

Original Research Article

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Effect of System of Wheat Intensification Technique on Growth Parameters of Organic Wheat (*Triticum aestivum* L.)

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ABSTRACT

Keywords

Organic wheat, SWI(t), Planting methods, Organic sources of nutrient and Growth parameters

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The experiment was carried out during Rabi season 2015-16 and 2016-17 at Crop Research Farm, SHUATS Model of Organic Farm (SMOF), Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) to study the 'Effect of System of Wheat Intensification technique on growth parameters of organic wheat (*Triticum aestivum* L.)'. The pooled data recorded that SWI technique has significant and highest plant height (109.71 cm), maximum number of tillers/ hill (22.38), highest plant dry weight (26.814 g/ hill) and maximum number of effective tillers/ hill (21.73) at 90 DAS. The pooled data also recorded Furrow Irrigated Raised Bed significant and highest crop growth (19.358 g/ m²/ day) at 75 to 90 DAS intervals. Considering farm yard manure (16 t/ ha) pooled data showed significantly maximum number of tillers/ hill (22.29), higher plant dry weight (26.497 g/ hill), crop growth rate (17.591 g/ m²/ day) and maximum number of effective tillers/ hill (21.59) at 90 DAS was recorded. Further, significantly taller plant height (108.76 cm) by S₁ (Poultry manure, 2.6 t/ ha) at 90 DAS in pooled was recorded.

Introduction

India has the largest area among wheat growing countries and stands third in production. It produces 99.70 m t of wheat in an area of 29.58 m ha with the productivity of 3.37 t/ ha (GOI, 2018). Wheat yield gains have slowed to only 1.1% per annum in India (Ray *et al.*, 2013). Hence, there is a need to increase the yield of wheat cultivation using reduced inputs and resources to meet the future food demands of an ever-growing population. India is facing several major constraints in wheat production, *viz.*, weather

factors (low and high heat stress, high relative humidity and severe drought), soil factors (soil texture, soil pH, EC and low availability of soil nutrients), low use of production inputs (seeds, fertilizers and irrigation), methodology factors (inadequate crop establishment methods, improper planting geometry, delayed sowing, poor soil fertility management system, continuous adoption of rice-wheat systems). Use of higher dose of high analysis fertilizers (containing only N, P and K) and inadequate use of organic materials has created deficiencies of secondary and micronutrients particularly Zn

and Fe (Takkar, 1996). Therefore, a suitable combination of organic and inorganic sources of nutrient is necessary for a suitable agriculture (Reganold *et al.*, 1990). Recently, System of Wheat Intensification (SWI) technique emerged from the principles and practices of System of Rice Intensification method of transplanting which has the potential to provides adequate aeration, water, light energy and available nutrients, leading to vigorous root system development (profuse root hair and root length) from initial stage of crop growth to harvest. SWI technique is a synergistic agronomic management system involving components of wheat cultivation such as maintaining optimum plant population, wider and square spacing and sowing of single seed per hill. Adoption of SWI technique can increase the productivity of wheat by more than 2 times (Uphoff *et al.*, 2011).

Application of organic manures for increasing soil fertility and crop productivity has gained importance in recent years due to speedy increasing the cost and adverse impact of continuous and indiscriminate use of synthetic fertilizers. Incorporation of organic manures has been given rise a hope to reduce the cost of cultivation and minimize adverse effects of inorganic fertilizers especially on deterioration of soil structure, soil health and environmental pollution. Utilization and scientific management of FYM, poultry manure, *bokashi* manure and green manures may be a good organic source for producing quality products and also maintaining environmentally-friendly sustainable agriculture. Keeping all these things in view to provide healthy crop growth system and to improve production the present investigation was undertaken to study the ‘Effect of System of Wheat Intensification technique on growth parameters of organic wheat (*Triticum aestivum* L.)’.

Materials and Methods

The experiment was carried out during *Rabi* season 2015-16 and 2016-17 at Crop Research Farm, SHUATS Model of Organic Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (U.P.). SHUATS Model Organic Farm (SMOF) was developed under the National Project on Organic Farming (NPOF) by the Department of Agronomy, with Dr. Thomas Abraham, Professor (Agronomy) as its Principal Investigator. The 2 hectares (5 acres) area has been Certified by Lacon Quality Certification (P) Ltd. [Accreditation No. NPOP/NAB/006, Ministry of Commerce, Govt. of India] till 2017 the field was in its 9th year of conversion. The soil of the experimental plot was sandy loam in texture, low in available nitrogen, medium in available phosphorus and high in available potash with 7.68 soil pH. The experiment was laid out in split plot design with three replications, having three planting methods, *viz.*, System of Wheat Intensification [SWI(t), 20 × 20 cm] technique, *Kera* method (22.5 × 10 cm) and Furrow Irrigated Raised Bed (FIRB, 22.5 × 10 cm); three organic sources of nutrient, *viz.*, Poultry manure (2.6 t/ ha), Farm yard manure (16 t/ ha) and *Bokashi* manure (3.2 t/ ha) were studied. Green manure *dhaincha* (*Sesbania aculeata* L.) was grown during *zaid* season and *Panchagavya* was sprayed in all the treatment; and the crop seeds were treated with *jeevamruth* organic formulation. There were total 9 treatment combinations in all. The net plot size was 5 × 4 m and net experimental area 540 m². The agronomic practices, *viz.*, weeding with cycle weeder in SWI technique, manual and hand weeding in *Kera* and FIRB methods were done and irrigation was given according to the schedules for all treatments. The wheat variety ‘SHIATS W8’ was sown. The Meteorological data observation maximum &

minimum temperatures during the wheat crop season ranged from 21.40 °C to 38.25 °C and 8.91 °C to 27.45 °C, respectively in 2015–16 and 20.15 °C to 38.74 °C and 7.75 °C to 18.30 °C, respectively in 2016–17. Data on plant height (cm), number of tillers/ hill, plant dry weight (g/ hill), CGR (g/ m²/ day), RGR (g/ g/ day), number of effective tillers/ hill were recorded. Data recorded on crop growth parameters were tabulated and subjected to statistical analysis as per Gomez and Gomez, 1976.

Results and Discussion

Plant height (cm)

Significantly tallest plant height (52.87, 77.68 and 109.61 cm in 2015-16; and 54.37, 78.72 and 109.81 cm in 2016-17) was recorded by M₁ (System of Wheat Intensification technique) at 60, 75 and 90 DAS respectively during both the years of experiments and in pooled. However, analysis of the data revealed that statistically at par by M₂ (*Kera* method) with M₁ (System of Wheat Intensification technique) at 60 DAS (52.06 cm) in 2015-16 (Table 1). Data observed that M₁ (System of Wheat Intensification technique) significantly superior to other planting methods in both the years of experiment and in pooled. Data also envisage that M₃ (Furrow Irrigated Raised Bed) had smaller plant height at all the stages of crop growth during both the years of experiment and in pooled. Plant height increased generally in treatment with System of Wheat Intensification technique, which might be due to enhanced sugar translocation and turgor pressure in plant cell that leads to cell enlargement and multiplication resulted taller plant (Nehra and Hooda, 2002; Abbasi *et al.*, 2014).

Data pertaining to organic sources of nutrient showed significant variation in plant height at

60, 75 and 90 DAS. It further revealed that S₂ (Farm yard manure, 16 t/ ha) produced significantly taller plant height (52.55 and 76.94 cm in 2015-16; and 54.02 and 78.39 cm in 2016-17 respectively) than to rest of the treatments at 60 and 75 DAS during both the years and in pooled. Further, it was noted significantly taller plant height (108.56 and 108.97 cm) by S₁ (Poultry manure, 2.6 t/ ha) at 90 DAS in both the years and pooled. However, analysis data observed statistically at par by S₂ (Farm yard manure, 16 t/ ha) with S₁ (Poultry manure, 2.6 t/ ha) at 90 DAS during both the years and in pooled; and by S₁ (Poultry manure, 2.6 t/ ha) with S₂ (Farm yard manure, 16 t/ ha) at 60 and 75 DAS during both the years and in pooled (Table 1). Taller plant height with organic source of nutrient could be due to the availability of more macro and micro nutrients by poultry manure to the plant throughout the growing period. These results are in accordance with the findings of Warren *et al.*, (2006); Mitchell and Tu (2005). Perusal of the data also reveals that interaction effect of planting methods and organic sources of nutrient did not affected the plant height of organic wheat during both the years and in pooled in all the stages of plant growth.

Number of tillers/ hill

Significant and maximum number of total tillers/ hill (13.36, 20.02 and 22.16 in 2015-16; and 14.04, 20.31 and 22.60 in 2016-17) was recorded in the treatment M₁ (System of Wheat Intensification technique) at 60, 75 and 90 DAS respectively, in both the years of experiment and pooled. It is evident from the data that other planting methods could reach the level of SWI technique of sowing. However, M₃ (Furrow Irrigated Raised Bed) was found to be at par with M₁ (System of Wheat Intensification technique) in 2016-17 at 60 and 75 DAS (Table 1). Maximum number of tillers per hill generally registered

with System of Wheat Intensification technique, which might be under wider spacing each individual plant effectively utilized more available resources such as space, nutrients and more light interception resulted bigger root system and enhanced tiller production. These findings corroborate with Thakur *et al.*, (2010) in rice.

The data registered significant and maximum number of total tillers/ hill (13.31, 19.76 and 21.89 in 2015-16 and 14.11, 20.40 and 22.69 in 2016-17) by S₂ (Farm yard manure, 16 t/ ha) at 60, 75 and 90 DAS, during both the years and pooled. However, it was observed statistically at par by S₁ (Poultry manure, 2.6 t/ ha) at 75 DAS in 2016-17 and pooled analysis. Data further revealed that S₁ (Poultry manure, 2.6 t/ ha) was observed statistically at par to S₂ (Farm yard manure, 10 t/ ha) at 60 and 90 DAS in both the years and pooled (Table 1). Maximum number of tillers with organic source of nutrient such as FYM, may be assigned to the fact that proper mineralization of the organic manure supplied available plant nutrients directly to plants and also had a solubilizing effect on fixed form of nutrients in soil, resulted increased growth and number of tillers (Singh and Singh, 2005). The similar findings corroborated with of Raghuvanshi and Umat (1994). Perusal of the data also reveals that interaction effect of planting methods and organic sources of nutrient did not affected the number of total tillers/ hill of organic wheat during both the years and in pooled.

Plant dry weight (g/ hill)

Mean data on plant dry weight revealed that there was significant difference in plant dry weight (6.483, 19.598 and 26.176 g in 2015-16; and 6.549, 19.662 and 27.452 g in 2016-17) of organic wheat in the treatment M₁ (System of Wheat Intensification technique) at 60, 75 and 90 DAS respectively during

both the years of experiment and also in pooled, which was superior to M₂ (Kera method) and M₃ (Furrow Irrigated Raised Bed). However, data further revealed that M₃ (Furrow Irrigated Raised Bed) was found to be statistically at par with M₁ (System of Wheat Intensification technique) at 75 DAS in both the years of experiment. Further, it was registered by M₃ (Furrow Irrigated Raised Bed) to be statistically at par with M₁ (System of Wheat Intensification technique) at 60 DAS in 2015-16 and pooled; and at 90 DAS in 2015-16 (Table 2). Higher plant dry weight with SWI technique which might have induced both greater and deeper root growth, thereby contributing to increased nutrient uptake throughout the crop cycle (Barison and Uphoff, 2011).

Among the different organic sources of nutrient significant influence on plant dry weight was recorded at 60, 75 and 90 DAS during both the years of experiment and also in pooled. S₂ (Farm yard manure, 16 t/ ha) produced significantly more plant dry weight (6.534, 19.256 and 25.766 g in 2015-16; and 6.530, 19.701 and 27.228 g in 2016-17) compare to other organic source treatment during both the years and in pooled. However, data further, revealed that S₁ (Poultry manure (2.6 t/ ha) was found to be statistically at par with S₂ (Farm yard manure, 16 t/ ha) at 60 DAS in 2016-17; and at 75 and 90 DAS during both the years of experiment and pooled (Table 2). Significantly higher plant dry weight with organic source of nutrient might be due to the stimulation effect of farm yard manure on improving the soil physical properties, increasing soil productivity and supplying higher amount of nutrients demand to plants uptake, which in turn improving the vegetative growth and dry matter production resulting higher plant dry weight. These findings are in corroboration with Sary *et al.*, (2014) and Ahmed *et al.*, (2012) in barley. Perusal of the data also reveals that

interaction effect of planting methods and organic sources of nutrient did not affected the plant dry weight of organic wheat during both the years and in pooled.

Crop Growth Rate (g/ m²/ day)

The data indicate that in general, there was an increase in the crop growth rate in initial growth stages, irrespective of treatments and thereafter, a gradual reduction in crop growth rate was recorded of the crop. A close scrutiny of mean data on crop growth rate revealed that the planting methods exerted significant influence on crop growth rate at 45 to 60, 60 to 75 and 75 to 90 DAS intervals during both the years and pooled. The mean data recorded significantly higher crop growth rate (37.551 and 18.218 g/ m² /day in 2015-16; and 39.006 and 20.498 g/ m² /day in 2016-17 respectively) by M₃ (Furrow Irrigated Raised Bed) at 60 to 75 DAT and 75 to 90 DAS intervals in both the years and pooled. Further, it was also registered significantly higher crop growth rate by M₃ (Furrow Irrigated Raised Bed) at 45 to 60 DAS intervals in 2015-16 and pooled; and by M₂ (*Kera* method) in 2016-17. However, M₂ (*Kera* method) was observed to be statistically at par with M₃ (Furrow Irrigated Raised Bed) at 45 to 60 DAS intervals in 2015-16 and pooled; and by M₃ (Furrow Irrigated Raised Bed) in 2016-17. Further, data also revealed that M₂ (*Kera* method) was observed to be statistically at par with M₃ (Furrow Irrigated Raised Bed) at 60 to 75 DAS intervals in both the year and at 75 to 90 DAS intervals during both the years and pooled (Table 2). A close examine of mean data indicated that M₁ (System of Wheat Intensification technique) had lowest crop growth rate at all the stages of crop growth intervals during both the years of experiment and in pooled. CGR generally increased rapidly to a peak between flag leaf emergence and heading and then declined to zero just

prior to soft dough stage. The dry matter loss of the crop at the end of the season may be attributed to negative net photosynthesis over the period of increasing moisture stress (Karimi and Siddique, 1991). This would be concluded from evidence that a sizeable fraction of carbohydrate is used for respiration, particularly with soil moisture stress at the end of the season (Davidson and Campbell, 1983).

Among the organic sources of nutrient S₂ (Farm yard manure, 16 t/ ha) was recorded highest crop growth rate at 45 to 60 DAS intervals in 2015-16 and at 75 to 90 DAS intervals in both the years, and found non significant. The significant and higher crop growth rate was by S₂ (Farm yard manure, 16 t/ ha) in 2016-17 and pooled at 45 to 60 DAS intervals; and in pooled at 75 to 90 DAS intervals. The mean data also recorded highest crop growth rate by S₁ (Poultry manure, 2.6 t/ ha) at 60 to 75 DAS intervals during both the years and pooled, and it was found non significant. However, S₁ (Poultry manure, 2.6 t/ ha) was observed to be statistically at par with S₂ (Farm yard manure, 16 t/ ha) at 45 to 60 DAS intervals in 2016-17 and pooled; and by S₁ (Poultry manure, 2.6 t/ ha) and S₃ (*Bokashi manure*, 3.2 t/ ha) at 75 to 90 DAS intervals in pooled. It was observed a general increase in the crop growth rate in all the organic sources of nutrient afterward it decreased (Table 2). Pradhan and Moharana (2015) reported that growth of a plant is the permanent and irreversible increase in its size and form. It is affected by its environment like availability of plant nutrients, water, solar energy, space, etc. Therefore, the growth of a plant in a community differs in many ways from the individual plant because of inter plant interaction in the field. Complete production potential of individual plants can only be realized when the growth and development conditions during the initial phases are optimal.

Table.1 Effect of planting methods and organic sources of nutrient on plant height and number of tillers of organic wheat at different intervals

| Treatment | Plant height (cm) | | | | | | | | | Number of tillers/ hill | | | | | | | | |
|------------------------------------|-------------------|---------|--------|---------|---------|--------|---------|---------|--------|-------------------------|---------|--------|---------|---------|--------|---------|---------|--------|
| | 60 DAS | | | 75 DAS | | | 90 DAS | | | 60 DAS | | | 75 DAS | | | 90 DAS | | |
| | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled |
| Planting methods | | | | | | | | | | | | | | | | | | |
| M ₁ | 52.87 | 54.37 | 53.62 | 77.68 | 78.72 | 78.20 | 109.61 | 109.81 | 109.71 | 13.36 | 14.04 | 13.70 | 20.02 | 20.31 | 20.17 | 22.16 | 22.60 | 22.38 |
| M ₂ | 52.06 | 53.45 | 52.76 | 76.33 | 77.62 | 76.97 | 106.89 | 108.00 | 107.45 | 13.04 | 13.87 | 13.46 | 19.31 | 19.84 | 19.58 | 21.27 | 22.04 | 21.66 |
| M ₃ | 51.59 | 53.32 | 52.45 | 76.17 | 77.57 | 76.87 | 107.34 | 107.80 | 107.57 | 12.87 | 14.00 | 13.43 | 19.24 | 20.02 | 19.63 | 21.27 | 22.22 | 21.74 |
| SE(d) ± | 0.31 | 0.14 | 0.16 | 0.16 | 0.21 | 0.15 | 0.41 | 0.25 | 0.25 | 0.10 | 0.04 | 0.06 | 0.15 | 0.12 | 0.11 | 0.24 | 0.13 | 0.17 |
| CD (P=0.05) | 0.86 | 0.38 | 0.44 | 0.44 | 0.59 | 0.42 | 1.13 | 0.69 | 0.69 | 0.27 | 0.12 | 0.17 | 0.42 | 0.34 | 0.30 | 0.67 | 0.36 | 0.48 |
| Organic sources of nutrient | | | | | | | | | | | | | | | | | | |
| S ₁ | 52.36 | 53.80 | 53.08 | 76.82 | 78.09 | 77.45 | 108.56 | 108.97 | 108.76 | 13.18 | 14.02 | 13.60 | 19.76 | 20.16 | 19.96 | 21.78 | 22.40 | 22.09 |
| S ₂ | 52.55 | 54.02 | 53.28 | 76.94 | 78.39 | 77.67 | 108.05 | 108.88 | 108.46 | 13.31 | 14.11 | 13.71 | 19.76 | 20.40 | 20.08 | 21.89 | 22.69 | 22.29 |
| S ₃ | 51.62 | 53.32 | 52.47 | 76.42 | 77.42 | 76.92 | 107.23 | 107.77 | 107.50 | 12.78 | 13.78 | 13.28 | 19.07 | 19.62 | 19.34 | 21.02 | 21.78 | 21.40 |
| SE(d) ± | 0.30 | 0.17 | 0.17 | 0.19 | 0.24 | 0.17 | 0.47 | 0.26 | 0.32 | 0.19 | 0.10 | 0.12 | 0.26 | 0.17 | 0.17 | 0.32 | 0.19 | 0.20 |
| CD (P=0.05) | 0.65 | 0.38 | 0.37 | 0.42 | 0.52 | 0.36 | 1.03 | 0.56 | 0.69 | 0.42 | 0.22 | 0.27 | 0.57 | 0.37 | 0.38 | 0.69 | 0.42 | 0.44 |
| Interaction (PM × OS) | | | | | | | | | | | | | | | | | | |
| SE(d) ± | 0.51 | 0.30 | 0.29 | 0.33 | 0.41 | 0.29 | 0.82 | 0.45 | 0.55 | 0.34 | 0.17 | 0.21 | 0.45 | 0.29 | 0.30 | 0.55 | 0.33 | 0.35 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

M₁ – System of Wheat Intensification (SWI) technique; M₂ – Kera method; M₃ – Furrow Irrigated Raised Bed (FIRB); S₁ – Poultry manure (2.6 t/ ha); S₂ – Farm yard manure (16 t/ ha); S₃ – Bokashi manure (3.2 t/ ha) (at 25, 35 and 50 DAS); DAS – Days after sowing; NS – Non-significant; SEd (±): Standard error of deviation; CD: Critical difference

Table.2 Effect of planting methods and organic sources of nutrient on plant dry weight and CGR of organic wheat at different intervals

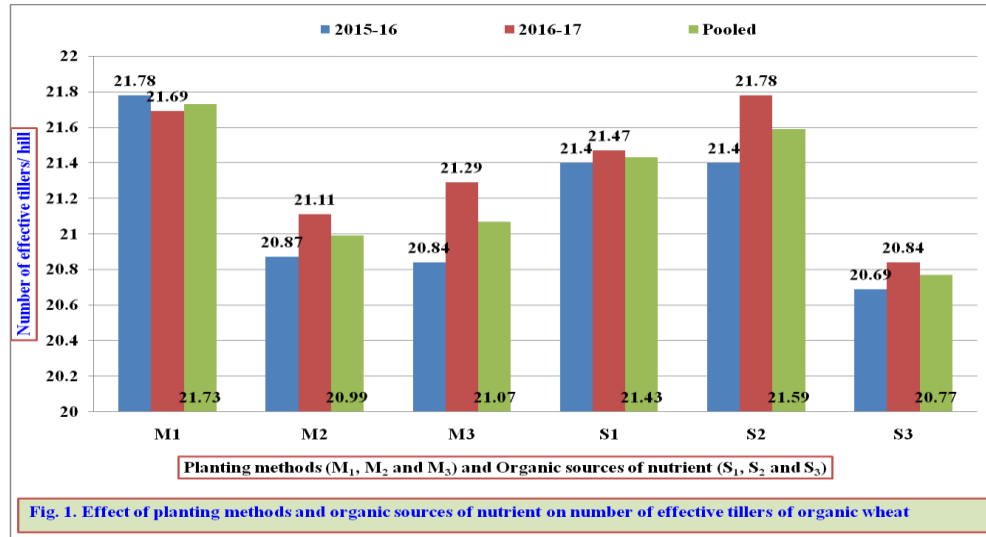
| Treatment | Plant dry weight (g/ hill) | | | | | | | | | Crop growth rate (g/ m ² / day) | | | | | | | | |
|------------------------------------|----------------------------|---------|--------|---------|---------|--------|---------|---------|--------|--|---------|--------|--------------|---------|--------|--------------|---------|--------|
| | 60 DAS | | | 75 DAS | | | 90 DAS | | | 45 to 60 DAS | | | 60 to 75 DAS | | | 75 to 90 DAS | | |
| | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled |
| Planting methods | | | | | | | | | | | | | | | | | | |
| M ₁ | 6.483 | 6.549 | 6.516 | 19.598 | 19.726 | 19.662 | 26.176 | 27.452 | 26.814 | 8.739 | 8.778 | 8.759 | 21.857 | 21.961 | 21.909 | 10.964 | 12.876 | 11.920 |
| M ₂ | 6.081 | 6.239 | 6.160 | 18.532 | 19.145 | 18.838 | 24.406 | 26.003 | 25.204 | 14.707 | 14.853 | 14.780 | 36.891 | 38.240 | 37.565 | 17.403 | 20.322 | 18.862 |
| M ₃ | 6.402 | 6.219 | 6.311 | 19.076 | 19.384 | 19.230 | 25.224 | 26.302 | 25.763 | 15.379 | 14.691 | 15.034 | 37.551 | 39.006 | 38.278 | 18.218 | 20.498 | 19.358 |
| SE(d) ± | 0.112 | 0.083 | 0.079 | 0.231 | 0.150 | 0.065 | 0.468 | 0.384 | 0.197 | 0.330 | 0.209 | 0.238 | 0.405 | 0.564 | 0.227 | 1.276 | 0.892 | 0.513 |
| CD (P=0.05) | 0.311 | 0.231 | 0.219 | 0.641 | 0.416 | 0.181 | 1.301 | 1.065 | 0.546 | 0.917 | 0.579 | 0.660 | 1.125 | 1.567 | 0.629 | 3.542 | 2.476 | 1.424 |
| Organic sources of nutrient | | | | | | | | | | | | | | | | | | |
| S ₁ | 6.285 | 6.409 | 6.347 | 19.202 | 19.626 | 19.414 | 25.500 | 26.841 | 26.171 | 12.909 | 12.992 | 12.950 | 32.427 | 33.351 | 32.889 | 15.742 | 17.924 | 16.833 |
| S ₂ | 6.534 | 6.530 | 6.532 | 19.256 | 19.701 | 19.478 | 25.766 | 27.228 | 26.497 | 13.259 | 13.057 | 13.158 | 32.113 | 33.290 | 32.701 | 16.340 | 18.842 | 17.591 |
| S ₃ | 6.148 | 6.069 | 6.109 | 18.748 | 18.927 | 18.837 | 24.539 | 25.688 | 25.114 | 12.657 | 12.273 | 12.465 | 31.758 | 32.566 | 32.162 | 14.503 | 16.931 | 15.717 |
| SE(d) ± | 0.101 | 0.106 | 0.078 | 0.191 | 0.173 | 0.084 | 0.405 | 0.311 | 0.267 | 0.317 | 0.269 | 0.222 | 0.512 | 0.473 | 0.294 | 1.175 | 0.774 | 0.673 |
| CD (P=0.05) | 0.221 | 0.232 | 0.170 | 0.416 | 0.376 | 0.183 | 0.883 | 0.677 | 0.581 | NS | 0.585 | 0.484 | NS | NS | NS | NS | NS | 2.540 |
| Interaction (PM × OS) | | | | | | | | | | | | | | | | | | |
| SE(d) ± | 0.175 | 0.184 | 0.135 | 0.330 | 0.299 | 0.145 | 0.702 | 0.539 | 0.462 | 0.549 | 0.465 | 0.385 | 0.887 | 0.819 | 0.509 | 2.036 | 1.341 | 1.166 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Table.3 Effect of planting methods and organic sources of nutrient on relative growth rate of organic wheat at different intervals

| Treatment | Relative growth rate (g/ g/ day) | | | | | | | | |
|------------------------------------|----------------------------------|---------|--------|--------------|---------|--------|--------------|---------|--------|
| | 45 to 60 DAS | | | 60 to 75 DAS | | | 75 to 90 DAS | | |
| | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled | 2015-16 | 2016-17 | Pooled |
| Planting methods | | | | | | | | | |
| M ₁ | 0.110 | 0.109 | 0.110 | 0.074 | 0.074 | 0.074 | 0.019 | 0.022 | 0.021 |
| M ₂ | 0.113 | 0.109 | 0.111 | 0.074 | 0.075 | 0.075 | 0.018 | 0.020 | 0.024 |
| M ₃ | 0.111 | 0.106 | 0.109 | 0.073 | 0.076 | 0.074 | 0.019 | 0.020 | 0.019 |
| | | | | | | | | | |
| SE(d) ± | 0.003 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.003 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | | | | | | | | | |
| Organic sources of nutrient | | | | | | | | | |
| S ₁ | 0.111 | 0.109 | 0.110 | 0.074 | 0.075 | 0.075 | 0.019 | 0.021 | 0.024 |
| S ₂ | 0.110 | 0.106 | 0.108 | 0.072 | 0.074 | 0.073 | 0.019 | 0.022 | 0.020 |
| S ₃ | 0.114 | 0.109 | 0.111 | 0.074 | 0.076 | 0.075 | 0.018 | 0.020 | 0.019 |
| | | | | | | | | | |
| SE(d) ± | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.004 |
| CD (P=0.05) | NS | NS | 0.003 | NS | NS | NS | NS | NS | NS |
| | | | | | | | | | |
| Interaction (PM × OS) | | | | | | | | | |
| SE(d) ± | 0.005 | 0.003 | 0.002 | 0.002 | 0.006 | 0.002 | 0.002 | 0.001 | 0.006 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | | | | | | | | | |

M₁ – System of Wheat Intensification (SWI) technique; M₂ – Kera method; M₃ – Furrow Irrigated Raised Bed (FIRB); S₁ – Poultry manure (2.6 t/ ha); S₂ – Farm yard manure (16 t/ ha); S₃ – Bokashi manure (3.2 t/ ha) (at 25, 35 and 50 DAS); DAS – Days after sowing; NS – Non-significant; SEd (±): Standard error of deviation; CD: Critical difference

Fig.1



They observed that the dry matter accumulation showed a typical sigmoidal curve. The pattern indicates that initial vegetative growth in rice tends to be exponential but because of mutual interactions within the individuals that impose limitation on growth, the actual growth curve falls away in sigmoidal manner which is more characteristic of its entire life span. Since growth is not exponential, CGR is not a constant value and it always declines and ascends later in the life curve (Evans, 1972). Perusal of the data also reveals that interaction effect of planting methods and organic sources of nutrient did not affected the crop growth rate of organic wheat during both the years and in pooled in all the stages of plant growth.

Relative Growth Rate (g/ g/ day)

A steady but marginal decrease in RGR was observed during the successive growth intervals. Data revealed that highest RGR (0.113 and 0.109 g/ g/ day) at 45 to 60 DAS intervals in the treatment M₂ (*Kera* method) in both the years and pooled, where also M₁ (System of Wheat Intensification technique) was registered with exactly same values with

M₂ (*Kera* method) in 2016-17, though it was registered no significance difference. The data also recorded highest RGR in the treatment M₂ (*Kera* method) in 2015-16 and pooled and by M₃ (Furrow Irrigated Raised Bed) in 2016-17 at 60 to 75 DAS intervals, whereas, M₁ (System of Wheat Intensification technique) was registered with exactly same values with M₂ (*Kera* method) in 2015-16; and by M₁ (System of Wheat Intensification technique) in both the years and by M₂ (*Kera* method) in pooled at 75 to 90 DAS intervals and found non significant. The data also registered with exactly same values by M₃ (Furrow Irrigated Raised Bed) with M₁ (System of Wheat Intensification technique) at 75 to 90 DAS in 2015-16 (Table 3).

Among the organic sources of nutrient highest on relative growth rate (0.114 and 0.074 g/ g/ day in 2015-16 and 0.109 and 0.076 g/ g/ day in 2016-17) was recorded in the treatment S₃ (*Bokashi manure*, 3.2 t/ ha) at 45 to 60 and 60 to 75 DAS intervals in both the years and pooled, though it was found no significance difference; it was also registered with exactly same values by S₁ (Poultry manure, 2.6 t/ ha) with S₃ (*Bokashi manure*, 3.2 t/ ha) at 45 to 60 DAS intervals in 2015-16 and at 60 to 75

DAS intervals in 2016-17 and pooled. Further, S₃ (*Bokashi manure*, 3.2 t/ ha) was registered significantly higher RGR at 45 to 60 DAS intervals in pooled and S₁ (Poultry manure, 2.6 t/ ha) and S₂ (Farm yard manure, 16 t/ ha) was observed statistically at par. Data further revealed that, S₂ (Farm yard manure, 16 t/ ha) with highest on relative growth rate in both the years and by S₁ (Poultry manure, 2.6 t/ ha) in pooled, where also S₁ (Poultry manure, 2.6 t/ ha) was registered with exactly same values in 2015-16, though it was found non significant (Table 3). It was observed from the perusal of data that interaction effect of planting methods and organic sources of nutrients did not affect the relative growth rate of organic wheat during both the years and in pooled.

Number of effective tillers/ hill (at 90 DAS)

Significant and Maximum number of effective tillers/ hill (21.78 and 21.69) was recorded by M₁ (System of Wheat Intensification technique) in both the years of experiments and in pooled. However, M₃ (Furrow Irrigated Raised Bed) was registered statistically at par with M₁ (System of Wheat Intensification technique) in 2016-17 (Fig. 1). Maximum number of effective tillers realized with System of Wheat Intensification technique may be due to the better concurrent utilization of moisture, nutrients and solar radiation as well as orientation of the leaves, thereby leading to greater amount of photosynthesis, which increases the expression of effective tiller. This finding is supported by Suryawanshi *et al.*, (2013); and Mithilesh and Abraham (2017).

Data pertaining to organic sources of nutrient showed significant variation in number of effective tillers/ hill at 90 DAS. It further revealed that S₂ (Farm yard manure, 16 t/ ha) produced significantly maximum number of effective tillers/ hill (21.40 and 21.78) than all

the other treatments during both the years and in pooled. However, S₁ (Poultry manure, 2.6 t/ ha) remained at par to S₂ (Farm yard manure, 16 t/ ha) 2016-17 and in pooled; it was also registered with exactly same values with S₁ (Poultry manure, 2.6 t/ ha) in 2015-16 (Fig. 1). Maximum number of effective tillers recorded with organic source of nutrient such as farm yard manure, which may have supplied available plant nutrient directly to plants and created favorable soil environment, thus increased the available nutrient and water-holding capacity of soil for longer time resulting increased number of effective tillers (Sarma *et al.*, 2007). Similar cause and effect was also found by Gupta *et al.*, (2006). It is clear from the data that interaction effect of planting methods and organic sources of nutrient did not affect the number of effective tillers/ hill of organic wheat during both the years and in pooled.

The results of two year study of organic wheat demonstrate that System of Wheat Intensification (SWI) technique, with the principles and practices of System of Rice Intensification (SRI) method of transplanting is more beneficial than other planting methods. The application of farm yard manure has been found to be the best for obtaining vigorous and healthy growth character of organic wheat than the application of other organic sources of nutrient.

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