Some agricultural practices for improving the productivity of moderately sodic soil II: wheat yield, nutrient status, and economic potentiality

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Abstract

To evaluate the effect of some agricultural practices, namely, tillage systems (shallow and subsoiling), gypsum application (0.0, 4.76 and 9.52 t/ha), and farmyard manure (FYM) application (0.0, 11.9, 23.8 and 35.7 m³/ha) on grain and/or straw yields, nutrient status and economic potentiality of wheat grown on moderately sodic soil, two successive seasons of 2015/2016 and 2016/2017 were carried out at Agricultural Farm of Sids Station, ARC, Egypt. The main results can be summarized as follow: Highest values of grain and/or straw yields, N, P, and K concentrations, and uptake of both grain and straw were recorded under subsoiling tillage, 9.52 t/ha gypsum or 35.7 m³/ha FYM than other treatments. Considering the economic analysis, the treatment of zero or 4.76 t/ha gypsum plus 35.7 m³/ha FYM under subsoiling operation resulted in the highest net return of wheat production. Therefore, under moderately sodic soil, it could be concluded to use subsoiling tillage and add 4.76 t/ha gypsum and 35.7 m³/ha FYM to attain maximum economic productivity of wheat.

Keywords Agricultural practices, Farmyard manure, Straw yields, Wheat production

Introduction

After maize and rice, wheat is the third cereal crop all over the world, but in human dietary intake, it is the second after rice as the main food crop. It supplies about 20% of food calories for world people (Hamouda et al., 2015), whereas in Egypt it provides about 37 and 40% of total calories and protein for the people, respectively. Wheat is used for making bread, pastas as well as other bakery products, therefore it considers the main source of nutrients for the world population. Also in Egypt, wheat straw is the main source of animal feeding. The total grain yield of wheat reached about a million tons, which cover only about 60% of local consumption demand. Therefore, the policy of the Egyptian Governorate aimed to increase wheat production by increasing the lands cultivated by wheat as well as improving the cultural practices for maximizing wheat yield such as growing high yielding varieties, tillage process, fertilization, elimination soil problems such as salinity and alkalinity, etc. Tillage systems are a cultural practice widely used all over the world with several different modifications aimed to, prepare seedbeds that are elevated above the land surface of the field.

Tillage defined as mechanical operations of the soil for plant growing resulted in various purposes such as improving soil temperature, infiltration rate, soil salinity and pH, and soil organic matter (Strudley et al., 2008). There are many factors used to choose the kind of tillage, such as climate, crops, labor-intensive management, fertility, water management, water, and wind erosion control. Irshad et al. (2017) mentioned that tillage can classify into two types: conventional tillage and conservation tillage. They added conventional tillage aims to keep the plant residues and manures soil surface, however conservation tillage is concerned with the preparation of seedbed that contains residue mulch and enhanced the roughness of soil surface. Furthermore, Li et al. (2020) stated that due to subsoil compaction resulting from long-term conventional tillage which is harmful to soil properties and plant growth, the use of deep tillage has a beneficial effect on these problems. They pointed out that deep tillage improved soil bulk density and soil porosity, increased soil water capacity, and aboveground biomass. Many workers stated the positive effect of subsoiling
tillage on soil properties and crop production (Jiao et al., 2017; Soltanabadi et al., 2018; Tahir et al. 2018; Wang et al., 2019).

Due to its cheaper, gypsum considers the most important amendment for sodic soil. Abdel-Fattah (2011) reported that gypsum application improved physical soil properties, such as pH, EC, ESP, bulk density as well as increased hydraulic conductivity and infiltration ratio. Also, Genaidy (2011) mentioned that added gypsum before crops planting in slightly to moderately sodic soil resulted in a positive effect on crop production, which mainly due to its amelioration effect, e.g. improved various physicochemical characters and promotive nutrient uptake. Wong et al. (2009), Chaudhary et al. (2015), Genedy et al. (2018) El-Sheref et al. (2019), and Abbas and Hussain (2020) stated that gypsum application increased wheat productivity and nutrient absorption by plant roots.

Organic manure has a favorable effect in sustaining soil properties and fertility by supplying plants with nutrients and improving soil physical properties. Youssef et al. (2020) indicated that farmyard manure application has many advances, such as increases in nutrient uptake, enhancing soil biological activity as well as improved chemical and physical soil properties. In addition, Ayyat (2017) mentioned that farmyard manure as an organic application resulted in enhanced nutrient release, has a positive effect on microorganisms and earthworms activity, improved root growth, and can control some plant diseases. Many investigators stated the beneficial effect of treated wheat plant with organic manure on nutrient uptake and yields Ali et al. (2009a), Shah et al. (2013) and Galal et al. (2017) for nutrient status and yields as well as Ali et al. (2009b) Genedy et al. (2018), and Hussain (2020) for wheat productivity.

The objective of this work is aimed to evaluate the response of wheat yields, nutrient uptake, and some economic parameters of wheat productivity to the application of gypsum and farmyard manure under two tillage systems, i.e., shallow and subsoiling tillage and their interaction.

**Materials and methods**

Two field experiments were conducted at the Sids Agricultural Research Station Farm, ARC, Beni Suef Governorate, Egypt (Lat. 29°04’ N, Long. 31°6’ E and 30.4 m above sea level) in two successive seasons of 2015/2016 and 2016/2017 to study the effect of gypsum (0.0, 4.76 and 9.52 t/ha) and farmyard manure (0.0, 11.9, 23.8 and 35.7 m³/ha) under two tillage systems (shallow and subsoiling) on wheat yield, nutrient status, and some economic measurements. A surface soil sample (0-30 cm depth) was taken before planting to determine soil physical and chemical properties according to A.O.A.C. (1990) and listed in Table 1.

The experimental design was split-split in four replications in complete randomized blocks. The tillage treatments were located in the main plot. The gypsum levels were arranged in sub-plots, while farmyard manure treatments were applied in sub-sub plots. The conventional tillage (T1) for wheat was done by using two passes of a disc, while sub-soiler (about 90 cm depth) represented the subsoiling tillage (T2). Representative samples of farmyard manure used in the two seasons were taken to determine its chemical properties according to A.O.A.C. (1990) and listed in Table 2.

### Table 1. Physico-chemical characteristics analysis of soil before sowing

| Characteristics                        | 1st season | 2nd season |
|----------------------------------------|------------|------------|
| Particle size distributions (%):       |            |            |
| Coarse sand                            | 0.36       | 0.55       |
| Fine sand                              | 18.73      | 15.17      |
| Silt                                   | 29.12      | 31.09      |
| Clay                                   | 51.79      | 53.19      |
| Textural class                         | Clay       | Clay       |
| ESP (%)                                | 14.70      | 14.35      |
| Field capacity (%)                     | 44.31      | 46.15      |
| Available water (%)                    | 22.72      | 21.22      |
| Wilting point (%)                      | 21.59      | 24.93      |
| pH (1:2.5 soil-water suspension)       | 8.43       | 8.45       |
| EC (dSm⁻¹), 1:5 soil-water extraction  | 1.42       | 1.49       |
| Total carbonate (mg/g)                 | 11.1       | 15.7       |
| Organic matter (mg/g)                  | 10.6       | 10.5       |
| Available N mg/kg soil                 | 19.35      | 21.27      |
| Available P mg/kg soil                 | 12.14      | 13.39      |
| Available K mg/kg soil                 | 176.4      | 186.1      |

### Table 2. Some chemical analysis of FYM used in the experiments in both growing seasons

| Chemical properties                  | 2015/2016 | 2016/2017 |
|--------------------------------------|-----------|-----------|
| EC (1:15, soil-water extraction)     | 5.90      | 6.20      |
| Organic carbon (mg/g)                | 169.0     | 184.0     |
| Organic matter (mg/g)                | 291.4     | 317.2     |
| Total N (mg/g)                       | 16.2      | 17.4      |
| Total P (mg/g)                       | 3.3       | 3.6       |
| Total K (mg/g)                       | 14.0      | 14.4      |
| C/N ratio                            | 10.1      | 11.1      |

Grains of Beni Suef 5 of wheat were planted on 15 and 20 November at rate of 142.8 kg/ha for the two studied seasons, respectively in plots (4 x 5.25 m = 21 m² = 1/476 ha) in 15 cm between rows. All plots fertilized with 178.5 kg N/ha as urea (46.0 % N), 54.74 kg P₂O₅/ha as mono-calcium superphosphate (15.5% P₂O₅) and 57.12 kg K/ha as potassium sulphate (48 % K₂O). The recommended cultural practices for wheat were done as in the district.

At harvest ten wheat plants were randomly taken to determine plant height, number of spikes/m², number of...
grains/spike, and 1000-grain weight. Also, grain and straw yields from grains and straw were randomly taken from each plot to determine N, P, and K concentrations in both grains and straw. N, P and K uptake in grains and/or straw were calculated by multiplying the nutrient concentration by grain or straw yields. Also, protein content in grains was calculated by multiplying nitrogen concentration by 5.70.

Some economic measurements, i.e., total gross parameters; total net return and beneficial cost ratio were estimated as follow:

- Total gross return (L.E/ha.) = Total grain or straw yield x its price.
- Total net return (L.E/ha.) = Total gross return – total cultivation cost.
- Beneficial cost ratio = \[
\frac{\text{Total gross return}}{\text{Total cultivation cost}}
\]

The total cultivation cost of wheat during the growing season was determined as the sum of land rent, land preparation; except tillage processes, irrigations, fertilizers, and cost of weed, insect, and fungi control as well as the cost of grains and straw harvest. Also, the cost of the studied factors, i.e., tillage, gypsum, and farmyard manure were estimated.

The results were subjected to statistical analysis according to the method described by Snedecor and Cochran (1980). The differences between the studied treatments were compared by using LSD at a 5% level of probability.

**Results and discussion**

**Yield potentiality**

The data of wheat yield potentiality in terms of grain yield, straw yield, and biological yield as affected by tillage system as well as gypsum and farmyard manure application were given Table 3. The main effect of tillage indicates that subsoiling tillage produced grain, straw and biological yields surpassed that due to shallow one by about 3.4, 3.9, and 3.7% in the first season. The corresponding increasing in the second season were 2.9, 2.5, and 2.7% in the abovementioned order. The promotive effect of deep tillage on wheat yields was mainly due to the positive effect of subsoiling on soil properties and soil fertility, which in turn improved wheat growth. These results are in line with those obtained by Hammel (1995) and Alam et al. (2014) who found that deeper tillage increased wheat grain and straw yields than a shallow one.

With regard to the main effect of gypsum, the data clearly show that wheat yields were gradually increased as gypsum levels increased. Comparing with no gypsum, added 9.52t gypsum/ha increased grain, straw and biological yields by about 8.5, 6.5 and 7.3% in the first season and 7.8, 7.5, and 7.7% in the second one. The beneficial effect of gypsum on wheat productivity is mainly due to its positive effect on improving physical and chemical soil properties, in turn, enhanced wheat growth (Table 6), consequently increasing grain and/or straw yields. These results were confirmed by many investigators such as Gelderman et al. (2004), Taha et al. (2010), Genaidy (2011), Bello (2012), Genedy et al. (2018), and El-Sheref et al. (2019) who reported that gypsum application had a positive effect on wheat productivity, especially under slightly or moderately saline soil. As for the main effect of farmyard manure, the obtained results show that wheat grain and/or straw were positively responded to FYM application. It is obvious to notice that wheat productivity was increased as FYM levels increased. The augmentation in wheat yields caused by organic manure application may be explained by the effect of organic manure on amelioration soil properties and fertility which enhanced wheat vegetative growth as discussed formerly. The results achieved from this research were confirmed to those established by many workers such as Ali et al. (2009a), Shah et al. (2010), Taha et al. (2010), Shah et al. (2013), Irshad et al. (2017), Galal et al. (2017) and Genedy et al. (2018) who stated that added FYM to wheat resulted in enhanced its grains and straw yields.

Concerning the response of wheat yields to the interaction between any two factors or among them, the data show that grain, straw, and biological yields were significantly affected by these interactions. Mixed gypsum with organic manure enhanced its effect on wheat productivity, especially under subsoiling tillage. In general, the maximum wheat productivity was produced for the treatment of subsoiling + 9.52 t/ha gypsum + 35.7 m³/ha FYM (7.081, 10.384, and 17.465 t/ha) in the first season and 7.363, 10.436, and 17.819 t/ha in the second one for grain, straw, and biological yields, respectively. On the other hand, the treatment of shallow tillage without both gypsum and FYM recorded the lowest abovementioned yield potentiality (5.238, 8.132, and 13.371 in the first season and 5.539, 8.249, and 13.818 t/ha in the second one, respectively). These results are similar to those obtained by Ghafoor et al. (2001), Choudhary et al. (2004), Wong et al. (2009), and Genedy et al. (2018) who mentioned that physical and chemical soil properties are improved due to mixed of gypsum with FYM as soil remediation for sustainable soil usage and crop production.

**Nutrients status**

The data in Tables 4, 5, and 6 represent the effect of tillage systems, gypsum, and FYM application on nutrients status of wheat expressed as N, P, and K uptake and protein yield in wheat grains; N, P, and K uptake in wheat straw and total N, P and K. As for the main effect of tillage, the data reveal that N, P and K uptake in grains and/or straw, as well as total N, P and K uptake, were significantly affected by tillage operation, where subsoiling tillage recorded the highest values of it. The increments in N, P and K uptake and protein yield in grains and total N, P and K in wheat plant were 7.0, 7.9, 5.4 and 7.0 and 7.1, 11.4 and 5.6% due to deep tillage when compared with shallow one in the first season, respectively. Same trends were obtained in the second season.
Table 3. Yield measurements of wheat as affected by gypsum and FYM application under different tillage systems

| Treatments | 2015/2016 | 2016/2017 |
|------------|-----------|-----------|
|            | Grain yield (t/ha) | Straw yield (t/ha) | Biogical yield (t/ha) | Grain yield (t/ha) | Straw yield (t/ha) | Biogical yield (t/ha) |
| Gypsum (t/ha) | FYM (m³/ha) | Gypsum (t/ha) | Mean | Gypsum (t/ha) | Mean | Gypsum (t/ha) | Mean |
| Shallow     | Gypsum (0.0) | 0.0 | 5.238 | 8.132 | 13.370 | 5.569 | 8.249 | 13.818 |
|             |            | 11.9 | 5.883 | 9.189 | 15.072 | 5.986 | 8.811 | 14.796 |
|             |            | 23.8 | 6.029 | 9.234 | 15.263 | 6.326 | 9.127 | 15.453 |
|             |            | 35.7 | 6.178 | 9.384 | 15.562 | 6.474 | 9.947 | 15.946 |
| Mean        |            |     | 6.382 | 9.895 | 14.817 | 6.089 | 8.915 | 15.004 |
| Gypsum (0.1) | 0.0 | 5.798 | 8.844 | 14.642 | 5.876 | 8.739 | 14.615 |
|             |            | 11.9 | 6.021 | 9.201 | 15.222 | 6.309 | 9.418 | 15.727 |
|             |            | 23.8 | 6.321 | 9.446 | 15.767 | 6.712 | 9.882 | 16.593 |
|             |            | 35.7 | 6.619 | 9.556 | 16.175 | 7.083 | 10.039 | 17.122 |
| Mean        |            |     | 6.190 | 9.262 | 15.452 | 6.495 | 9.519 | 16.014 |
| Gypsum (0.5) | 0.0 | 5.857 | 9.092 | 14.949 | 5.952 | 8.832 | 14.784 |
|             |            | 11.9 | 6.010 | 9.444 | 15.454 | 6.488 | 9.665 | 16.153 |
|             |            | 23.8 | 6.402 | 9.572 | 15.974 | 7.104 | 9.879 | 16.153 |
|             |            | 35.7 | 6.712 | 9.906 | 16.618 | 7.166 | 10.044 | 17.210 |
| Mean        |            |     | 6.245 | 9.503 | 15.748 | 6.678 | 9.605 | 16.283 |
| Gypsum (1.0) | 0.0 | 5.548 | 8.454 | 14.002 | 5.838 | 8.594 | 14.432 |
|             |            | 11.9 | 5.933 | 9.294 | 15.227 | 6.226 | 9.044 | 15.270 |
|             |            | 23.8 | 6.119 | 9.558 | 15.677 | 6.628 | 9.342 | 15.970 |
|             |            | 35.7 | 6.233 | 9.599 | 15.382 | 6.902 | 9.741 | 16.643 |
| Mean        |            |     | 5.958 | 9.226 | 15.184 | 6.399 | 9.180 | 15.579 |
| Gypsum (1.5) | 0.0 | 5.926 | 9.130 | 15.056 | 5.869 | 9.044 | 14.913 |
|             |            | 11.9 | 6.086 | 9.551 | 15.637 | 6.495 | 9.532 | 16.027 |
|             |            | 23.8 | 6.507 | 9.891 | 16.398 | 6.907 | 9.903 | 16.810 |
|             |            | 35.7 | 7.004 | 10.272 | 17.276 | 7.319 | 10.353 | 17.672 |
| Mean        |            |     | 6.381 | 9.711 | 16.092 | 6.648 | 9.708 | 16.356 |
| Gypsum (2.0) | 0.0 | 5.988 | 9.199 | 15.187 | 5.976 | 9.282 | 15.258 |
|             |            | 11.9 | 6.355 | 9.765 | 16.120 | 6.676 | 9.665 | 16.341 |
|             |            | 23.8 | 6.771 | 10.213 | 16.984 | 7.095 | 10.046 | 17.141 |
|             |            | 35.7 | 7.081 | 10.384 | 17.465 | 7.383 | 10.436 | 17.819 |
| Mean        |            |     | 6.549 | 9.890 | 16.439 | 6.783 | 9.857 | 16.640 |
| Mean of gypsum (t/ha) | 0.0 | 5.895 | 9.106 | 15.001 | 6.244 | 9.048 | 15.291 |
|             | 4.76 | 6.285 | 9.486 | 15.771 | 6.571 | 9.614 | 16.185 |
|             | 9.52 | 6.397 | 9.697 | 16.094 | 6.730 | 9.731 | 16.461 |
| Mean of FYM (m³/ha) | 0.0 | 5.726 | 8.808 | 14.534 | 5.847 | 8.790 | 14.637 |
|             | 11.9 | 6.048 | 9.407 | 15.545 | 6.363 | 9.356 | 15.719 |
|             | 23.8 | 6.358 | 9.652 | 16.010 | 6.795 | 9.697 | 16.492 |
|             | 35.7 | 6.638 | 9.850 | 16.488 | 7.054 | 10.014 | 17.069 |
| L.S.D at 0.05 | A | 0.014 | 0.068 | 0.082 | 0.022 | 0.089 | 0.068 |
|             | B | 0.027 | 0.052 | 0.081 | 0.011 | 0.060 | 0.068 |
|             | AB | 0.038 | 0.074 | 0.116 | 0.016 | 0.084 | 0.096 |
|             | C | 0.015 | 0.048 | 0.052 | 0.016 | 0.069 | 0.065 |
|             | AC | 0.021 | 0.068 | 0.074 | 0.022 | 0.097 | 0.092 |
|             | BC | 0.025 | 0.084 | 0.090 | 0.028 | 0.118 | 0.113 |
|             | ABC | 0.036 | 0.118 | 0.127 | 0.039 | 0.167 | 0.160 |
The positive effect of deep tillage in nutrient uptake may be due to subsoiling operations reduced the penetration resistance in soil, consequently improved root growth and nutrient absorption by crops (Rusu et al., 2011) and Moraru and Rusu (2012). Moreover, Alam et al. (2014) reported that deep tillage improved nutrient uptake of wheat by increasing the root mass density of wheat. These results are in line with those obtained by Taha et al. (2010) and Alam et al. (2014).

season. Similar trends were obtained for the second season and wheat straw. The decline in soil pH resulting from gypsum application and the enhancement in soil fertility due to gypsum is a good explanation for its beneficial effect on the nutrient status of wheat. These findings are in harmony with those obtained by Genaidy (2011), Genedy et al. (2018), and El-Shereif et al. (2019) who stated that gypsum application to wheat plants enhanced its nutrient content in both grains and straw.

As for organic manure, the results show that irrespective of tillage and gypsum treatments, farmyard manure had a positive effect on nutrient adsorption in both grains and straw. The maximum nutrient uptake was recorded under using 35.7 t/ha FYM, where it enhanced N, P, and K uptake and protein in grains as well as total N, P, and K by about 22.6, 37.3, 32.5 and 22.6 and 23.0, 40.0 and 22.0 % over without manure, respectively in the first season. The same trends were obtained in the second season and wheat straw. The improvement in nutrient status could be attributed to chelated compounds resulting by FYM decomposition (Ali et al., 2009b). These results confirmed by many authors such as Mekail et al. (2006), Shah et al. (2013), and Galal et al. (2017).

Considering the effect of the interaction between treatments, the results show that nutrient status in wheat plants were significantly affected by the interaction between the studied factors. Gypsum application has a synergistic effect on the enhancement of nutrient status caused by organic manure under deep tillage. The relative increasing of N, P and K uptake and protein in grains and total N, P and K uptake due to incorporated gypsum with FYM under subsoiling tillage reached to 43.0, 64.9, 72.0 and 43.0 and 45.8, 72.2 and 46.6 % when compared with the treatment of without both gypsum and farmyard manure under shallow tillage.

**Economic analysis**

Gross income, i.e., human labor costs (L.E./ha), machine labor costs (L.E./ha), variable costs (L.E./ha), total cultivation costs (L.E./ha), gross return (L.E./ha), net return (L.E./ha), return over variable costs (L.E./ha), beneficial cost ratio and product profit margin ratio (%) were calculated to represent the economic measurements for these studied factors. Table 7 represents the total cultivation cost of wheat production, whether the common costs or variable costs, put the main effect of gypsum into consideration, the data reveal that nutrient uptake was positively affected by gypsum application, where increasing gypsum levels resulted in a significant increase in nutrient status. The relative increments in N, P and K uptake and protein yield in grains as well as total N, P and K uptake in the wheat plant caused by 9.52 t/ha gypsum were 10.4, 12.7, 14.9 and 10.4 and 9.8, 11.4, and 8.2 % over without gypsum, respectively in the first while Tables 8 and 9 show the effect of the studied variables on this economic analysis. In general, the obtained results indicate that the subsoiling system enhanced the studied economic measurements than the shallow one. The values of the abovementioned parameters owing to deep tillage were 3631.9 (L.E.), 2582.3 (L.E.), 10598.9 (L.E.), 21701.6 (L.E.), 25315.7 (L.E.), 3614.1 (L.E.), 14716.8 (L.E.), 1.17 and 14.14 %, while these values due to shallow one were 3542.2 (L.E.), 2461.3 (L.E.), 10122.9 (L.E.), 21225.6 (L.E.), 24477.3 (L.E.), 3251.6 (L.E.), 14354.3 (L.E.), 1.15 and 13.20 % in the first season, respectively. Similar results were obtained by Megahed and Salleh (2014). As for gypsum, the data reveal that human labor costs (L.E./ha), machine labor costs (L.E./ha), variable costs (L.E./ha), total cultivation costs (L.E./ha), gross return (L.E./ha), net return (L.E./ha), return over variable costs (L.E./ha), beneficial cost ratio and product profit margin ratio (%) was increased as gypsum levels increased up to 9.52 t/ha. The relative increments of these measurements due to added 9.52 t/ha gypsum were 3.2, 7.9, 15.9, 7.4, 7.5, 12.8, 2.8, 0.9, and 4.4% over without gypsum in the first season, respectively. The same trend was observed in the second season. Also, the data indicate that increasing organic manure levels were positively affected all studied economic measurements. Comparing with no manuring added 35.7 m³/ha FYM increased these parameters by about 4.5, 8.0, 20.3, 9.3, 14.7, 37.5, 10.8, 4.4 and 37.3%, respectively in the first season. The corresponding increments in the second season were 4.5, 8.2, 18.6, 8.5, 18.5, 67.4, 19.0, 9.1 and 40.5%. The data of the interaction clearly show that mixed 4.76 t/ha gypsum with 35.7 m³/ha FYM recorded the highest net return under subsoiling tillage, where the difference between them did not reached to the significant value.

Moreover, the T-Test analysis of some economic measurements, i.e., human labor cost (L.E./ha), machine labor costs (L.E./ha), variable cost (L.E./ha), total cost (L.E./ha), gross return (L.E./ha), net return (L.E./ha), return over variable costs (L.E./ha), beneficial cost ratio and product profit % are given in Table 10. The data clearly confirmed the positive effect of subsoiling as well as gypsum and FYM application on these economic parameters. Similar results were obtained by Ghoname et al. (2014).
Table 4. N, P and K uptake (kg/ha) and protein yield (kg/ha) in grains as affected by gypsum and FYM application under different tillage systems

| Treatments | 2015/2016 | 2016/2017 |
|------------|-----------|-----------|
|            | N uptake  | P uptake  | K uptake  | Protein yield | N uptake  | P uptake  | K uptake  | Protein yield |
| Shallow    |           |           |           |               |           |           |           |               |
| Gypsum (0.0) | 108.96   | 19.749   | 17.286   | 621.063       | 111.38   | 22.053    | 18.935    | 634.889       |
| Gypsum (4.76) | 108.96   | 19.749   | 17.286   | 621.063       | 111.38   | 22.053    | 18.935    | 634.889       |
| Mean       | 126.35    | 24.233   | 22.367   | 720.184       | 137.20   | 27.255    | 24.561    | 782.021       |
| Subsoiling |           |           |           |               |           |           |           |               |
| Gypsum (0.0) | 113.18   | 21.082   | 18.307   | 645.097       | 120.27   | 23.353    | 19.966    | 685.514       |
| Gypsum (4.76) | 126.90   | 24.021   | 25.501   | 711.924       | 138.42   | 27.266    | 24.010    | 789.003       |
| Mean       | 126.90    | 24.021   | 25.501   | 711.924       | 138.42   | 27.266    | 24.010    | 789.003       |
| Mean of gypsum (t/ha) | 126.35    | 24.233   | 22.367   | 720.184       | 137.20   | 27.255    | 24.561    | 782.021       |
| Mean of FYM (m³/ha) | 126.35    | 24.233   | 22.367   | 720.184       | 137.20   | 27.255    | 24.561    | 782.021       |
| L.S.D at 0.05 |           |           |           |               |           |           |           |               |
| A           | 1.875     | 0.577    | 0.685    | 6.210         | 1.840    | 0.630     | 0.141     | 8.543         |
| B           | 0.771     | 0.452    | 0.218    | 2.546         | 0.937    | 0.297     | 0.169     | 5.849         |
| AB          | 1.090     | 0.639    | 0.308    | 3.601         | 1.325    | 0.420     | 0.240     | 8.272         |
| C           | 0.671     | 0.441    | 0.229    | 5.321         | 0.507    | 0.245     | 0.193     | 3.002         |
| AC          | 0.950     | 0.623    | 0.325    | 7.525         | 0.717    | 0.346     | 0.272     | 4.424         |
| BC          | 1.163     | 0.763    | 0.398    | 9.216         | 0.878    | 0.424     | 0.334     | 5.200         |
| ABC         | 1.644     | 1.080    | 0.562    | 13.034        | 1.242    | 0.599     | 0.472     | 7.354         |
Table 5. N, P and K uptake (kg/ha) in straw as affected by gypsum and FYM application under different tillage systems

| Tillage       | Gypsum (t/ha) | FYM (m³/ha) | N Uptake  | P uptake | K uptake  | N uptake | P Uptake | K uptake |
|---------------|---------------|-------------|-----------|----------|-----------|----------|----------|----------|
|               |               |             | 2015/2016 |          | 2016/2017 |          |          |          |
| Shallow       |               |             |           |          |           |          |          |          |
| Gypsum (0.0) | 0.0           | 40.662      | 10.979    | 121.987  | 49.494    | 13.942   | 131.985  |
|               | 11.9          | 49.621      | 14.704    | 142.433  | 54.627    | 15.507   | 145.378  |
|               | 23.8          | 53.560      | 15.698    | 147.750  | 54.764    | 16.612   | 150.600  |
|               | 35.7          | 56.306      | 16.891    | 154.843  | 56.834    | 17.429   | 156.295  |
| Mean          |               | 50.037      | 14.568    | 141.753  | 53.930    | 15.872   | 146.064  |
| Gypsum (4.76) | 0.0           | 47.757      | 13.621    | 137.969  | 50.689    | 15.206   | 138.083  |
|               | 11.9          | 50.606      | 15.826    | 147.217  | 57.448    | 18.081   | 150.683  |
|               | 23.8          | 56.677      | 18.515    | 151.140  | 63.243    | 19.368   | 166.014  |
|               | 35.7          | 57.334      | 19.111    | 156.713  | 60.233    | 20.881   | 172.668  |
| Mean          |               | 53.094      | 16.768    | 148.259  | 57.903    | 18.384   | 156.862  |
| Gypsum (9.52) |               |             |           |          |           |          |          |          |
| Mean          |               | 54.461      | 15.733    | 152.155  | 57.904    | 17.384   | 157.217  |
| Mean          | 52.531        | 15.690      | 147.389   | 56.579   | 17.214    | 153.381  |
|               |               | 46.496      | 13.526    | 130.188  | 48.988    | 15.125   | 135.788  |
|               | 11.9          | 52.976      | 15.801    | 148.702  | 51.551    | 16.460   | 146.513  |
|               | 23.8          | 55.436      | 17.204    | 157.707  | 57.917    | 17.188   | 154.135  |
|               | 35.7          | 59.433      | 18.821    | 163.442  | 60.262    | 20.288   | 165.719  |
| Mean          |               | 53.606      | 16.432    | 149.465  | 54.713    | 17.259   | 150.023  |
| Mean          | 51.127        | 14.607      | 142.424   | 54.264   | 15.917    | 144.704  |
|               | 11.9          | 55.395      | 16.810    | 152.815  | 59.098    | 17.919   | 156.323  |
|               | 23.8          | 61.325      | 20.773    | 162.216  | 61.399    | 22.382   | 168.354  |
|               | 35.7          | 62.660      | 20.955    | 172.571  | 65.224    | 21.120   | 178.072  |
| Mean          |               | 57.627      | 18.286    | 157.506  | 59.995    | 19.334   | 161.863  |
| Gypsum (9.52) |               |             |           |          |           |          |          |          |
| Mean          |               | 57.918      | 18.222    | 160.190  | 59.212    | 18.914   | 161.601  |
| Mean          | 56.383        | 17.647      | 155.720   | 57.973   | 18.503    | 157.829  |
| Mean of gypsum (t/ha) |         | 51.821      | 15.500    | 145.608  | 54.321    | 16.566   | 148.043  |
|               | 4.76          | 55.360      | 17.527    | 152.883  | 58.950    | 18.860   | 159.362  |
|               | 9.52          | 56.189      | 16.978    | 156.172  | 58.557    | 18.149   | 159.409  |
| Mean          |               | 51.080      | 13.332    | 136.011  | 51.408    | 14.964   | 139.159  |
| Mean of FYM (m³/ha) |            | 52.857      | 15.971    | 149.752  | 56.290    | 17.127   | 152.330  |
|               | 23.8          | 57.299      | 18.148    | 156.577  | 60.477    | 19.269   | 162.308  |
|               | 35.7          | 59.591      | 19.221    | 163.879  | 60.928    | 20.073   | 168.623  |
| L.S.D at 0.05 | A             | 1.976       | 0.285     | 3.330    | 0.869     | 1.113    | 0.961    |
|               | B             | 1.473       | 0.135     | 1.002    | 0.556     | 0.053    | 1.100    |
|               | AB            | 2.084       | 0.191     | 1.416    | 0.786     | 0.075    | 1.557    |
|               | C             | 0.799       | 0.163     | 1.235    | 0.657     | 0.152    | 1.270    |
|               | AC            | 1.130       | 0.232     | 1.746    | 0.929     | 0.215    | 1.795    |
|               | BC            | 1.384       | 0.283     | 2.139    | 1.138     | 0.264    | 2.199    |
|               | ABC           | 1.957       | 0.385     | 3.025    | 1.610     | 0.372    | 3.109    |
**Table 6. Total N, P and K (kg/ha) as affected by gypsum and FYM application under different tillage systems**

| Treatments | FYM (m^3/ha) | N Total | P Total | K Total | N Total | P Total | K Total |
|------------|--------------|---------|---------|---------|---------|---------|---------|
| Gypsum (0.0) | 0.0 | 149.621 | 30.728 | 139.273 | 160.878 | 35.995 | 150.921 |
| | 11.9 | 174.347 | 37.061 | 162.849 | 176.735 | 39.809 | 167.355 |
| | 23.8 | 176.541 | 39.813 | 171.262 | 188.876 | 43.814 | 175.778 |
| | 35.7 | 184.819 | 42.224 | 178.074 | 196.664 | 45.654 | 181.542 |
| Mean | 171.331 | 37.456 | 162.866 | 180.788 | 41.318 | 168.896 |
| Gypsum (4.76) | 0.0 | 161.393 | 33.913 | 157.680 | 170.563 | 39.827 | 158.649 |
| | 11.9 | 175.851 | 39.911 | 168.894 | 193.732 | 44.580 | 174.659 |
| | 23.8 | 190.688 | 45.064 | 176.425 | 216.268 | 48.228 | 193.397 |
| | 35.7 | 195.005 | 47.572 | 181.865 | 211.807 | 51.762 | 200.645 |
| Mean | 180.734 | 41.615 | 171.216 | 198.092 | 44.100 | 181.837 |
| Gypsum (9.2) | 0.0 | 167.147 | 33.815 | 160.248 | 175.920 | 36.880 | 159.500 |
| | 11.9 | 175.479 | 37.946 | 172.736 | 195.534 | 42.962 | 183.163 |
| | 23.8 | 191.246 | 41.882 | 177.486 | 217.547 | 50.425 | 194.036 |
| | 35.7 | 204.404 | 49.023 | 190.288 | 220.784 | 53.683 | 195.674 |
| Mean | 184.569 | 40.666 | 175.190 | 202.446 | 45.988 | 183.093 |
| Mean | 178.879 | 39.312 | 169.756 | 193.775 | 44.468 | 177.942 |
| Gypsum (0.0) | 0.0 | 159.669 | 34.608 | 148.495 | 169.254 | 38.477 | 155.754 |
| | 11.9 | 177.577 | 39.534 | 170.063 | 186.034 | 42.610 | 169.238 |
| | 23.8 | 187.606 | 42.292 | 179.735 | 206.391 | 45.690 | 179.322 |
| | 35.7 | 189.162 | 45.377 | 185.565 | 210.860 | 51.321 | 191.815 |
| Mean | 178.504 | 40.452 | 170.965 | 193.134 | 44.525 | 174.032 |
| Gypsum (4.76) | 0.0 | 172.023 | 35.942 | 163.166 | 178.688 | 39.394 | 165.715 |
| | 11.9 | 184.410 | 41.762 | 176.184 | 201.988 | 44.549 | 182.563 |
| | 23.8 | 209.683 | 48.752 | 186.942 | 223.018 | 53.462 | 196.119 |
| | 35.7 | 219.557 | 52.475 | 197.086 | 235.013 | 54.785 | 205.516 |
| Mean | 196.418 | 44.732 | 180.845 | 209.678 | 48.048 | 187.474 |
| Gypsum (9.2) | 0.0 | 174.590 | 37.887 | 163.239 | 179.602 | 41.024 | 167.243 |
| | 11.9 | 190.379 | 44.266 | 181.025 | 203.895 | 45.822 | 183.412 |
| | 23.8 | 215.657 | 49.542 | 195.924 | 228.892 | 50.694 | 199.634 |
| | 35.7 | 218.075 | 52.923 | 204.188 | 233.897 | 54.416 | 208.183 |
| Mean | 199.675 | 46.154 | 186.094 | 221.572 | 47.989 | 189.618 |
| Mean | 191.532 | 43.780 | 179.301 | 201.794 | 46.854 | 183.710 |
| Mean of gypsum (t/ha) | 0.0 | 174.918 | 38.954 | 166.914 | 186.961 | 42.421 | 171.464 |
| | 4.76 | 188.576 | 43.174 | 176.030 | 203.884 | 47.074 | 184.658 |
| | 9.52 | 192.122 | 43.410 | 180.642 | 207.009 | 46.988 | 186.355 |
| Mean of FYM (m³/ha) | 0.0 | 164.074 | 34.482 | 155.350 | 172.484 | 38.600 | 159.630 |
| | 11.9 | 179.674 | 40.080 | 172.958 | 192.986 | 43.889 | 176.730 |
| | 23.8 | 195.237 | 44.557 | 181.296 | 213.499 | 48.719 | 189.714 |
| | 35.7 | 201.837 | 48.265 | 189.511 | 218.171 | 51.937 | 197.229 |

L.S.D at 0.05

| | A | 0.736 | 0.668 | 3.948 | 2.650 | 0.568 | 1.096 |
| | B | 1.351 | 0.478 | 0.901 | 0.853 | 0.334 | 1.151 |
| | C | 1.911 | 0.676 | 1.274 | 1.206 | 0.473 | 1.629 |
| | AB | 1.236 | 0.446 | 1.300 | 0.809 | 0.279 | 1.355 |
| | AC | 1.747 | 0.631 | 1.839 | 1.144 | 0.279 | 1.917 |
| | BC | 2.140 | 0.773 | 2.253 | 1.402 | 0.383 | 2.348 |
| | ABC | 3.027 | 1.093 | 3.173 | 1.982 | 0.684 | 3.321 |
Table 7. Estimating guide of wheat crop costs

| Common Cost:          | 1st season | 2nd season |
|-----------------------|------------|------------|
| Land rent             | 11102.7    | 11900      |
| Land preparation      | 535.5      | 595        |
| Seeds                 | 714        | 833        |
| Planting              | 357        | 476        |
| Irrigation            | 1071       | 1190       |
| Fertilizers           | 1666       | 1904       |
| Weed Control          | 357        | 357        |
| Harvesting            | 2023       | 2261       |
| Threshing             | 952        | 1190       |
| Total                 | 18778.2    | 20706      |

Costs of Variables:

| Tillage system        | 1st season | 2nd season |
|-----------------------|------------|------------|
| Shallow               | 714        | 833        |
| Subsoiling            | 833        | 952        |
| Gypsum (t/ha)         | 0.0        | 0.0        |
|                       | 4.76       | 785.4      |
|                       | 9.52       | 1523.2     |

| Farmyard manure (m³/ha) | 1st season | 2nd season |
|-------------------------|------------|------------|
| 0.0                     | 0.0        | 0.0        |
| 11.9                    | 666.4      | 690.2      |
| 23.8                    | 1285.2     | 1428       |
| 35.7                    | 1904       | 1927.8     |
Table 8. Some economic measurements of wheat production as affected by tillage system as well as gypsum and FYM application during 2015/2016

| Treatments       | FYM (m3/ha) | Human labor costs (L.E./ha) | Machine labor costs (L.E./ha) | Variable costs (L.E./ha) | Total cultivation cost (L.E./ha) | Gross return (L.E./ha) | Net Return over variable costs (L.E./ha) | Return on investment (%) | Beneficial cost ratio | Productive margin ratio (%) |
|------------------|-------------|-----------------------------|-------------------------------|--------------------------|---------------------------------|------------------------|------------------------------------------|----------------------------|------------------------|-----------------------------|
| Tillage          |             |                             |                               |                          |                                 |                        |                                          |                            |                        |                             |
| Gypsum (0.0)     | 0.0         | 3391.5                      | 2261.0                        | 8389.5                   | 19492.2                         | 21173.4                | 1681.2                                    | 12783.9                     | 1.09                   | 7.94                        |
|                  | 11.9        | 3462.9                      | 2321.4                        | 9055.9                   | 20158.6                         | 23824.8                | 3666.2                                    | 14766.9                     | 1.18                   | 13.59                       |
|                  | 23.8        | 3510.5                      | 2380.0                        | 9674.7                   | 20777.4                         | 24267.4                | 3490.0                                    | 14592.7                     | 1.17                   | 14.38                       |
|                  | 35.7        | 3558.1                      | 2451.4                        | 10293.9                  | 21396.2                         | 24807.2                | 3410.0                                    | 14513.7                     | 1.16                   | 13.75                       |
| Mean             | 3480.8      | 2356.2                      | 9353.4                        | 20456.1                  | 23518.2                         | 3062.1                 | 14166.8                                   | 1.12                        | 15.27                  |
| Shallow          |             |                             |                               |                          |                                 |                        |                                          |                            |                        |                             |
| Gypsum (0.67)    | 0.0         | 3351.5                      | 2251.4                        | 9147.6                   | 20277.6                         | 23308.8                | 3031.2                                    | 14139.9                     | 1.15                   | 13.00                       |
|                  | 11.9        | 3434.3                      | 2451.4                        | 9841.3                   | 20944.0                         | 24220.8                | 3276.8                                    | 14379.5                     | 1.16                   | 13.53                       |
|                  | 23.8        | 3581.9                      | 2499.0                        | 10461.0                  | 21562.8                         | 25256.6                | 3639.8                                    | 14796.5                     | 1.17                   | 14.63                       |
|                  | 35.7        | 3629.5                      | 2570.4                        | 11078.9                  | 22181.6                         | 26179.0                | 3997.4                                    | 15001.0                     | 1.18                   | 15.27                       |
| Mean             | 3552.2      | 2472.5                      | 10138.6                       | 21241.5                  | 24741.3                         | 3499.8                 | 14602.5                                   | 1.11                        | 14.11                  |
| Subsoiling       |             |                             |                               |                          |                                 |                        |                                          |                            |                        |                             |
| Gypsum (9.32)    | 0.0         | 3351.5                      | 2251.4                        | 9147.6                   | 20277.6                         | 23308.8                | 3031.2                                    | 14139.9                     | 1.15                   | 13.00                       |
|                  | 11.9        | 3434.3                      | 2451.4                        | 9841.3                   | 20944.0                         | 24220.8                | 3276.8                                    | 14379.5                     | 1.16                   | 13.53                       |
|                  | 23.8        | 3581.9                      | 2499.0                        | 10461.0                  | 21562.8                         | 25256.6                | 3639.8                                    | 14796.5                     | 1.17                   | 14.63                       |
|                  | 35.7        | 3629.5                      | 2570.4                        | 11078.9                  | 22181.6                         | 26179.0                | 3997.4                                    | 15001.0                     | 1.18                   | 15.27                       |
| Mean             | 3552.2      | 2472.5                      | 10138.6                       | 21241.5                  | 24741.3                         | 3499.8                 | 14602.5                                   | 1.11                        | 14.11                  |
| Mean of Gypsum (t/ha) | 0.0 | 3525.8                      | 2418.7                        | 9591.4                   | 20994.1                         | 23791.2                | 3097.1                                    | 14499.8                     | 1.15                   | 12.91                       |
|                  | 4.76        | 3596.6                      | 2537.7                        | 10376.8                  | 21479.5                         | 25188.1                | 3708.6                                    | 14813.7                     | 1.17                   | 16.63                       |
|                  | 9.52        | 3638.8                      | 2609.1                        | 11114.6                  | 22217.3                         | 25710.2                | 3492.9                                    | 14595.6                     | 1.16                   | 13.48                       |
| Mean of FYM (m3/ha) | 0.0 | 3500.0                      | 2423.6                        | 9397.0                   | 20499.7                         | 23079.2                | 2579.4                                    | 13682.1                     | 1.13                   | 11.12                       |
|                  | 11.9        | 3570.7                      | 2499.0                        | 10063.4                  | 21166.1                         | 24515.7                | 3349.6                                    | 14452.3                     | 1.16                   | 13.68                       |
|                  | 23.8        | 3619.0                      | 2546.6                        | 10682.2                  | 21784.6                         | 25524.9                | 3739.9                                    | 14842.6                     | 1.17                   | 14.63                       |
|                  | 35.7        | 3658.6                      | 2618.0                        | 11301.8                  | 22403.7                         | 26466.2                | 4062.5                                    | 15165.2                     | 1.18                   | 15.27                       |
| Mean             | 3631.9      | 2582.3                      | 10589.8                       | 21701.6                  | 25315.7                         | 3614.1                 | 14716.8                                   | 1.17                        | 14.14                  |
| Mean of Yields  | A           | 7.66                        | 54.70                         | 123.39                   | 123.39                           | 7.58                   | 122.29                                    | 122.29                      | 0.007                  | 0.55                        |
| L.S.D. at 0.05   | B           | 6.31                        | 30.45                         | 202.00                   | 202.00                           | 4.96                   | 202.41                                    | 202.41                      | 0.011                  | 0.84                        |
|                  | AB          | 8.92                        | 43.10                         | 285.67                   | 285.67                           | 7.02                   | 286.25                                    | 286.25                      | 0.016                  | 1.18                        |
|                  | C           | 7.79                        | 20.81                         | 104.50                   | 104.50                           | 3.84                   | 104.82                                    | 104.82                      | 0.008                  | 0.44                        |
|                  | AC          | 11.03                       | 29.43                         | 147.79                   | 147.79                           | 5.43                   | 148.24                                    | 148.24                      | 0.010                  | 0.62                        |
|                  | BC          | 13.51                       | 36.05                         | 181.00                   | 181.00                           | 6.65                   | 181.55                                    | 181.55                      | 0.014                  | 0.76                        |
|                  | ABC         | 19.10                       | 50.98                         | 255.97                   | 255.97                           | 9.41                   | 256.76                                    | 256.76                      | 0.015                  | 1.08                        |
Table 9. Some economic measurements of wheat production as affected by tillage system as well as gypsum and FYM application during 2016/2017

| Treatments | 2016/2017 |  |  |  |  |  |  |  |  |
|------------|-----------|----|----|----|----|----|----|----|----|
|            | FYM (m²/ha) | Gypsum (t/ha) | FYM (L.E./ha) | Gypsum (L.E./ha) | Total cultivatio (L.E./ha) | Gross return (L.E./ha) | Net Return (L.E./ha) | Return over variable costs (L.E./ha) | Beneficial cost ratio (%) | Product profit margin ratio (%) |
| Shallow    |           | 0.0 | 1418.8 | 3975.0 | 4236.4 | 4188.8 | 4284.0 | 4379.2 | 4295.9 |
| Subsoiling |           | 0.0 | 3154 | 3107 | 3792 | 3579 | 4030 | 4450 | 4287 |
| Mean       |           | 0.0 | 2424 | 2257 | 3457 | 3579 | 4287 | 4450 | 4287 |
| Mean of Gypsum (t/ha) | 0.0 | 2424 | 2257 | 3457 | 3579 | 4287 | 4450 | 4287 | 4287 |
| Mean of FYM (m³/ha) | 0.0 | 2424 | 2257 | 3457 | 3579 | 4287 | 4450 | 4287 | 4287 |
| L.S.D. at 0.05 | 0.0 | 2424 | 2257 | 3457 | 3579 | 4287 | 4450 | 4287 | 4287 |
### Table 10. T-Test between and shallow and subsoiling systems as well as between without and with high level of gypsum or farmyard manure application for some economic easements

| Average value of variables | 2015/2016 | 2016/2017 |
|---------------------------|-----------|-----------|
|                           | Tillage   | Gypsum (t/ha) | FYM (m³/ha) | Tillage   | Gypsum (t/ha) | FYM (m³/ha) |
|                           | Shallow (1) | Subsoiling | The amount of change (L.E) | T-Test between them | Without | 9.52 ton/ha | The amount of change (L.E) | T-Test between them | Without | 35.7 m³/ha | The amount of change (L.E) | T-Test between them |
| Human labor cost (L.E/ha) | 3542.2    | 3631.9    | 90       | 4.89(**)(2) | 3525.5    | 3638.8    | 113.3    | 5.17(**)(2) | 3500.0    | 3658.6    | 158.6    | 7.17(**)(2) |
| Machine labor costs (L.E/ha) | 2461.3  | 2582.3    | 121      | 4.52(**)(2) | 2418.7    | 2609.1    | 190.4    | 6.31(**)(2) | 2423.6    | 2618.0    | 194.4    | 5.25(***)(2) |
| Variable cost (L.E/ha)     | 10122.9   | 10598.9   | 476      | 2.07(***)(2) | 9591.4    | 11114.6   | 1523.2   | 6.73(***)(2) | 9397.0    | 11301.0   | 1904    | 8.05(***)(2) |
| Total cost (L.E/ha)        | 21225.6   | 21701.6   | 476      | 2.07(***)(2) | 20694.1   | 22217.3   | 1523.2   | 5.83(***)(2) | 20499.7   | 22403.7   | 1904    | 8.05(***)(2) |
| Gross return (L.E/ha)      | 24477.3   | 25315.7   | 838.4    | 2.28(***)(2) | 23791.2   | 25710.2   | 1919    | 6.73(***)(2) | 23079.2   | 26466.2   | 3387    | 8.63(***)(2) |
| Net return (L.E/ha)        | 3251.6    | 3614.1    | 362.5    | 2.08(***)(2) | 3097.1    | 3492.9    | 395.8    | 1.89(***)(2) | 2579.4    | 4062.5    | 1483.1   | 6.78(***)(2) |
| Return over variable costs (L.E/ha) | 14354.3 | 14716.8   | 362.5    | 2.08(***)(2) | 13961.8   | 14357.6   | 395.8    | 1.89(***)(2) | 13682.1   | 15165.2   | 1483.1   | 6.98(***)(2) |
| Beneficial cost ratio      | 1.15      | 1.17      | 0.02     | 1.70(***)(2) | 1.15      | 1.16      | 0.01     | 0.84(***)(2) | 1.13      | 1.18      | 0.05    | 6.08(***)(2) |
| Product profit margin ratio % (2) | 13.20% | 14.32%    | 1.12%    | 4.80(***)(2) | 12.91%    | 13.48%    | 0.57     | 0.82(***)(2) | 11.11%    | 15.27%    | 4.16%    | 6.10(***)(2) |

1- The amount of change between the two levels= Subsoiling- Shallow.
2- Product profit% = (Net return / Total return) x 100.
Conclusions

From the results of this investigation, it could be recommended to use subsoiling tillage and apply 9.52 t/ha gypsum + 35.7 m³/ha farmyard manure to maximizing yields of wheat grown in moderately sodic soil. In economic view, it could be recommended to add 4.76 t/ha gypsum + 35.7 m³/ha FYM under subsoiling tillage to attain the highest net return of wheat productivity grown in moderately sodic soil.

Conflict of Interest

The author hereby declares no conflict of interest.

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