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Research Article

# Tillage and Nutrient Effect on Growth, Yield, Economics and Total Nutrient Harvest Index of Grain Corn (*Zea Mays L.*)

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## Abstract

Field experiment consisted of six tillage options i.e. FIRBS, Conventional Tillage (CT), Sub Soiling (SS), Zero Tillage (ZT), Minimum Tillage with two pass of rotavator (MT) and Permanent Raised Bed System (PRBS) in main plot and 03 nutrient levels i.e. 50% of Recommended Dose of Fertilizers (50% RDF), Site Specific Nutrient Management (SSNM) and 100% Recommended Dose of Fertilizers (RDF) in sub plot was conducted at Norman E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, India during Kharif 2013 and 2014 in split plot design with three replications to study the effect of tillage and nutrient on growth, yield, economics and Total Nutrient Harvest Index (TNHI) of grain corn (*Zea mays L.*). Geographically Pantnagar is situated at 29˚N - 79.5˚ E at 243.84 msl in the foothills of Himalayas. The site was silty clay loam having soil pH 7.21, organic carbon 0.684% and 242.42, 22.56 and 240.32 kg available N, $P_2O_5$ and $K_2O$/ha, respectively. 'Nutrient Expert of Maize' was used to calculate the fertilizer doses under SSNM. The fertilizer dose was 120:60:40::N:$P_2O_5$:$K_2O$ under 100% RDF, 120:10:37 SSNM and 60:30:20 50% RDF kg/ha, respectively. The highest grain yield was recorded under FIRBS with 18.3, 17.2 and 14.2% greater than CT, SS and ZT, respectively. RDF produced significantly higher corn yield with 9% and 37.2% greater than SSNM and 50% RDF. FIRBS had significantly higher gross, net return and B: C ratio. RDF had the highest gross and net returns, B: C ratio as well as Total Nutrient Harvest Index (TNHI) but remained statistically similar to SSNM. It is therefore concluded that grain corn may be planted on either FIRBS or PRBS with application of precision fertilizer dose 120:10:37::N:$P_2O_5$:$K_2O$ kg/ha for higher productivity, profitability and total nutrient harvest index in Indo-Gangetic plains of India.

**Keywords:** FIRBS; PRBS; Tillage; Total Nutrient Harvest Index; Zero Tillage

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## Introduction

Corn is 3rd most important cereal of India after rice and wheat accounts 9.43 million hectare area, 24.35 million tons production and productivity 2583 kg/ha. The productivity is still very low compared to world average of over 5 ton/ha. The rice-wheat system is presently a major cropping system of India but the changing scenario of climate has reflected that this rotation may not continue longer mainly because of poor and erratic rainfall, decreasing share of water for irrigation, dwindling ground water resources as well as degrading quality of irrigation water. Therefore maize is emerging a potential substitute of rice in whole Indo-Gangetic plains of India because it's wider suitability under stressed conditions. At present, it is difficult to increase acreage as well as irrigation water under different crops because of stiff competition among different sectors, therefore to enhance the crop productivity is the only option to sustain food and nutritional security of the country. Hence different interventions like production of hybrids and genetically modified crops, development of climate resilient crops and varieties, adoption of different tillage systems, improving site specific plant nutrition, integrated pest and diseases management, post harvest technologies, protective agriculture, application of organized remote-sensing and GIS, nanotechnology, micro-biology, biotechnology etc. are to be looked into for improving crop productivity.

The paradigm shift in tillage options like minimum tillage, zero tillage, FIRBS, raised bed planting has been observed world over. Due to the availability of herbicides, insecticides and fungicides and also more mechanization, the farmers prefer new tillage options compared to conventional tillage that is required mainly for seedbed preparation and weed control [1]. The research findings have confirmed that minimum tillage increases aggregate stability [2] zero tillage also promotes high aggregate stability, decreases soil temperature and maintains high carbon and nitrogen [3]. Zero tillage also reduces weed population in wheat [4]. The cost of cultivation, irrigation and nutrient requirement in rice-wheat system are reduced under FIRBS and raised bed planting systems and increased soil quality [5]. The sub soiling is an urgent need to break the hard pan and also improve the soil porosity and percolation. Therefore, some of the research findings have already indicated that the sub soiling may be beneficial to improve the productivity and profitability of the system compared to conventional tillage system.

The research findings have also revealed that the farmers of Indo-Gangetic plains of India often apply very high dose of nitrogen in form of urea and very little phosphorous and potassium and almost nil secondary and micronutrients [6] leading to imbalance, toxicity as well as inadequate use of nutrients with reduce nutrient use efficiency

and profitability. In addition, it increases environment risk associated with loss of unutilized nutrient through emission or leaching [7]. Therefore, the intervention on plant nutrition like site-specific nutrient management and recommended fertilizer dose based on proper field experimentations and crop response, covering special variability in indigenous nutrient supplying capacity of soil [8] are urgently required. The response of mainly N, P and K, separately on different crops has been explored widely but the research work on combined effect of balanced fertilization particularly on maize and wheat is meager. Similarly the response of balanced fertilizers on different crops under different tillage systems is limited and needs attention of the researchers on different crops mainly for increased input use efficiency, system productivity and its profitability under different tillage and cropping systems Therefore, in view of the above fact, the present investigation was carried out to study the effect of tillage and nutrient management on growth, yield and yield attributes of system crops in Indo-Gangetic plains of India.

## Materials and Methods

Field experiment was carried out during 2013-14 and 2014-15 at Norman E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar district dham Singh Nagar, Uttarakhand representing the Tarai belt of Uttarakhand to study the effect of tillage and nutrient effect on growth, yield, economics and total nutrient harvest index of grain corn (*Zea mays* L.). Geographically Pantnagar is situated at 29˚N latitude, 79.5˚E longitude and at an altitude of 243.84 m above mean sea level in the foot hills of Himalayas. The experimental site was silty clay loam having soil pH 7.21, organic carbon 0.684% and 242.42, 22.56 and 240.32 kg available N, $P_2O^5$ and $K_20$/ha, respectively. The experiment was laid out in a split plot design with 18 treatments with six tillage options i.e. FIRBS, Conventional Tillage (CT), Sub Soiling (SS), Zero Tillage (ZT), Minimum Tillage with two pass of rotavator (MT) and Permanent Raised Bed System (PRBS) in main plot and 03 nutrient levels i.e. 50% of recommended dose of fertilizers (50% RDF), Site Specific Nutrient Management (SSNM) and 100% Recommended Dose Of Fertilizer (RDF) in sub plot with three replications. The crop was grown as per recommended practices. The corn hybrid i.e. 31Y45 and 4212 was planted on 2013 and 2014 respectively. The fertilizer dose i.e. N:$P_2O_5$:$K_2O$ applied was 120:60:40 under 100% RDF, 120:10:37 under SSNM) and 60:30:20 under 50% RDF kg/ha. The fertilizer dose under SSNM was estimated based on decision support system on nutrient management of maize developed by IPNM. One third of nitrogen and full dose of phosphorus and potash was applied as basal and remaining nitrogen was top dressed in two equal splits at knee high and tasseling stage. The growth parameters like plant height, dry matter accumulation, leaf area, leaf area index growth analysis like mean crop growth rate (, relative growth rate (, net assimilation rate (, and leaf area ratio ( at different growth stages [9], grain yield and economics were studied. The crop samples of 5 plants were collected from second row of each plot at different growth stages and analyzed for different attributes. At harvest, the net plot was harvested and grain yield was converted into tons/ha. The minimum support price of grain and prevailing rates of straw was taken for calculation of cost of cultivation and gross returns.

## Results and Discussion

### Effect of Tillage Options

**Plant Height:** Tillage options did not have significant effect on plant height but dry matter differed significantly among tillage options at harvest stage (Table 1). At harvest, the tallest plants were found at PRBS and MT during 2013 and 2014, respectively. The pooled values also indicated that the highest plant height was recorded under FIRBS and PRBS at harvest. The higher plant height under FIRBS and PRBS might be caused by higher availability of nutrients and moisture. Similar finding were also reported [10].

**Dry Matter Accumulation:** The dry matter accumulation was significantly affected by tillage options during both years (Table 1). At harvest stage, PRBS and FIRBS produced significantly highest dry matter accumulation in 2013 and 2014, respectively. The pooled values revealed that significantly highest dry matter accumulation was noticed under PRBS that remained significantly similar to FIRBS. In general, MT gave the lowest dry matter followed by SS and CT because FIRBS and PRBS produced better physical condition for growth and development resulting into vigorous plant growth leading to more dry matter accumulation also reported higher dry matter production under FIRBS and deep tillage were also reported in earlier findings [11,12].

**Leaf Area/Plant:** The leaf area varied among different tillage options and significantly highest leaf area was recorded under PRBS and SS during both the years but it remained non significant with PRBS and FIRBS in 2014 at 30 DAS (Figure 1a). In 2014, SS produced significantly higher leaf area that was statistically equal to PRBS, FIRBS and MT. The pooled leaf area was also recorded significantly higher under PRBS and was statistically at par with FIRBS. At 60 DAS, significantly highest leaf area was recorded under PRBS (Figure 1b), while at harvest; it followed the same trend during both years as well as on pooled values but it was statistically similar to SS, ZT and MT in 2013 and ZT and SS on pooled basis (Figure 1c). In general, ZT, MT and CT gave the lower values at all the stages during both the years. The higher leaf area was the result of more number of leaves recorded under PRBS and FIRBS.

**Leaf Area Index:** At 30 DAS, the FIRBS had significantly highest LAI that remained non-significant with PRBS. Significantly highest LAI was recorded under FIRBS that remained significant with MT and SS and lowest LAI was observed under ZT that was found statistically at par with CT in 2014 and similar trend was found in pooled data (Figure 2a). At 60 DAS, FIRBS had significantly higher LAI that was significantly equal to ZT and PRBS in 2013 but in 2014, ZT gave the highest LAI and remained non-significant with all other tillage options (Figure 2b). The pooled values showed that FIRBS recorded significantly higher LAI that was statistically at par with ZT and PRBS. The lowest LAI was found under CT that was non-significant with SS and MT. LAI at harvest was recorded significantly higher under ZT that was statistically at par with SS and MT in 2013. The LAI values in 2014 and pooled basis did not differ significantly among tillage options however the highest value was recorded under PRBS and SS, respectively (Figure 2c). Higher LAI was the result of higher leaf area. [13] also reported higher LAI under PRBS than CT.

**Growth Analysis:** Tillage options significant influence on mean Crop Growth Rate **(**CGR), Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and Leaf Area Ratio (LAR) during both years. The

| Treatment | Plant Height (cm) | | | Dry Matter (g/plant) | | | Grain Yield (t/ha) | | | Straw Yield (t/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | pooled | 2013 | 2014 | pooled | 2013 | 2014 | pooled | 2013 | 2014 | pooled |
| **Tillage options (T)** | | | | | | | | | | | | |
| **FIRBS** | 200 | 178 | 189 | 220.6 | 218.6 | 219.6 | 6.65 | 6.75 | 6.70 | 8.06 | 8.13 | 8.09 |
| **CT** | 199 | 181 | 190 | 208.5 | 207.9 | 208.2 | 5.60 | 5.73 | 5.67 | 7.10 | 7.18 | 7.14 |
| **SS** | 202 | 179 | 190 | 201.9 | 179.8 | 203.1 | 5.82 | 5.91 | 5.86 | 7.10 | 7.20 | 7.15 |
| **ZT** | 200 | 169 | 185 | 226.9 | 180.1 | 203.4 | 5.67 | 5.77 | 5.72 | 7.02 | 7.16 | 7.09 |
| **MT** | 192 | 182 | 187 | 191.9 | 209.3 | 186.0 | 5.83 | 5.90 | 5.87 | 6.95 | 7.12 | 7.04 |
| **PRBS** | 206 | 177 | 191 | 241.0 | 209.3 | 225.2 | 6.59 | 6.65 | 6.62 | 7.62 | 7.72 | 7.67 |
| **SEm±** | 4.17 | 4.17 | 3.66 | 2.5 | 2.6 | 1.9 | 0.14 | 0.09 | 0.08 | 0.24 | 0.18 | 0.17 |
| **CD at 5%** | ns | ns | ns | 7.9 | 8.1 | 5.9 | 0.43 | 0.28 | 0.26 | 0.76 | 0.58 | 0.53 |
| **Nutrient management (N)** | | | | | | | | | | | | |
| **50%RDF** | 195 | 173 | 184 | 176.4 | 170.9 | 173.7 | 4.98 | 5.061 | 5.02 | 6.60 | 6.70 | 6.10 |
| **SSNM** | 201 | 177 | 189 | 218.6 | 201.7 | 210.2 | 6.26 | 6.381 | 6.32 | 7.47 | 7.60 | 7.52 |
| **RDF** | 204 | 183 | 193 | 250.6 | 227.3 | 238.9 | 6.85 | 6.92 | 6.89 | 7.89 | 8.03 | 7.96 |
| **SEm±** | 2.69 | 2.17 | 1.20 | 2.0 | 1.4 | 1.4 | 0.09 | 0.07 | 0.07 | 0.11 | 0.14 | 0.11 |
| **CD at 5%** | 04 | 06 | 04 | 6.0 | 4.2 | | 0.26 | 0.21 | 0.19 | 0.33 | 0.39 | 0.31 |
| **Interaction (T x N)** | ns | ns | ns | s | s | s | ns | ns | ns | ns | ns | ns |

**Table 1:** Effect of tillage options and nutrient management on plant height, dry matter, leaf area and leaf area index of maize during 2013 and 2014.

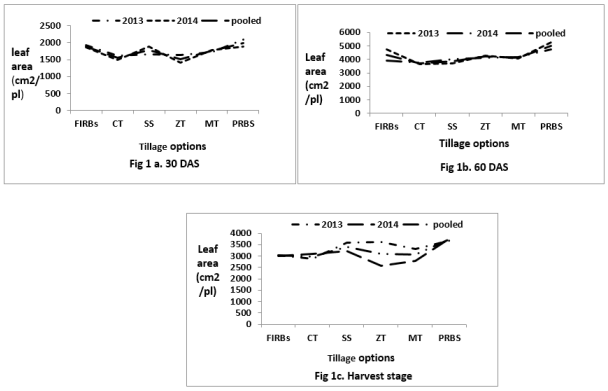


**Figure 1:** Effect of tillage options on leaf area of corn at 30 and 60 days after sowing and at harvest stage.

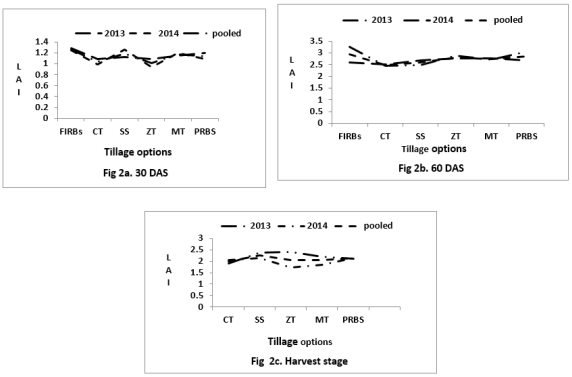


**Figure 2:** Effect of tillage options on Leaf Area Index (LAI) at 30 & 60 DAS and at harvest stage.

FIRBS had the highest mean CGR but remained non-significant with PRBS and ZT at 30-60 DAS during 2013 but in 2014, PRBS gave the highest value that remained statistically at par with FIRBS and CT. The pooled values revealed that the highest CGR was found under FIRBS that was statistically at par with PRBS. The CGR at 60 DAS to harvest was found significantly highest under ZT that remained non-significant with CT in 2013 but FIRBS gave the highest value that was significantly equal to SS during 2014. The pooled CGR was also found significantly higher under FIRBS that remained non-significant with CT and SS (Figure 3). The CGR depends on growth rate of dry matter accumulation per day per unit area, hence higher crop growth was due to accumulation of better plant growth and dry matter accumulation per day per unit area. The PRBS recorded significantly mean highest RGR at 30-60 DAS during both the years and pooled values but it was found statistically at par with ZT in 2014. The pooled values indicated that FIRBS and ZT as well as CT, SS and MT had non-significant values. At 60 DAS to harvest RGR was recorded highly variable under different tillage options. CT recorded significantly the highest value during 2013 but the highest values were recorded under SS that remained non-significant with FIRBS in 2014. The pooled values showed that CT had the highest RGR that remained statistically at par with SS and the significantly lowest value was obtained under MT (Figure 4).

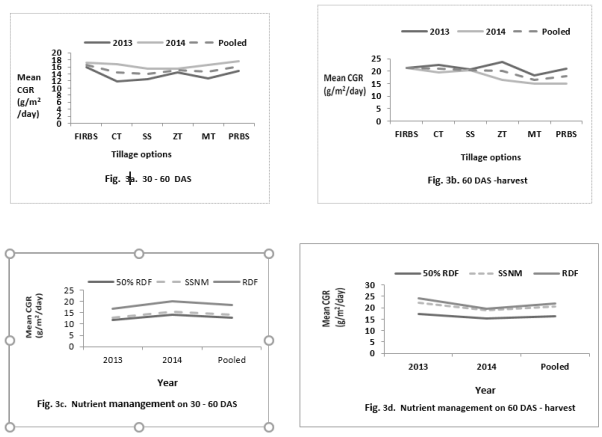


**Figure 3:** Effect of tillage options and nutrient management on mean CGR at 30 – 60 DAS and 60 DAS to harvest.

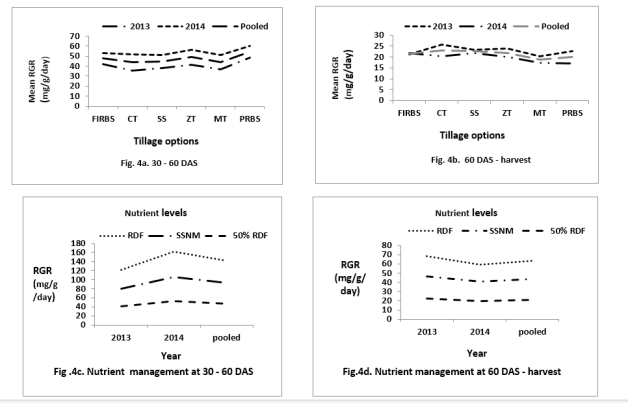


**Figure 4:** Effect of tillage options and nutrient management on mean RGR at 30 – 60 DAS and 60 DAS to harvest.

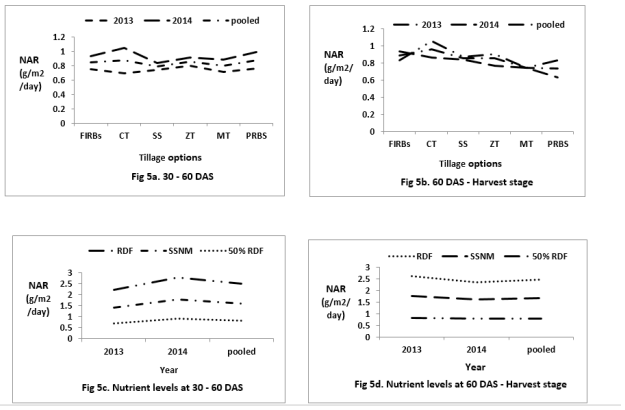


**Figure 5:** Effect of tillage options and nutrient management on mean NAR at 30 - 60 DAS and 60 DAS to harvest stage.

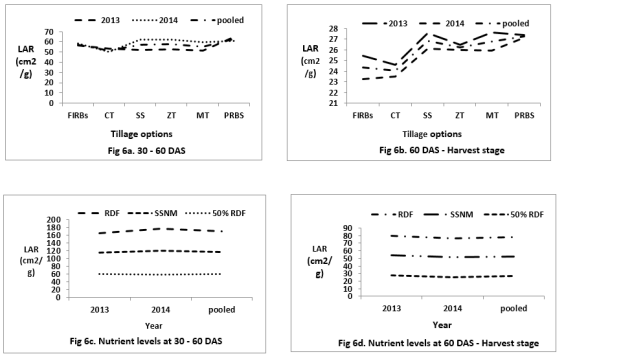


**Figure 6:** Effect of tillage options and nutrient management on mean LAR at 30 – 60 DAS and 60 DAS to harvest stage.

At 30-60 DAS, ZT and CT had the higher mean NAR values during both the years but it remained significantly at par with PRBS during 2014. The pooled values indicated the highest NAR was found under PRBS that remained statistically at par with CT, ZT and FIRBS. At 60 DAS to harvest, the CT and FIRBS had the significantly higher NAR but it remained non-significant with CT and SS during 2014. The pooled NAR was observed significantly highest under CT and the lowest under MT that remained statistically at par with PRBS (Figure 5). Higher NAR is the result of higher dry matter accumulation per unit area and time. At 30-60 DAS, significantly highest LAR was recorded under PRBS but FIRBS had significantly higher LAR than CT, SS, ZT and MT during 2013. However during 2014, SS gave the highest mean LAR that remained significantly equal to ZT, MT. and PRBS. The pooled value revealed that PRBS had significantly highest LAR values. The FIRBS gave significantly higher LAR that remained significantly at par with SS and ZT. Significantly lowest values were noticed under CT followed by MT. The LAR at 60 DAS-harvest was recorded highest under MT that remained non-significant with all tillage options except CT during 2013 but in 2014, the highest value was obtained under PRBS that was significantly equal to SS, ZT and MT (Figure 6). Similar trend was found for pooled values. The higher LAR was the result of higher LAI recorded in PRBS and FIRBS at all the growth stages.

**Grain and Straw Yield:** The grain and straw yield of maize differed greatly with tillage options during both years. The grain yield was affected significantly during both years as well as pooled values. Significantly higher grain yield was recorded under FIRBS that remained significantly at par with PRBS during both years. The lowest grain yield of maize was recorded in CT that was significantly equal to SS, ZT and MT during both years. The pooled values also followed the above trend. The corn grain yield was recorded 18.3, 17.2 and 14.2% higher under FIRBS than CT, SS and ZT, respectively (Table 1). However, the FIRBS and PRBS had significantly similar values. The higher grain yield is cumulative result of greater values of cob length, cob girth, grain weight/cob and also 1000 grain weight. [14] also reported similar results. [10] also found greater maize yield under raised bed followed by CT and ZT. The RDF produced significantly highest straw yield during both the years as well as pooled values followed by SSNM and significantly lowest values were obtained under 50% RDF. The higher straw yield at higher dose of fertilizers was due to better plant growth and development including plant dry matter accumulation. The grain and straw yield had non-significant interaction effect between tillage and nutrient levels.

**Economics:** The FIRBS had significantly higher gross and net return that remained statistically similar with PRBS during both year as well as pooled values. Significantly lower gross and net return was found under CT that remained significantly similar to SS, ZT and MT during both the years and pooled values. The benefit: cost ratio was also

| Treatment | Gross returns (Rs/ha)) | | | Net return (Rs/ha) | | | B:C ratio | | | TNHI | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | pooled | 2013 | 2014 | pooled | 2013 | 2014 | pooled | 2013 | 2014 | pooled |
| **Tillage options (T)** | | | | | | | | | | | | |
| **FIRBS** | 99247 | 100651 | 99949 | 65401 | 65865 | 65633 | 1.93 | 1.89 | 1.91 | 0.446 | 0.438 | 0.442 |
| **CT** | 84016 | 85869 | 84943 | 51670 | 52583 | 52127 | 1.59 | 1.57 | 1.58 | 0.480 | 0.459 | 0.468 |
| **SS** | 86848 | 88236 | 87542 | 53502 | 53949 | 53726 | 1.60 | 1.57 | 1.58 | 0.457 | 0.449 | 0.452 |
| **ZT** | 84880 | 86356 | 85618 | 54039 | 54585 | 54312 | 1.75 | 1.71 | 1.73 | 0.455 | 0.446 | 0.450 |
| **MT** | 86828 | 88052 | 87440 | 55983 | 56266 | 56124 | 1.81 | 1.76 | 1.78 | 0.475 | 0.446 | 0.470 |
| **PRBS** | 97824 | 98700 | 98262 | 63978 | 63914 | 63946 | 1.89 | 1.83 | 1.86 | 0.489 | 0.481 | 0.485 |
| **SEm±** | 1798 | 1430 | 1198 | 1798 | 1430 | 1198 | 0.06 | 0.04 | 0.04 | 0.013 | 0.004 | 0.007 |
| **CD at 5%** | 5663 | 4504 | 3773 | 5663 | 4504 | 3773 | 0.18 | 0.14 | 0.12 | 0.041 | 0.014 | 0.021 |
| **Nutrient Management (N)** | | | | | | | | | | | | |
| **50%RDF** | 75062 | 76312 | 75687 | 43799 | 44109 | 43954 | 1.40 | 1.37 | 1.38 | 0.443 | 0.441 | 0.442 |
| **SSNM** | 93162 | 94925 | 94043 | 61361 | 62187 | 61774 | 1.93 | 1.90 | 1.91 | 0.467 | 0.457 | 0.462 |
| **RDF** | 101599 | 102695 | 102147 | 67126 | 67284 | 67205 | 1.95 | 1.90 | 1.92 | 0.49 | 0.471 | 0.480 |
| **SEm±** | 1213 | 1089 | 942 | 1213 | 1089 | 942 | 0.04 | 0.03 | 0.03 | 0.008 | 0.005 | 0.005 |
| **CD at 5%** | 3540 | 3179 | 2750 | 3540 | 3180 | 2750 | 0.11 | 0.10 | 0.84 | 0.024 | 0.015 | 0.015 |
| **Interaction (T x N)** | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns |

**Table 2:** Effect of tillage options and nutrient management on economics and Total Nutrient Harvest Index (TNHI) of maize during 2013 and 2014.

recorded significantly higher under FIRBS that remained non-significant with PRBS, MT and ZT in 2013 and PRBS and MT in 2014. The lowest value was recorded under CT that was significantly similar with SS and ZT during both the years. The pooled benefit: cost ratio was again found significantly higher under FIRBS that was statistically at par with PRBS. The lowest value was recorded under CT followed by SS (Table 2).

**Total Nutrient Harvest Index:** The PRBS had the highest TNHI during both the years but remained non-significant with CT, MT, SS and ZT during 2013 and the lowest values were found in FIRBS during both years (Table 2). The pooled values also revealed that significantly highest TNHI was observed under PRBS that was non-significant with MT and CT but the lowest TNHI was noticed under FIRBS that was statistically similar to ZT and SS. Higher TNHI was the result of higher economic yield and nutrient contents and its uptake.

## Effect of Nutrient Management

Nutrient management had significant impact on plant height, dry matter accumulation, leaf area, leaf area index and growth analysis during both years (Table 1).

**Plant Height:** The plant height was significantly affected by nutrient levels at all the crop growth stages during both the years (Table 1). In general, the tallest plants were recorded at RDF that remained significantly equal to SSNM and the shortest plants were found at 50% RDF. Higher plant height at RDF and SSNM was due to higher availability of essential nutrients that extended vegetative growth period which increased photosynthetic formation and also partioning to stem that had favorable impact on plant height. These results were close conformity with the results indicating that plant height in maize increased with increasing fertilizers rates [15,16]. The interaction effect between tillage options and nutrient levels was found non-significant at all the crop growth stage during both the years.

**Dry Matter Accumulation:** The nutrients levels also had significant influence on dry matter accumulation at all the crop growth stages. In general, RDF produced significantly highest dry matter accumulation during both the years followed by SSNM and the lowest value under 50% RDF. The pooled values also followed similar trend (Table 1). The higher dry matter production was the result of higher plant height and more number of leaves per plant. [17] also recorded more dry matter accumulation at higher dose of nitrogen application. Similar findings were also confirmed by [16]. The interaction effect of tillage options and nutrient levels on dry matter accumulation was found significant at all the crop growth stages during both the year except 30 DAS during 2014.

**Leaf Area:** The leaf area differed greatly among different nutrient levels but significantly highest leaf area was recorded under RDF at all the stages during both the years followed by SSNM and significantly lowest at 50% RDF (Figure 7). Significantly higher leaf area under RDF might be ascribed to better growth of maize shoots due to more supply of nitrogen. Nitrogen being vital part of protoplasm helped in cell-division and thus favored more production of leaves. The higher value of leaf area was again the result of more number of leaves and its expansion. [18] also reported higher leaf area of maize at 180 kg N/ha compared to 120kgN/ha. Significantly higher leaf area under 100% nitrogen applications was noticed [19,20]. The interaction effect was found non-significant during both the years.

**Leaf Area Index:** The LAI was influenced by nutrient levels and significantly highest LAI was recorded under RDF followed by SSNM and significantly lowest LAI under 50% RDF at all the growth stages during both years and pooled values (Figure 8). The higher LAI was the result of more plant height and leaf area, recorded at higher dose of plant nutrition. [21]. reported maximum LAI at application of N90P20K25+Biocompost (equivalent to 30 kg N/ha). Significantly higher LAI under 100% recommended N dose might be ascribed to more leaf area leading to better growth of maize shoots due to more supply of nitrogen [20]. Tillage options and nutrient levels had non-significantly effect on LAI at all the growth stages during both years and pooled values.

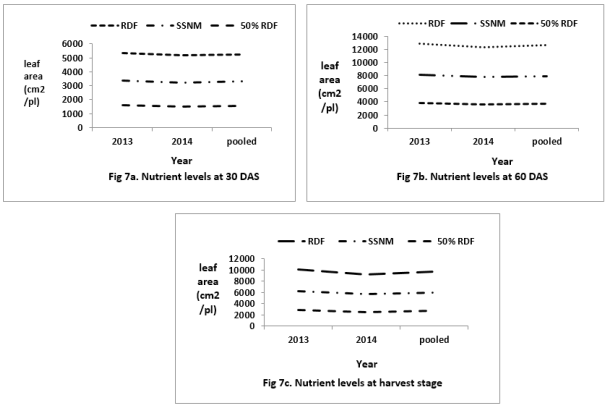


**Figure 7:** Effect of nutrient levels on leaf area of corn at 30 and 60 days after sowing and at harvest stage.

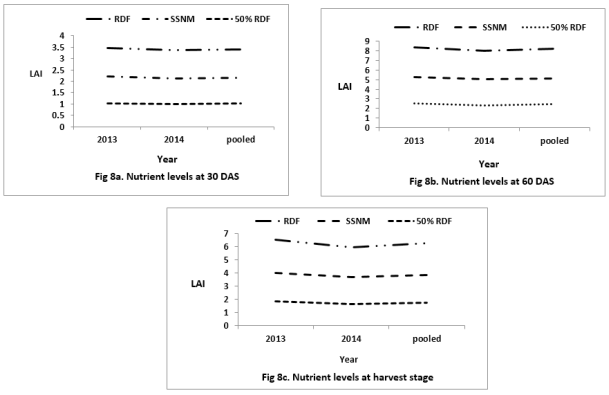


**Figure 8:** Effect of nutrient management on LAI at 30 & 60 DAS and at harvest stage.

**Growth Analysis:** The mean CGR at 30-60 DAS, 60 DAS–harvest and pooled CGR was recorded significantly highest under RDF during both the years as however it was found non-significant with the SSNM at 60 DAS - harvest during 2014 (Figure 3). The lowest value was recorded under 50% RDF at all the stages. Application of RDF resulted into more dry matter accumulation than 50% application, hence attained more CGR. These results were supported with the findings of [19] who reported higher CGR under 100% RDF. The interaction effect was found significant at all the growth stages. The RGR at 30-60 DAS was recorded significantly higher at 50% RDF that was non-significant with RDF. At 60- harvest, RGR was recorded significantly highest under SSNM but 50% RDF and RDF had significantly equal values. The pooled values also followed the similar trend (Figure 4). The interaction effect between tillage options and nutrient levels was found significant at 30-60 DAS and 60 DAS - harvest stages during both years, however the pooled values had non-significant effect only at 60 DAS – harvest.

The NAR was found significantly highest under RDF and SSNM at 30-60 DAS and 60 DAS -harvest, respectively during both the years, however it remained statistically at par at with 50% RDF at 60 DAS -harvest in 2014. The pooled NAR was also found significantly highest at 30-60 DAS and 60 DAS to harvest under RDF and SSNM, during 2013 and 2014, respectively (Figure 5). The interaction effect remained significant at both the stages during both years except at 30-60 DAS in 2014. The LAR was recorded significantly highest at 50% RDF in 2013 but SSNM gave significantly higher LAR in 2014 and remained significantly similar to 50% RDF. The pooled LAR was found significantly higher at 50% RDF and it was non-significant with SSNM. The lowest LAR was recorded under RDF during both the years as well as pooled values (Figure 6). The interaction between tillage options and nutrient levels at 30-60 DAS and60 DAS - harvest remained non-significant at both stages during both the years as well as for pooled values.

**Grain and Straw Yield:** The grain and straw yield differed greatly with nutrient levels during both years. Significantly highest and lowest grain yield was obtained at RDF and 50% RDF, respectively (Table 1). The SSNM gave significantly higher value compared to 50% RDF and the lower compared to RDF during both years. The pooled data also followed above trend and produced 9.0 and 37.2% greater grain yield under RDF than SSNM and 50% RDF, respectively. SSNM also produced 25.8% higher grain yield than 50% RDF. The higher grain yield is the cumulative effect of higher values of yield attributes. These results are in conformity with [19,20,22] who reported significantly higher grain yield of corn at 100% of recommended dose of nitrogen. The RDF produced significantly highest straw yield during both the years as well as pooled values followed by SSNM and significantly lowest values were obtained under 50% RDF. The higher straw yield at higher dose of fertilizers was due to better plant growth and development including plant dry matter accumulation. Non-significant interaction effect was found between tillage and nutrient levels for both grain and straw yield.

**Economics:** RDF had significantly highest gross and net returns followed by SSNM and lowest value under 50%RDF during both years and pooled values (Table 2). The benefit cost ratio was recorded significantly higher under RDF that remained non-significant with SSNM during both years and pooled values. Tillage options and nutrients levels had non-significant interaction effect on gross return, net return as well as benefit: cost ratio during both years.

**Total Nutrient Harvest Index:** The highest TNHI was recorded under RDF that remained statistically similar to SSNM and the lowest value was observed under 50% RDF during both years. The pooled TNHI was also observed significantly highest and lowest under RDF and 50% RDF, respectively. Higher nutrients gave higher yield, nutrient contents and its uptake in grain and straw leading to greater TNHI. The interaction effect was found non-significant (Table.2).

## Conclusion

It is therefore concluded that grain corn may be planted on either FIRBS or PRBS and be applied site specific nutrients i.e. N:$P_2O_5$:$K_2O$:: 120:10:37 kg/ha for higher growth, productivity, profitability and total nutrient harvest index in Indo-Gangetic plains of India and it may be also be followed in other maize growing Asian countries.

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## References

1. Mohanty M, Painuli DK, Misra AK, Bandyopadhyaya KK, Ghosh PK (2006) Estimating impact of puddling, tillage and residue management on wheat (*T. aestivum* L.) seedling emergence and growth in a rice wheat system using nonlinear regression models. Soil and Tillage Res 87: 119-130.
2. Rusu T (2005) The Influence of minimum tillage systems upon the soil properties and yield. J of Geodesy and Cadastre 242-245.
3. Irizar A, Andriuo A, Mary B (2013) Long-term impact of no Tillage in two intensified crop rotations on different soil organic matter fractions in Argentine rolling pampa. The Open Agric Journal 7: 22-31.
4. Sen D, Singh R, Shyam R (2002) Efficacy of tillage and weed management practices on weed infestation and yield of wheat. Indian J of Weed Sci 42: 57-61.
5. Govarts B, Sayre KD, Lichter K (1999) Influence of permanent raised bed planting and residue management on physical and chemical soil quality in rainfed maize/wheat system. Plant and Soil 291: 39-54.
6. Singh B, Kular JS, Mandal MS (2014) Relative abundance and damage of some insect-pest of wheat under different tillage practice in rice-wheat cropping in India. Crop Protection 61: 16-22.
7. Pompolino MF, Witt C, Pasuquin JM, Tuhniton A, Fisher MJ (2012) Development approach and evaluated of the nutrient expert left water fornnutrients management in wheat crops E lecton. Agric -888. 103 Nitrogen and food productivity in India. International J of Agric Sci 7: 66-62.
8. Majumdar K, Jat ML, Pampolino M, Dutta S, Kumar A (2013) Nutrient management in wheat. Current scenario, improved strategies and future research needs. Indian J. Wheat Res 4: 1-10.
9. Radford PJ (1967) Growth analysis formulae, their use and abase. Crop Sci 7: 171-175.
10. Singh YV, Dhar DW, Agarwal B (2011) Influence of organic nutrient management on basmati rice (*Oryza sativa*)-wheat (*Triticum aestivum*)-green gram (*Vigna radiata*) cropping system. Indian J Agro 56: 169-75.
11. Naresh RK, Singh B, Singh SP, Singh PK, Kumar A, et al. (2012) Effect of furrow irrigated raised bed planting technique for diversification of rice-wheat system for western IGP Region. International J Life Sci Bt and Pharm Res 1: 134-141.
12. Memon SQ, Mirjat MS, Mughal AQ, Amjad N (2013) Effect of conventional and non-conventional tillage practices on maize production. Pak J Agri 29: 155-163.
13. Hakim B, Helena GM, Francisco JV (2011) Permanent bed planting in irrigated Mediterranean conditions: short-term effects on soil quality, crop yield and water use efficiency. Field Crops Research 130: 120-127.
14. Sharma GD, Thakur R, RAJ S, Kauraw DL, Kulhare PS (2013) Impact of integrated nutrient management on yield, nutrient uptake, protein content of wheat and soil fertility in a Typic Haplustert. The Bioscan 8: 1159-1164.
15. Meena D (2014) Effect of planting geometry and nutrient management on quality production of baby corn (*Zea mays* L.). Thesis submitted to the G. B. Pant university of Agriculture and Technology, Pantnagar 88.
16. Akbar F, Wahid A, Akhtar S, Ahmad AN, Chaudhary FM (1999) Optimization of method and time of nitrogen application for increased nitrogen use efficiency and yield in maize. Pak J Bot 3: 337-341.
17. Singh G, Sharma GL, Shankar (2012) Effect of integrated nutrient management on quality protein maize. Crop Res 44: 26-29.
18. Amanullah K, Marwat B, Shah P, Maula N, Arifullah S (2009) Nitrogen+ levels and its time of application influence leaf area, height and biomass of maize planted at low and high density. Pak J Bot 41: 761-768.
19. Kumar R, Singh D, Jat BL (2017) Nitrogen management maize based legume intercropping. Asian Journals of Bio Science 12: 51-78.
20. Layek J, Shivakumar BG, Rana DS, Munda S, Lakshman K (2012) Growth pattern, physiological indices and productivity of different soybean (*Glycine max*) based intercrops as influenced by nitrogen nutrition. Indian J Agron 57: 349-356.
21. Meena SR, Kumar A, Jat NK, Meena BP, Rana DS, et al. (2012) Influence of nutrient sources on growth, productivity and economics of baby corn (*Zea mays*)-mungbean (*Vigna radiata*) cropping system. Indian J Agron 57: 217-221.
22. Mashingaidze AB, Lotz LA, Werf WV, Chipomho J (2010) The influence of fertilizer placement on maize yield and growth of weeds. Scientific Conference Proceedings 786-800.

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