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# EFFECT OF CROP ESTABLISHMENT METHODS AND SEED RATES ON PRODUCTIVITY AND NUTRIENT UPTAKE BY WHEAT AND LENTIL, AND SOIL PROPERTIES

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## ABSTRACT

*A field experiment was conducted at the Crop Research Station, Ghaghraghat, Bahraich (U.P.) to study the effect of crop establishment method and seed rate on productivity and nutrient uptake by wheat and lentil crop and physico-chemical properties of soil.The treatments comprised of 4 crop establishment methods, and 3 seeding rates in wheat and lentil crop. The experiment was laid out in split-plot design with 4 replication. Sowing of wheat and lentil by zero till drill gave significantly higher grain and straw yield, wheat equivalent yield (WEY), and harvest index over reduced tillage, conventional tillage and surface seeding. The increase in grain yield due to zero-tillage was to the tune of 5.82, 15.95 and 24.18% in wheat and 3.73, 8.94 and 15.40% in lentil over reduced tillage, conventional tillage and surface seeding, respectively. The bulk density of soil, and uptake of nitrogen and phosphorus by wheat and lentil was significantly highest with zero tillage over reduced tillage, conventional tillage and surface seeding. The pH and electrical conductivity (EC) of soil were reduced under both zero tillage and surface seeding as compared to rest of tillage methods. The available N, P and K in soil after harvest of both crop was lowest with zero tillage. However, content of organic carbon was highest with zero tillage followed by reduced tillage. Sowing of 50% extra seed than normal seed rate recorded significantly higher grain, straw of wheat and lentil and wheat equivalent yield as compared to rest of seed rates. The uptake of N and P by wheat and lentil crop improved with increasing seed rate. The values of bulk density, electrical conductivity, available N, P and K and pH were reduced with increasing seed rate and lowest value were recorded with 50% extra seed. The organic carbon improved with increasing seed rate after both the crops.*

**Keywords:** Crop establishment method, seed rates, productivity, wheat, lentil

## INTRODUCTION

Rice-wheat is the most popular crop sequence in tarai areas of North eastern Plain Zone (NEPZ). Lower productivity and profitability of rice-wheat system is a major concern of the present time. Continuous growing of rice-wheat system had led to imbalance in soil fertility resulted in declining productivity. Inclusion of pulses in rice-wheat system will be helpful in improving the soil fertility and the economic conditions of small and marginal farmers owing to higher price. Patro *et al.* (2005) reported both rice and wheat are heavy feeders of nutrients and cultivation of both the cereals in a year on same piece of land has led to imbalance in soil fertility resulting in decline in yield of both crops. Since rice is the staple food of this area, one can think of replacing wheat only. Further, spread of rice-wheat system in India caused an unfavourable effect on sustainability of soil productivit; hence inclusion of legume crops in the system is essential to improve soil physical and biological properties of soil and its productivity. Rice-wheat sequence is very exhaustive as compared to rice- pulse and rice-oilseed. Continuous cropping with rice-wheat has also adversely affected the physical properties of soil. Pulse and oilseeds as receiving more attention owing to higher prices due to increased demand. To fulfill the demand of cereal, pulses and oilseeds of ever-increasing population, inclusion of pulses and oilseeds in rice based cropping sequence was found more beneficial than cereal (Kumar *et al.*, 2008). In high moisture area like tarai of Bahraich, a seed of wheat and lentil is generally broadcasted in well prepared field after rice harvest. Sowing of rice succeeding crops like wheat and lentil in this tract is generally gets delayed due to the cultivation of medium-and long-duration rice varieties and time required in field preparation of both the crops. The timely sowing of wheat and lentil is only possible by using zero till drill without tillage on residual soil moisture after the harvest of rice. Use of optimum amount of seed rate and proper method of establishment plays a vital role for timely sowing and in maintaining the adequate plant population which is a pre-requisite for obtaining higher yields. Thus, use of optimum amount of seed would be helpful in maintaining the optimum plant stand and finally the yield of crop. The scientific information on effect of crop establishment method and seed rate on wheat and lentil crop in tarai region is lacking. Keeping this in view, the present study was planned to work out a suitable combination of crop establishment method and seed rate for achieving higher productivity and profitability of wheat and lentil crops.

## MATERIALS AND METHODS

A field experiment was conducted at the Crop Research Station, Ghaghraghat, Bahraich (2705' N latitude, 8102' longitude, 112m above mean sea-level) to study the effect of crop establishment method and seed rate on productivity and nutrient uptake by wheat and lentil crop and physico-chemical properties of soil. to study the effect of crop establishment method and seed rate on productivity and nutrient uptake by wheat and lentil crop and physico-chemical properties of soil. The soil of experimental site was sandy loam with pH 8.1, low in organic C (3.7g $kg^{-1}$), low in available N (195.6 kg $ha^{-1}$), medium in available P (18.9 kg $ha^{-1}$) and K (179.5 kg $ha^{-1}$).The experiment was laid out in split-plot design, consisting of 4 crop establishment methods, viz. surface seeding, zero tillage, conventional tillage and reduced tillage as a main-plot treatments and 3 seed rates viz. 100% recommended, 25% extra than recommended and 50% extra than recommended as sub-plot treatments with 4 replications for both wheat and lentil cops. The recommended seed rate was 100 kg $ha^{-1}$ and 40 kg $ha^{-1}$ for wheat and lentil crops, respectively. Wheat Cv. 'HUW 234' and lentil Cv. 'Pant L 406' were used for sowing. Sowing in surface seeding and zero tillage was done wiyhout tillage whereas in conventional tillage, (4 ploughings) i.e. 2 ploughing by disc harrow and 2 ploughing by cultivator followed by planking after each ploughing, and in reduced tillage 2 ploughings each by disc harrow and cultivator followed by planking was performed in wheat crop. In case of lentil, conventional tillage consisted of 2 ploughings each by disc harrow and cultivator followed by planking, and reduced tillage recieved one ploughing by harrow and planking was done. In surface seeding, wheat and lentil seed were uniformly broadcasted in un-tilled wet soil surface after rice harvest. In zero tillage treatment, wheat and lentil was directly sown by zero till-drill. In conventional tillage, the seeds of both crops were broadcasted and mix-up on last ploughing, while in reduced tillage, sowing was done by seed-cum-ferti-drill. The sowing of seed of both crops was done on December 15 in surface seeding, December 21 in zero tillage and December 31in conventional and reduced tillage, respectively during both the years. Wheat and lentil crop was fertilized @ 120:60:40 and 20:40:20 kg NPK kg $ha^{-1}$, respectively, The half amount of N, and full of P and K was applied as basal in lentil, whereas, in wheat, 50% N as basal, 25% N at first irrigation and the remaining 25% N at second irrigation. All standard agronomic practices were followed to raise the experimental crops. The content of organic C and available N,P and K in the soil was determined before seeding, and after harvest of both the crops.The content of N and P in grain and straw of wheat and lentil was also analysed (Jackson 1973) for determining uptake of nutrients. The bulk density was determined using core sampler before sowing and after harvest of wheat and lentil crop. The yield of wheat and lentil crops was converted into wheat equivalent yield (WEY) by multiplying the yield with the prevailing market price of lentil and divided by price of wheat. Benefit:cost ratio (B:C ratio) was expressed as ratio of net returns divided by cost of cultivation. The soil samples collected from individual treatment after harvest of wheat and lentil crop and were analysed for available N (Subbiah and Asija, 1956), available phosphorus (Olsen *et al.*, 1954) and available K (Jackson, 1973).

## RESULTS AND DISCUSSION

### Crop establishment methods

Grain and straw yield of wheat and lentil was significantly highest (42.37 and 61.54 q $ha^{-1}$) and (13.64 and 26.69 q $ha^{-1}$) , respectively with zero tillage seeding as compared to reduced tillage, conventional tillage and surface seeding. Sowing by zero tillage increased the grain yield to the tune of 5.82, 15.95 and 24.18% in case of wheat and 3.73, 8.94 and 15.40% in case of lentil over reduced tillage, conventional tillage and surface seeding, respectively. Higher yield with zero tillage could be attributed to proper placement of fertilizer and seed which is in turn better root development and higher nutrient absorption which improved yield attributing character and finally the yield of both crops. Similar higher yield of wheat and lentil crop with zero tillage was reported by Singh *et al.* (2008) and Mishra *et al.* (2010). However, delayed sowing, uneven distribution and improper depth of sowing with conventional tillage caused significant reduction in plant population and finally the yield of both crops.The higher values of harvest index i.e. 40.77% in wheat and 33.80% in lentil was recorded with zero tillage followed by reduced tillage, conventional tillage and surface seeding.This was because of higher proportion of grain yield to total biological yield with zero tillage treatment. Surface seeding had the lowest values of harvest index i.e. 40.64% in wheat and 33.31% in lentil. The higher values of harvest index with Zero tillage could be attributed to higher proportion of grain yield in total biological yield. Zero tillage had the highest wheat equivalent yield (51.78 q $ha^{-1}$) which was followed by reduced tillage, conventional tillage and surface seeding owing to higher yields. This was because of higher yield with zero tillage.

Table 1: Effect of crop establishment and seed rate on yield of wheat and lentil and wheat grain equivalent yield (average of 2 years)

| Treatment | Wheat yield (q ha$^{-1}$) | | Harvest index (%) | Lentil yield (q ha$^{-1}$) | | Harvest index ( %) | WEY (q ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| | Grain | Straw | | Grain | Straw | | |
| Crop establishment | | | | | | | |
| Surface seeding | 34.12 | 49.83 | 40.64 | 11.82 | 23.51 | 33.46 | 44.87 |
| Zero tillage | 42.37 | 61.54 | 40.77 | 13.64 | 26.69 | 33.80 | 51.78 |
| Conventional tillage | 36.54 | 53.34 | 40.65 | 12.52 | 25.00 | 33.31 | 47.53 |
| Reduced tillage | 40.04 | 58.22 | 40.75 | 13.15 | 26.25 | 33.37 | 49.92 |
| SEm $^{+}_{-}$ | 0.45 | 0.64 | 0.06 | 0.13 | 0.25 | 0.04 | 0.57 |
| CD (P=0.05) | 0.95 | 1.36 | NS | 0.27 | 0.53 | 0.09 | 1.29 |
| Seed rate (kg ha$^{-1}$) | | | | | | | |
| Wheat Lentil | | | | | | | |
| 100 40 | 35.33 | 51.44 | 40.71 | 11.89 | 23.55 | 33.53 | 45.14 |
| 125 50 | 39.14 | 56.99 | 40.71 | 13.04 | 25.88 | 33.50 | 49.50 |
| 150 60 | 40.34 | 58.77 | 40.70 | 13.41 | 26.66 | 33.45 | 50.91 |
| SEm $\pm$ | 0.44 | 0.64 | 0.02 | 0.13 | 0.29 | 0.04 | 0.53 |
| CD (P=0.05) | 0.88 | 1.29 | NS | 0.26 | 0.59 | NS | 1.09 |

The uptake of nitrogen and phosphorus by wheat through grain and straw was significantly highest (77.51 and 21.33 kg ha$^{-1}$) and (22.44 and 6.72 kg ha$^{-1}$), respectively with zero tillage over reduced tillage, conventional tillage and surface seeding. Reduced tillage depleted significantly higher amount of nitrogen and phosphorus by wheat through grain and straw as compared to conventional tillage and surface seeding. Surface seeding recorded significantly the lowest uptake of N and P by wheat through grain and straw. The higher uptake of N and P by wheat under zero tillage was mainly due to higher grain and straw yield. However, poor grain and straw yield with surface seeding resulted in the lowest uptake of N and P by wheat through grain and straw (Kumar and Yadav, 2005 and Singh *et al.*, 2008).Lentil sown either zero tillage or reduced tillage was on par but recorded higher uptake of N and P through grain and straw as compared to conventional tillage and surface seeding. This higher uptake with zero tillage and reduced tillage was because of higher grain and straw yield. The amounts of residual available N,P and K after harvest of both crops were reduced due to different method of establishment as compared to its initial values. However, sowing of both crops by zero tillage recorded the lowest residual available N, P and K followed by reduced tillage, conventional tillage and surface seeding. This could be attributed to higher uptake of nutrients due to higher grain yield and straw yield of both crops sown under zero tillage and reduced tillage resulted in lower amount of available N,P and K in soil. The reduction of available N, P and K in soil as compared to its initial values, in general was mainly due to addition of insufficient amount of above nutrients to soil. Contrary, to this lower yield and uptake of nutrients under surface seeding and conventional tillage resulted higher amount of residual available N, P and K in soil after harvest of both crops. The bulk density was maximum (1.49 Mg m$^{-3}$) in wheat and (1.48 Mg m$^{-3}$) in lentil under surface seeding followed by zero tillage with 1.48 Mg m$^{-3}$ in wheat and 1.46 Mg m-3 in lentil. Conventional tillage recorded the lowest values of bulk density i.e. 1.40 Mg m$^{-3}$ after harvest of both the crops. The higher bulk density under surface seeding and zero tillage was due to compaction of soil owing to decrease in volume of soil due to its less disturbances. However, lower values of bulk density with conventional tillage might be attributed to increased soil volume under pulverised condition due to loosening of soil mass. The pH and electrical conductivity of soil were reduced under zero tillage followed by surface seeding, conventional tillage and reduced tillage. This is because of increase in organic carbon content in soil due to higher root biomass which released certain organic acids during decomposition resulted in lowering the soil pH.The content of organic carbon in soil improved with both zero tillage and surface seeding, however, remained uncharged under conventional tillage and reduced tillage. This improvement may be due to addition of organic matter through higher root biomass under zero tillage as compared to conventional tillage and reduced tillage.

**Effect of seed rate**

The grain and straw yield of wheat and lentil crop increased significantly with increasing seed rate from 100% recommended to 50% extra than recommended seed rate. Sowing of 50% extra seed than normal seed rate recorded significantly higher grain and straw (40.34 and 58.77 q ha$^{-1}$) of wheat and (13.41 and 26.66 q ha$^{-1}$) lentil yield, respectively as compared to 25% extra seed than normal and 100%

Table 2: Effect of crop establishment and seed rate on N and P uptake (Kg $ha^{-1}$) by wheat and lentil crop (average of 2 years)

| Treatment | Wheat | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|
| | N uptake | | P uptake | | N uptake | | P uptake | |
| | Grain | Straw | Grain | Straw | Grain | Straw | Grain | Straw |
| Crop establishment | | | | | | | | |
| Surface seeding | 63.81 | 18.27 | 18.46 | 5.94 | 46.28 | 20.33 | 5.13 | 4.51 |
| Zero tillage | 77.51 | 21.33 | 22.44 | 6.72 | 52.62 | 22.42 | 5.64 | 4.84 |
| Conventional tillage | 67.80 | 19.31 | 19.90 | 5.80 | 48.86 | 21.50 | 5.43 | 4.68 |
| Reduced tillage | 73.46 | 20.17 | 21.40 | 6.05 | 50.81 | 22.17 | 5.51 | 4.77 |
| SEm $^{+}$ | 1.22 | 0.26 | 0.34 | 0.15 | 1.31 | o.61 | 0.18 | 0.13 |
| CD (P=0.05) | 2.76 | 0.59 | 0.77 | 0.34 | 2.96 | 1.62 | 0.41 | 0.30 |
| Seed rate (kg $ha^{-1}$) | | | | | | | | |
| Wheat Lentil | | | | | | | | |
| 100 40 | 66.03 | 18.44 | 19.25 | 5.91 | 46.69 | 20.31 | 5.18 | 4.52 |
| 125 50 | 72.66 | 20.12 | 20.93 | 6.09 | 50.55 | 21.93 | 5.54 | 4.72 |
| 150 60 | 73.76 | 20.76 | 21.57 | 6.39 | 51.68 | 22.59 | 5.57 | 4.86 |
| SEm $\pm$ | 1.25 | 0.31 | 0.42 | 0.16 | 0.97 | 0.90 | 0.19 | 0.14 |
| CD (P=0.05) | 2.58 | 0.64 | 0.87 | 0.38 | 2.00 | 1.86 | NS | 0.29 |

recommended seed rate. The percent increase in grain yield due to 50% extra seed than normal was recorded to be 14.18 and 10.78 with wheat and 12.78 and 9.67 with lentil, respectively over 25% extra than recommended and 100% recommended, respectively. The values of harvest index of both crop was reduced with increasing seed rate from 100% recommended seed rate to 50% extra seed than 100% recommended due to decrease the proportion of grain yield to total biological yield with increasing seed rate.The higher grain and straw yield with 50% extra seed than normal seed rate was mainly due to higher number of effective shoot/unit area. Similar higher grain and straw yield with higher seed was reported by Pandey *et al.* (2004) in wheat and Singh and Singh (2007) in lentil crop.

Table 3: Effect of crop establishment and seed rate on soil properties after 2 years

| Treatment | Bulk density ($Mg/m^3$) | Soil pH | Soil EC ($dS\ m^{-1}$) | Organic carbon ($g\ kg^{-1}$) | Available nutrients (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|
| | | | | | N | P | K |
| Crop establishment | | | | Wheat | | | |
| Surface seeding | 1.49 | 7.32 | 0.410 | 0.40 | 173.8 | 15.8 | 169.5 |
| Zero tillage | 1.48 | 7.85 | 0.411 | 0.40 | 164.7 | 15.0 | 165.2 |
| Conventional tillage | 1.40 | 8.17 | 0.415 | 0.37 | 172.4 | 15.7 | 168.9 |
| Reduced tillage | 1.42 | 8.07 | 0.413 | 0.38 | 170.3 | 15.4 | 167.0 |
| SEm $^{\pm}$ | 0.02 | 0.04 | 0.002 | 0.01 | 1.24 | 0.22 | 1.32 |
| CD (P=0.05) | 0.05 | 0.36 | NS | 0.02 | 2.80 | 0.50 | 2.99 |
| Seed rates | | | | | | | |
| 100 | 1.46 | 8.01 | 0.413 | 0.38 | 171.2 | 15.6 | 168.2 |
| 125 | 1.45 | 7.98 | 0.412 | 0.39 | 170.2 | 15.4 | 167.5 |
| 150 | 1.44 | 7.93 | 0.411 | 0.40 | 169.3 | 15.3 | 167.3 |
| SEm$^{\pm}$ | 0.01 | 0.02 | 0.003 | 0.01 | 1.33 | 0.28 | 0.86 |
| CD (P=0.05) | NS | 0.05 | NS | NS | NS | NS | NS |
| Crop establishment | | | | Lentil | | | |
| Surface seeding | 1.48 | 7.91 | 0.389 | 0.49 | 181.7 | 16.7 | 172.3 |
| Zero tillage | 1.46 | 7.90 | 0.389 | 0.50 | 172.4 | 15.5 | 168.1 |
| Conventional tillage | 1.40 | 8.14 | 0.393 | 0.46 | 180.2 | 16.4 | 171.8 |
| Reduced tillage | 1.43 | 8.05 | 0.392 | 0.47 | 178.1 | 16.2 | 169.8 |
| SEm $^{\pm}$ | 0.01 | 0.12 | 0.002 | 0.01 | 1.25 | 0.20 | 1.36 |
| CD (P=0.05) | 0.02 | 0.30 | NS | 0.02 | 2.83 | 0.45 | 3.08 |
| Seed rates | | | | | | | |
| 40 | 1.45 | 7.99 | 0.391 | 0.47 | 179.1 | 16.5 | 171.0 |
| 50 | 1.44 | 7.96 | 0.391 | 0.48 | 178.0 | 16.1 | 170.3 |
| 60 | 1.44 | 7.94 | 0.390 | 0.49 | 177.4 | 16.0 | 170.3 |
| SEm$^{\pm}$ | 0.01 | 0.02 | 0.001 | 0.01 | 1.36 | 0.27 | 0.90 |
| CD (P=0.05) | NS | 0.05 | NS | NS | NS | NS | NS |
| Initial Value | 1.40 | 8.10 | 0.417 | 3.7 | 195.6 | 18.9 | 179.5 |

Wheat equivalent yield was significantly increased with corresponding increase in seed rate from 100% recommended to 50% extra seed than recommended However, the maximum WEY (50.91 q $ha^{-1}$) being with 50% extra seed than recommended which was followed by 25% extra seed than recommended (49.50 q $ha^{-1}$) and 100% recommended seed rate (45.14 q $ha^{-1}$). The bulk density, electrical conductivity, available N,P and K and pH reduced with increasing seed rate from 100% recommended to 50% extra seed than recommended after both crops ( Table 3). However, sowing of 50% extra seed than normal recorded the lowest values of bulk density, pH, available N, P and K as compared to its initial values. The reduction in bulk density, EC and pH with higher seed rate might be due to addition of organic carbon due to better root development and higher root biomass in soil plays a vital role in improving physico-chemical properties of soil in terms of bulk density, EC and soil pH. The reduction of available N, P and K in soil after harvest of both crops due to increasing seed rate was mainly due to absorption of more nutrients by crop due to higher yield resulted in lower amount of residual available N, P and K in soil.The organic carbon was improved with increasing seed rate in both the crops. Higher root biomass within higher plant population of crops sown with higher seed rate resulted in significant improvement in organic carbon in soil.

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