counted one meter row length marked in each plot for observation at 60 DAS and at maturity and mean number of shoots was computed to number of shoots/m$^2$. The dry matter of crop and all the weed species at 60 DAS and maturity was observed by quadrate (50 cm x 50cm) and all plants falling within quadrate were cut from the base and air dried first (4-5 days) separately and then dried in a hot air oven at 70$^o$C±5$^0$C temperature and was expressed as gram per square metre. The number of weeds in each plot was counted by using quadrate of 50cm x 50cm from area marked for observation at 60, 80 DAS and at maturity of crop and was computed as number of weeds/m$^2$. In weeds nitrogen (Subbiah and Asija, 1956), phosphorous (Olsen's *et al*., 1954) and potassium content (Jackson, 1973) was estimated by modified Alkaline $KmNO_4$ method, Olsen's method and Flame emission spectrophotometer method, respectively. Nutrient removal by weeds was calculated by using the following formula(1):

The weed control efficiency of all the treatments was calculated by using the following formula in relation to reduction of total dry weight of weeds in treated plot over the weedy plot which was expressed as percentage (Mani *et al*., 1973).

Different yield attributes were also observed. Number of panicles was counted and expressed as number of panicles per square metre. Plant height and grains per panicle was calculated by averaging 5 panicles. The number of total grains was counted and grain weight was expressed by computing 1000 grain weight in gram. The grain and straw yield was recorded from net plot area expressed as tonnes per hectare. The weight of total produce (biological yield) per net plot as mentioned in grain yield parameter. The net plot area (4m x 2m), (4m x 1.75m), (4m x 1.5 m) was harvested from the gross plot area of 5m x 3m. Harvest index (HI) was worked out by using following formula:

$$\text{HI (Harvest Index)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Cost of production and the additional weed management treatment was calculated. Benefit: cost ratio was calculated to assess the economics of the crop produce influenced by different treatments.

## RESULTS AND DISCUSSION

### Relative weed density

The major weed flora in the experimental field at 60 DAS were observed as follows *Echinochloa colona* (10%) as grassy, *Alternenthera sessilis* (15%) as broad leaf weeds, *Cyperus iria* (15%) and *Cyperus difformis* (19%) as sedges under weedy situation. However, other weeds species such as *Echinochloa crus-galli*, *Leptochloa chinensis*, *Ammania baccifera*, *Fimbristylis miliaceae* and *Celosia argentia* with relative weed density of 41% were recorded in weedy check plot.

**Fig. A view of experiment**

### Plant height

Plant height of rice crop was not influenced significantly with different row spacing at 60 DAS and maturity crop growth stages (Table 1). Among the different herbicidal treatments pendimethalin 1.0 kg /ha *fb* penoxsulam 22.5 g/ha achieved significantly higher plant height with the weed free at 60 DAS. Weedy situation recorded lowest plant height, as dominating weeds competed with the rice

$$\text{Nutrient uptake (kg/ha)} = \text{Nutrient content (\%)} \times \text{Dry matter of weeds (kg/ha)} \qquad \text{..........1}$$

$$\text{WCE (\%)} = \frac{\text{DW of weeds in weedy plot} - \text{DW of weeds in treated plot}}{\text{DW of weeds in weedy plot}} \times 100 \qquad \text{.........2}$$

**Table 1: Effect of different row spacing and weed management practices on plant growth (at 60 DAS and at maturity), total weed density and dry matter accumulation and weed control efficiency at 60 DAS**

| Treatments | Plant height (cm) | | Shoots/m$^2$ | | Crop dry matter accumulation (g/m$^2$) | | Total weed density (No./m$^2$) | Total weed dry matter accumulation (g/m$^2$) | Weed control efficiency (%) |
|---|---|---|---|---|---|---|---|---|---|
| | 60 DAS | At maturity | 60 DAS | At maturity | 60 DAS | At maturity | 60 DAS | 60 DAS | 60 DAS |
| Row spacing (cm) | | | | | | | | | |
| 20 | 73.1 | 94.1 | 228 | 227 | 405.7 | 550.5 | 2.79 (8.59) | 3.05 (10.59) | 63.9 |
| 25 | 76.9 | 94.7 | 231 | 229 | 398.1 | 549.1 | 2.65 (7.65) | 2.71 (7.67) | 73.9 |
| 30 | 73.6 | 94.2 | 223 | 223 | 396.1 | 548.2 | 3.78(17.14) | 3.99 (19.52) | 33.5 |
| SEm± | 1.57 | 2.04 | 0.95 | 1.43 | 1.84 | 2.16 | 0.09 | 0.04 | - |
| CD at 5% | NS | NS | 3.37 | 5.04 | 6.5 | NS | 0.33 | 0.15 | - |
| Weed management | | | | | | | | | |
| Weedy | 65.4 | 87.7 | 126 | 125 | 132.8 | 201.9 | 5.01(25.45) | 5.36 (29.34) | - |
| Pendimethalin@1kg/ha *fb* Penoxsulam @22.5 g/ha | 80.9 | 96.8 | 283 | 280 | 492.26 | 666.9 | 2.98 (8.61) | 3.28 (10.20) | 65.2 |
| Cyhalofop-butyl+Penoxsulam @ 150g/ha | 74.0 | 94.9 | 270 | 272 | 480.84 | 659.9 | 3.07 (9.36) | 3.37 (10.83) | 63.1 |
| Weed free | 77.7 | 97.9 | 231 | 229 | 493.9 | 668.2 | 1.0 (0.0) | 1.0 (0.0) | 100 |
| SEm± | 1.35 | 1.26 | 2.19 | 2.59 | 1.94 | 4.33 | 0.25 | 0.05 | - |
| CD at 5% | 4.86 | 3.7 | 6.4 | 7.57 | 5.68 | 8.6 | 0.75 | 0.16 | - |

Original values are given in *parentheses*

**Table 2: Effect of different row spacing and weed management treatments on nutrient content and removal by weeds at 80 DAS**

| Treatment | Nitrogen content (%) | Nitrogen removal (kg/ha) | Phosphorous content (%) | Phosphorous removal(kg/ha) | Potash content (%) | Potash removal (kg/ha) |
|---|---|---|---|---|---|---|
| Row spacing(cm) | | | | | | |
| 20 | 0.80 | 09.71 | 0.10 | 2.60 | 0.40 | 22.10 |
| 25 | 0.80 | 11.20 | 0.10 | 2.22 | 0.40 | 21.90 |
| 30 | 0.90 | 11.80 | 0.10 | 2.90 | 0.40 | 22.20 |
| SEm± | 0.01 | 1.00 | 0.01 | 0.30 | 0.01 | 1.96 |
| CD at 5% | NS | 3.47 | NS | 1.04 | NS | 6.78 |
| Weed management | | | | | | |
| Weedy | 1.20 | 26.12 | 0.30 | 5.47 | 0.60 | 52.82 |
| Pendimethalin@1kg/ha *fb* Penoxsulam @22.5 g/ha | 1.10 | 07.49 | 0.20 | 2.22 | 0.50 | 14.76 |
| Cyhalofop-butyl+Penoxsulam @ 150g/ha | 1.20 | 10.02 | 0.20 | 2.61 | 0.60 | 20.89 |
| Weed free | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SEm± | 0.01 | 1.26 | 0.01 | 0.25 | 0.01 | 3.1 |
| CD at 5% | 0.04 | 3.67 | 0.03 | 0.76 | 0.03 | 9.0 |

**Table 3: Effect of different row spacing and weed management practices on the yield attributes and yield of aerobic rice**

| Treatment | Panicles/m$^2$ | Grains/panicle | 1000-grain weight (g) | Grain yield (t/ha) | Straw yield (t/ha) | Biological yield (t/ha) | Harvest index (%) |
|---|---|---|---|---|---|---|---|
| Row spacing (cm) | | | | | | | |
| 20 | 185 | 99 | 23.21 | 4.00 | 8.00 | 12.00 | 33.6 |
| 25 | 187 | 106 | 23.45 | 4.20 | 8.30 | 12.50 | 37.4 |
| 30 | 186 | 102 | 23.41 | 3.40 | 7.10 | 10.60 | 31.5 |
| SEm± | 2.78 | 0.78 | 0.16 | 0.25 | 0.39 | 0.54 | 1.63 |
| CD at 5% | NS | 2.78 | NS | 0.72 | 0.86 | NS | NS |
| Weed management | | | | | | | |
| Weedy | 106 | 98 | 22.74 | 2.1 | 4.5 | 6.6 | 31.3 |
| Pendimethalin@1kg/ha *fb* Penoxsulam @22.5 g/ha | 218 | 105 | 23.35 | 4.4 | 8.8 | 13.2 | 35.3 |
| Cyhalofop-butyl + Penoxsulam @ 150g/ha | 199 | 101 | 22.71 | 4.3 | 9.2 | 13.5 | 33.5 |
| Weed free | 222 | 105 | 24.63 | 4.8 | 8.7 | 13.5 | 36.5 |
| SEm± | 3.44 | 0.88 | 0.17 | 0.14 | 0.44 | 0.48 | 2.34 |
| CD at 5% | 10.04 | 2.59 | 0.51 | 0.42 | 1.05 | 1.41 | NS |

**Table 4: Effect of different row spacing and Weed Management Practices on economics of rice production**

| Treatments | | | | | | |
|---|---|---|---|---|---|---|
| Row spacing (cm) | Weed management | Dose (g /ha) | Cost of cultivation | Gross return | Net return | B:C ratio |
| 20 | Weedy check | - | 22480 | 32395 | 9915 | 0.4 |
| 20 | Pendimethalin *fb* Penoxsulam | 1000 *fb* 22.5 | 27,060 | 70060 | 43000 | 1.5 |
| 20 | Cyhalofop-butyl + Penoxsulam | 150 | 24980 | 66650 | 41670 | 1.6 |
| 20 | Weed free (Pendimethalin+2HW 20 and 40 DAS) | 1000 *fb* 20 and 40 | 27,300 | 75950 | 48650 | 1.7 |
| 25 | Weedy check | - | 22840 | 46965 | 24485 | 1.0 |
| 25 | Pendimethalin + Penoxsulam | 1000 *fb* 22.5 | 27,060 | 83235 | 56175 | 2.0 |
| 25 | Cyhalofop-butyl + Penoxsulam | 150 | 24980 | 68665 | 43685 | 1.7 |
| 25 | Weed free (Pendimethalin+2HW at 20 and 40 DAS) | 1000 *fb* 20 and 40 | 27,300 | 83700 | 56400 | 2.0 |
| 30 | Weedy check | - | 22840 | 26350 | 3510 | 0.1 |
| 30 | Pendimethalin *fb* Penoxsulam | 1000 *fb* 22.5 | 27,060 | 58900 | 31840 | 1.1 |
| 30 | Cyhalofop-butyl + Penoxsulam | 150 | 24980 | 60450 | 35470 | 1.4 |
| 30 | Weed free (Pendimethalin+2HW 20 and 40 DAS) | 1000 *fb* 20 and 40 | 27,300 | 65100 | 37800 | 1.3 |

crop for natural resources and checked the growth of the crop due to which height was reduced.

**Plant density**

Number of shoots/$m^2$ increased with the advancement of growth up to 60 DAS in all the treatments but after 60 DAS, reduction in number of shoots/$m^2$ was observed under different treatments due to the competition. Among different row spacing, 25 cm recorded highest number of shoots which was at par with 20 cm and significantly higher than 30 cm row spacing at 60 DAS and at maturity. These findings were in accordance with Singh *et al.* (2011). Under different weed management practices, pendimethalin 1.0 kg/ha *fb* penoxsulam 22.5 g/ha recorded significantly higher number of shoots/$m^2$ over all the other treatments at 60 DAS and at maturity. Lowest numbers of shoots were recorded under weedy condition (Table 1). Increasing in plant spacing is associated with increase in number of tillers because the plant has got more area to draw nutrients required for tiller formation Munyithya *et al*. (2017), however, beyond 25 cm row spacing no. of plants per unit becomes less that is why no. of shoots per metre square is less in 30 cm spacing.

**Dry matter accumulation of crop**

The dry weight increased with the advancement of crop growth and highest dry weight was obtained at harvest stage. Considering the dry matter accumulation of rice crop at various growth stages highest dry matter accumulation was recorded with 20cm row spacing which was significantly higher than other two spacing (25 and 30cm) at 60 DAS. Irrespective of the weed management practices, crop dry matter production increased with advancement in crop age. Crop dry matter accumulation in weed free treatment was at par with pendimethalin 1.0 kg/ha *fb* penoxsulam 22.5 g/ha and significantly higher over other treatments at 60 DAS and at maturity (Table 1). This might be due to application of both pre and post-emergence herbicide which controlled weeds at both early and later stage resulted in optimum tiller density ($m^2$), more number of grains/panicle and hence more population of rice in closer spacing which resulted in more total dry matter production (Hasanuzzaman *et al*., 2008).

**Total weed density and dry matter of total weed species at 60 DAS**

Among different row spacing the lowest total weed density and dry matter were recorded with 25 cm row spacing. However, pendimethalin 1.0 kg/ha *fb* penoxsulam 22.5 g/ ha recorded lowest total weed density and dry matter among different weed management practices (Table 1). Total weed density increased up to 60 DAS and declined thereafter. This might be due to coverage of crop canopy at later stage may smothered weeds. These results were in accordance with the findings of Prakash *et al.* (2013).

The use of any single strategy cannot provide effective, season-long weed control as different weeds vary in their dormancy and growth habit. So, there is a need to integrate different weed management, such as the use of agronomic practices by altering row spacing followed by the use of pre- and post-emergence herbicides (Chauhan, 2012).

**Nutrient content and removal by the weeds**

Nutrient removal by weeds was the manifestation of weed biomass in the field (Payman and Singh, 2008). Different row spacing of rice had significant effect on nutrients (N, P and K) uptake by weeds at 80 DAS. The highest removal of nitrogen (11.8kg/ha), phosphorous (2.90 kg/ha) and potassium (22.2 kg/ha) was recorded under the 30 cm row spacing at 80 DAS. Among weed management practices the highest removal of nitrogen (26.12 kg/ha), phosphorous

(5.47 kg/ha) and potassium (52.82 kg/ha) by weeds was achieved in weedy check. Weed free treatment gave significantly lowest nutrient removal followed by pendimethalin 1.0 kg/ha *fb* penoxsulam 22.5 g/ha at 80 DAS (Table 2). This was attributed due to lesser weed dry matter production. Results clearly showed that major parts of the nutrient are utilized by the weeds which create competition between crop and weeds.

**Weed control efficiency**

The highest weed control efficiency 96.59, 72.81 and 82.32 % was obtained at row spacing of 25 cm with the pre- and post- emergence application of pendimethalin 1.0 kg /ha *fb* penoxsulam 22.5 g/ha (S2W2) at 40, 60 and 80 DAS, respectively and proved to be superior over other treatments. This might be due to control of weeds more effectively through the pre and post-emergence herbicide at early and later stages of crop. These findings are in support with the findings given by Singh *et al*. (2007)**.**

**Yield and Yield contributing characters**

All the yield attributing characters except grains/panicle were not influenced significantly by different row spacing. Highest no. of grains/panicle (106) was achieved with row spacing of 25 cm compared to other two row spacing (20 and 30cm). However, among weed management practices pendimethalin 1.0 kg/ha *fb* penoxsulam 22.5 g/ha recorded highest panicle/m$^2$ (218), grains/panicle (105) and 1000 grain weight (23.35 gm) after weed free and found superior over other herbicidal treatments (Table 3).

Highest grain yield (4.2 t/ha) and straw yield (8.3 t/ha) were achieved with 25 cm row spacing. Among, the weed management practices pendimethalin 1.0 kg/ha *fb* penoxsulam 22.5 g/ha recorded highest grain yield (4.4 t/ha) over other herbicidal treatments after weed free (4.8 t/ha). However, biological yield in varying row spacing and harvest index in both varying row spacing and in weed management practices were found non-significant (Table 3).

**Economics**

The highest cost involved in the case of weed free treatment. Highest gross return (83235 Rs/ha), net return (56175 Rs/ha) and B:C ratio (2.0) was achieved with pendimethalin 1.0 kg/ha *fb* penoxsulam 22.5 g/ha along with the 25cm row spacing (S2W2) followed by 20cm row spacing along with post-emergence application of cyhalofop-butyl + penoxsulam (readymix) 150g/ha (S1W3)after weed free treatment (S2W4). While, lowest net return, gross return, B: C ratio was attained in 30 cm row spacing along with all the weed management practices after the weedy check. This might be due to the lowest grain yield and straw yield in 30cm row spacing (Table 4).It is concluded that pendimethalin 1.0 kg/ha *fb* penoxsulam 22.5 g/ha along with 25cm row spacing showed better control of grassy, broad leaf and sedges and yielded highest rice grain yield among different executed treatments.

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**REFERENCES**

Chauhan, B.S. (2012). Weed ecology and weed management strategies for dry-seeded rice in Asia. *Weed Technol*., 26: 1-13.

Chauhan, B.S. and Johnson, D.E. (2011). Row spacing and weed control timing affect yield of aerobic rice. *Field Crops Res.,* 121: 226-231

Chauhan, B.S. and Opena, J. (2012). Effect of tillage systems and herbicides on weed emergence, weed growth, and grain yield in dry-seeded rice systems. *Field Crop Res.,* 137: 56–69. doi:10.1016/j.fcr.2012.08.016

Ghosh, A., Dey, R. and Singh, O.N. (2012). Improved management alleviating impact of water stress on yield decline of tropical aerobic rice. *Climatology & Water Management*, 104 (3): 584-588.

Hasanuzzaman, M.I., Obaidul and Shafiuddin, B. (2008). Efficacy of different herbicides over manual weeding in controlling weeds in transplanted rice. *Australian Journal of Crop Science,* 2(1): 18-24.

Jackson, M.L. (1973). Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd., New Delhi, Pp. 38-56.

Joshi N., Singh V.P, Dhyani V.C, Singh S.P. and Tej Pratap (2016). Effect of geometry and weed management practices on crop growth and yield of direct seeded (Aerobic) rice (*Oryza sativa* L.). *Ecology, Environment and Conservation*, 22 (371-376) ISSN0971-765X.

Kumar, V. and Ladha, J.K. (2011). Direct seeding of rice: recent developments and future research needs. *Adv Agron*., 111:297–413

Mani, V.S., Malla, M.L., Gautam, K.C. and Bhagwndas (1973). Weed killing chemicals in potato cultivation. *Indian Farm*., VXXII: 17-18.

Munyithya, A.K., Murori, R., Chemining, G.N. and

Kinama, J. (2017). Effect of plant spacing and intermittent flooding on growth and yield of selected lowland rice varieties in Kenya. *Int. J. Agron. Agri. R.,* 11:123-130.

Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean. L. A. (1954). Estimation of available phosphorus in soils by extraction with NaHCO3, USDA Cir.939. U.S. Washington.

Prakash, C. Shivram, R. K. and Koli, N.R. (2013). Bioefficacy of penoxsulan against broad spectrum weed control in transplanted rice. *Indian Journal of Weed Science*, 45(4):228-230.

Payman, G. and Singh, S. (2008). Effect of seed rate, spacing and herbicide use on weed management in direct seeded upland rice (*Oryza sativa* L.). *Indian J. of Weed Sci.,* 40 (1& 2): 11-15.

Rao, A.S., Ratnam, M. and Reddy, T.Y. (2008). Weed Management in Direct-seeded Semi Dry Rice. *Indian J. Weed Sci.,* 40 (3 & 4): 153-156.

Singh, Y., Singh, V.P., Singh, G., Yadav, D.S., Sinha, R.K.P., Johnson, D.E. and Mortimer, A.M. (2011). The implication of land preparation, crop establishment method and weed management on rice yield variation in the rice wheat system in the Indo-Gangetic plains. *Field Crops Res.,* 121:64-74.

Singh, V.P., Singh, S.P., Kumar, A. and Singh, M.K. (2007). Resource conservation through direct seeding rice and zero tillage of wheat in the Indo-Gangetic Plains, IRRI.

Sirazuddin, Singh, S.P., Singh, V.P. and Mahapatra, B.S. (2015). Effect of establishment methods and weed control measures on broad leaf weeds, yield attributes and harvest index of wheat (*Triticum aestivum* L.). *International Journal of Engineering Research and Science*, 1(6):34-37.

Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available N in the soils. *Current Science*, 25: 259

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