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Effects of Different Land Leveling Systems and Sowing Methods on the Growth and Yield of Wheat in the Upper Terraces of the Northern State - Sudan

Abdalla N. O. Kheiry[1], Mohamed Hassan Dahab [2] and Hassan Mohamed Ahmed Alhag[2]

[1] Department of Agricultural Engineering - Colleges of Agricultural Studies, Sudan University of Science and Technology
[2] Faculty of Agricultural, University of Khartoum, Sudan
Corresponding author: Mohamed Hassan Dahab

Abstract: *The current study was aimed to evaluate the effects of three different land leveling techniques (laser scraper, tractor scraper and animal drawn scraper) and two sowing methods on growth and yield of wheat crop were therefore examined in a bid to establish their optimum conditions. The study was performed at Dongola Agricultural Research Farm in Northern State - Sudan. Split plot design with two factors and three replications were used in the study. Results indicated that, variation in land leveling treatment and sowing methods showed a highly significant impact on observed parameters, the mean of plant population for laser scraper, tractor scraper and traditional scraper at mechanical sowing were 385, 370 and 360 respectively. The treatment of laser leveling implement + mechanical sowing, considered as best optimized value for grain yield which is recorded 5 ton/ha. A statistically, there were significant influences of leveling techniques on plant height and total biological yield (P<0.05).*

Keywords: land leveling,; sowing methods; upper terraces;; wheat crop; growth and yield

Introduction:

Agricultural operations are taking progressing manner regarding new inputs, food storage and new farming techniques. Wheat is the most important crop in the Northern State. The government of the Sudan aim to grow more than (4,500,000 Feddan) throughout Merowe high dam, under national strategy for wheat production in Northern State.

Arable land in the Northern and the River Nile State estimated to be 4.8 million feddan (2.02 million hectares). In season 2009/2010, the total area cultivated in the Northern State was (388968 feddan), (162070 ha) and the main crops were wheat (44.4%) of the cultivated area, faba bean (14.3%) and maize, onion, Alfa Alfa, orchards, cereal forage (sorghum species), sunflower and fenugreek accounted for (41.3%) of the total area cultivated.

One of the reasons of declining crop production is the soil health which can be degraded by use of unsuitable management practices (Ramos at al., 2011). The key aspect which affects crop yield and properties of soil\ is the soil tillage (Khurshid et al., 2006). Tillage is mechanical handling of soil which makes the soil fine and favorable for planting, affects soil properties and provides favorable conditions for the growth and development of plants (Abolanle et al., 2015).

Northern state of Sudan is located in the desert zone between longitude 32°,25´E and latitude 22°,16´N. rainfall varies from 100 mm in the south to 25mm or non in the northern part of the state. The main source of water in the Northern State is the flood of the Nile north of Atbara town. Crop production here, are only through irrigation, by pumping water from the main Nile or by using the ground water.

Studies indicate significant increase in irrigation efficiencies of wheat and rice through precision leveling using Laser and land leveler (Rajut and Patel, 2004). A significant reduction in total water use in wheat as well as rice was recorded due to precision land leveling compared to traditional land leveling. The total water use in wheat and rice in laser leveling was reduced to 49.5 and 31.7%, respectively, (Jat *et al* 2003).

Farmers in northern Sudan especially in small scales areas leveled their fields using animal drawn or tractor drawn levelers. These levelers are implements consisting of blade acting as small bucket for shifting the soil from higher to low-lying positions. This method of level in excessive loss of irrigation water through deep percolation and reduces the application efficiency up to 25% (Satter, *et al*. 2003). Precision land leveling helps distribution of soluble salts, Increases cultivable land area up to 3 – 5%, Improves crop establishment and reduces weed intensity (Khan, 1986; Rickman, 2002; Chudhary *et al*. 2002; Jat, *et al*. 2003). A field leveled with conventional equipment can attain a standard deviation of 20 – 30 mm, while using laser leveling the technical limit extend up to 10 mm. (Playan *et al*. 1996).

The need for more food to satisfy the demand of the ever-increasing population necessitates the cultivation of these problematic soils. Furthermore, the land is much fractionated due to land tenure laws and family inheritance. Due to these limitations, many farmers moved to the upper terrace. Governmental agricultural schemes in northern state are also established in the upper terrace soils. Thus, the expansion of agriculture into the upper terrace soils is necessary to crop with the growing population and fill in market deficit in some strategic crops such as wheat.

Land topography in the Northern State is uneven, and because the main irrigation method is the surface irrigation, the land needs to be properly leveled to insure even distribution of water, improve uniform crop maturity and allow full mechanization of the crop. Thus, the objectives of the present study to evaluate the effect of different land leveling system and sowing methods on wheat crop growth and yield to find the best optimized values of leveling systems – sowing methods combination with respect to observed parameters, such as plant population, plant height, crop grain yield, total biological yield and harvesting index.

Materials and Methods

Experimental site:

The experiments were carried out for two successive growing in the Dongola Research Station Farm (DRSF). The farm is situated in the upper terrace soils, south of the Arab Sudanese seed company (ASSCO) premises, and the location is about fire kilometer south of Dongola city.

Experimental design and treatments applications:

In this study, a factorial experiment was (arranged in a split plot design with three replicates for each, the three leveling equipment' s (laser scraper (L), tractor scraper (S) and traditional scraper using animal power (T) were assigned to the main plots while the two sowing methods A seed drill machine (S1) and manual method (S2) were distributed to the sub-plot respectively, giving a total of 18 plots. The treatments were randomly distributed in the main plot and sub plot, the sub plot area was 72 m^2 (9m × 8m) and was separated by a distance of 1 m between each sub plots and 2m between replicates and by distance of 10m at the end of sub plot. The land was prepared by the heavy offset disc harrow for every replication, then the three leveling equipment' s were used, after the soil was prepared the crop was sown using the two different sowing methods. The crop sowing was done with variety Wadi Elneil at the rate of 50kg/feddan (120kg/ha.). Nitrogen fertilizer was applied at rate of 80kg/fed. A dose of 40kg/feddan, was applied at the third irrigation, while the second dose of 40kg/feddan was given at the fifth irrigation. Triple super phosphate fertilizer was applied at sowing at the rate of 40kg/feddan.

Measurement

Plant population and emergence

Plant population per meter squire was determined by using one meter squadron. It was thrown randomly over the growing plants in each plot; three samples were taken from each plot and averaged.

Plant height (cm):

Three samples from each treatment in each replicate were selected randomly at age of 85 days from sowing (first irrigation). These samples were measured and the average was taken to represent plant height for each treatment.

Crop grain yield (ton/hectare).

Harvesting was done by cutting an area of 15m2 randomly from each plot. The crop materials from each plot threshed, cleaned and weighed. The grain yield in ton/hectare was calculated.

Total biological yield (ton/ha)

Materials, which were collected for grain yield, was weighed after drying for each plot before threshing and recorded as total biological yield, then converted to ton/ha.

Harvest index (%)

Harvesting index is the percentage of total grain yield to the total biological yield was calculated as follows:

$$\text{Harvesting Index} = \frac{Final\ grain\ yield\ (\frac{ton}{ha})}{Total\ biomass\ (\frac{ton}{ha})} \times 100$$

Statistical Analysis of the data

In order to see the significance of results for observed parameters the data were subjected to the statistical analysis by the analysis of variance technique programme given by Statistix8. Least significance difference (LSD) was also calculated at 5 percent level of significance.

Results and Discussion

In order to determine the effect of different land leveling treatments and sowing methods in the experiment field on Plant population, plant height, crop grain yield, total biological yield, and harvesting index, the variance analysis are given in Table 1.

Table 1: ANOVA description for all observed parameters at Land Leveling systems and Sowing Methods and their interactions.

Observed Parameters	Plant population		Plant height		Grain yield		TBY		Harvesting index	
Source	P	MS	P	MS	P	MS	P	MS	P	MS

Land Leveling systems	0.000	730.5	0.0059	9.75	0.000	3.61	0.000	9.62	0.000	0.00639
Sowing Methods	0.000	578.0	0.0008	15.4	0.000	1.67	0.000	2.71	0.000	0.00366
Leveling× Sowing	0.039	15.5	0.003	6.513	0.000	0.27	0.000	0.266	0.019	0.00028

P = probability; MS = Mean of Squire; TBY = Total biological yield

Effect of Different Land Leveling systems and Sowing Methods on Plant population:

The statistical analysis of data on the effect of study variables on the Plant population indicated that, the Plant population was influenced by interaction of different leveling system and sowing methods ($P<0.05$) and there was a highly significant effect by different land leveling treatments and sowing method individually at 5% level of significance as shown in (Table 1). The mean values of Plant population at different land leveling systems and sowing methods (when averaged over two seasons) are shown in Fig. 1. From Fig. 1, it can be seen that as the land leveling method Changed from Laser leveling to tractor drawn scraper leveling treatment and from scraper leveling to traditional treatment, the plant population decreased from 385 to 370, and from 370 to 360 at mechanical sowing treatment. Similarly the plant population decreased from 370 to 360 and decreased from 360 to 351 as the leveling treatment changed from laser to scraper and from Scraper to traditional leveling treatment at manual sowing method, respectively. From Fig. 1, it can also be seen that as the sowing method changed from mechanical to manual, the plant population decreased from 385 to 370 and from 370 to 360 and further decreased from 360 to 351 at laser scraper, tractor scraper and traditional scraper, respectively. The treatment of laser scraper + mechanical sowing may be considered as best optimized value for plant population (385) of the wheat crop.

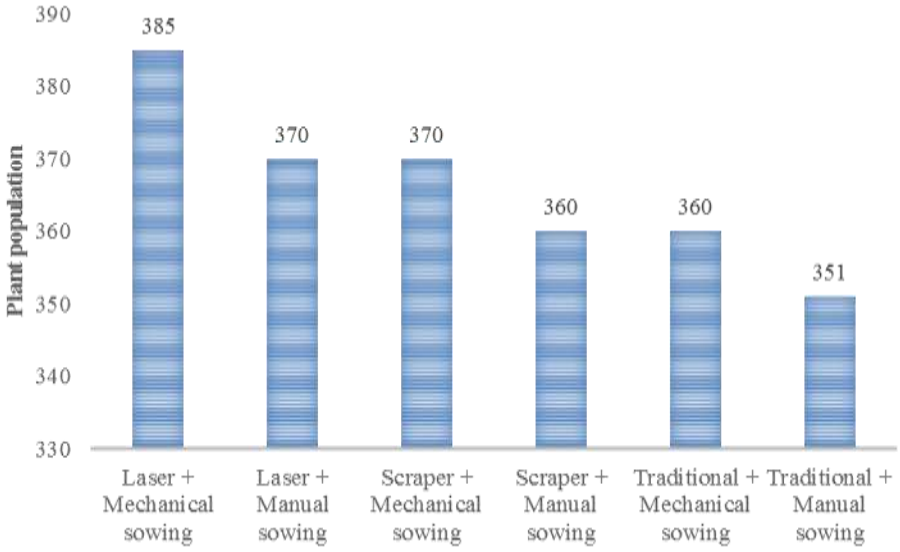

Fig. 1: Two seasons Mean Plant population affected by Different Land Leveling systems and Sowing Methods.(mean followed by the different letter differ significantly according to LSD test

Effect of Different Land Leveling systems and Sowing Methods on Plant height:

Variation in land leveling treatment and sowing methods showed a highly significant impact on plant height at ($P<0.05$) (Table 1). Further, the values of plant height were also significant for interaction of land leveling treatment and sowing methods as indicated in Table 1. The mean values when average the two seasons of plant height at land leveling treatment and Sowing Methods are shown in Fig. 2. From Fig. 2, it can be seen that as the land leveling treatments changed from laser leveling treatment to tractor scraper treatment and from scraper treatment to traditional treatment (animal drawn scraper), the plant height decreased from 90 to 88.9cm and from 88.9 to 85 cm when mechanical sowing was used. Similarly the plant height slightly decreased from 86.5 to 86 when the leveling treatments changed from laser leveling to scraper, While it slightly increased from 86 to 86.15 when the treatment changed from scraper leveling to traditional leveling respectively, at manual sowing treatments. From Fig. 2, also it could be seen that when the sowing method changed from mechanical to manual method, the average of two seasons of the plant height decreased from 90 to 86.8 cm at laser leveling treatment and further decreased from 88.9 to 86 cm at tractor scraper treatment, while the average values of two seasons for the plant height increased from 85 to 86.15 cm at the traditional scraper. The treatment of laser leveling

treatment and tractor drawn scraper + mechanical sowing treatment, may be considered as best optimized value for plant height (90 and 88.9cm) of the wheat crop, respectively.

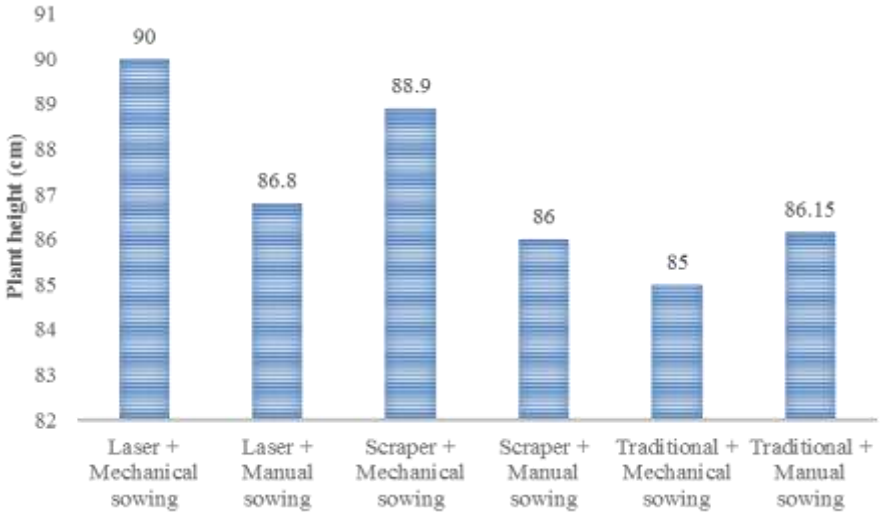

Fig. 2: Two seasons Mean Plant height (cm) affected by Different Land Leveling systems and Sowing Methods.(mean followed by the different letter differ significantly according to LSD test

Effect of Different Land Leveling systems and Sowing Methods on Crop grain yield

Table (1) indicates that, there was a highly significant difference on Crop grain yield when it was influenced by the interaction of Different Land Leveling systems and Sowing Methods (P>0.05), Similarly, the effect of Different Land Leveling systems and Sowing Methods on Crop grain yield was shown highly significant at (P>0.05) (Table 1). There was a consistent increase in the Crop grain yield with change in leveling treatment from laser leveling treatment to tractor drawn scraper and traditional leveling. Pooled data of Crop grain yield showed that laser leveling treatment was having the highest Crop grain yield of (5 ton/ha) which was nearly 19.8% and 38.6% more than that at scraper and traditional treatments, respectively at mechanical sowing (Fig.3). Similarly, with changing the leveling treatments from laser treatment to traditional treatment, the Crop grain yield goes on decreasing. Highest Crop grain yield of 4.1 ton/ha was recorded at laser leveling treatment as compared to other two leveling treatments of scraper and traditional at annual sowing (Fig. 3). From Fig. 3, it could also be seen that when the sowing method changed from mechanical treatment to manual sowing treatment, the grain yield decreased by 18%, 20.1% and 12% at laser, scraper and traditional leveling treatments, respectively. The treatment of laser leveling + mechanical sowing may be considered as best optimized value for Crop grain yield of the tested treatments, Fig. 3.

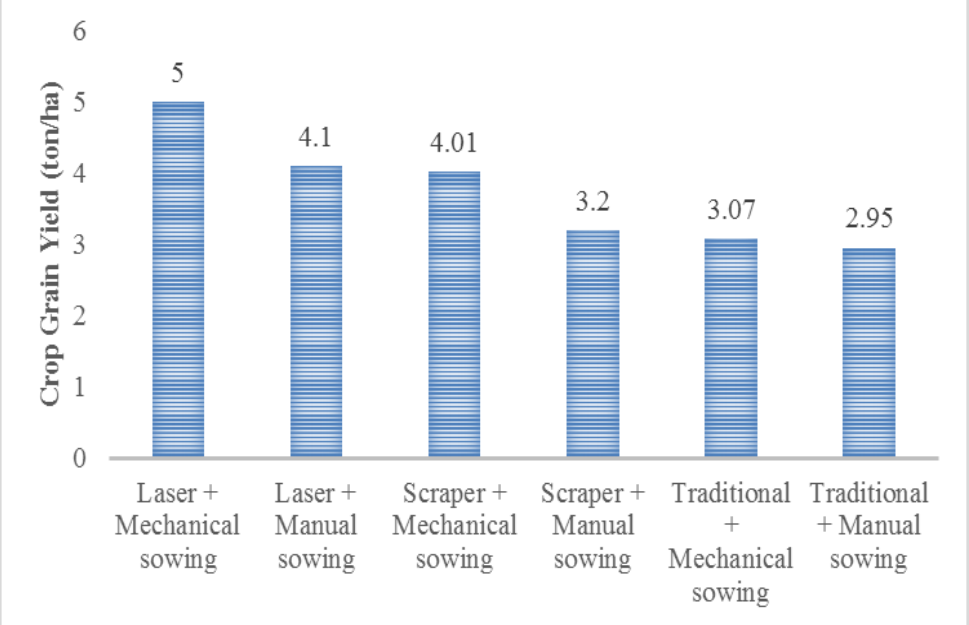

Fig. 3: Two seasons Mean Crop grain yield (ton/ha) affected by Different Land Leveling systems and Sowing Methods.(mean followed by the different letter differ significantly according to LSD test

Effect of Different Land Leveling systems and Sowing Methods on Total biological yield

The average values of total biological yield (when average the two seasons) were highly significant for different leveling systems, sowing methods and interaction of leveling systems and sowing methods as presented in Table (1). The details of the values of total biological yield affected by leveling systems and sowing methods are given in Fig. 4. From Fig. 4 it can be showed that, as the leveling systems changed from laser to tractor scraper and from tractor scraper to traditional leveler the leveling systems decreased from 13.63 to 12.2 ton/ha and from 12.2 to 10.5 ton/ha, respectively at the mechanical sowing. Furthermore, the results showed that the average total biological yield in the laser leveler was generally higher compared to other levelers. The average total biological yield 13.63 ton/ha which recorded for the laser scraper was observed to be higher than (tractor scraper) and (traditional scraper) by 10.49% and 11.47%, respectively at the mechanical sowing, (Fig. 4). Similarly a decreasing trend was observed for the total biological yield from 12.7 ton/ha to 11.1 ton/ha and from 11.1 ton/ha to 10.5 ton/ha as the leveling systems changed from laser to tractor scraper and from tractor scraper to traditional one, respectively at the manual sowing (Fig.4). Fig. 4 showed that, when the sowing method changed from mechanical to manual, the total biological yield decreased from 13.63 to 12.7 and from 12.2 to 11.1 and further decreased from 10.8 to 10.5 at laser scraper, tractor scraper and traditional scraper, respectively. The treatment of laser scraper + mechanical sowing may be considered as best optimized value for total biological yield (Fig. 4).

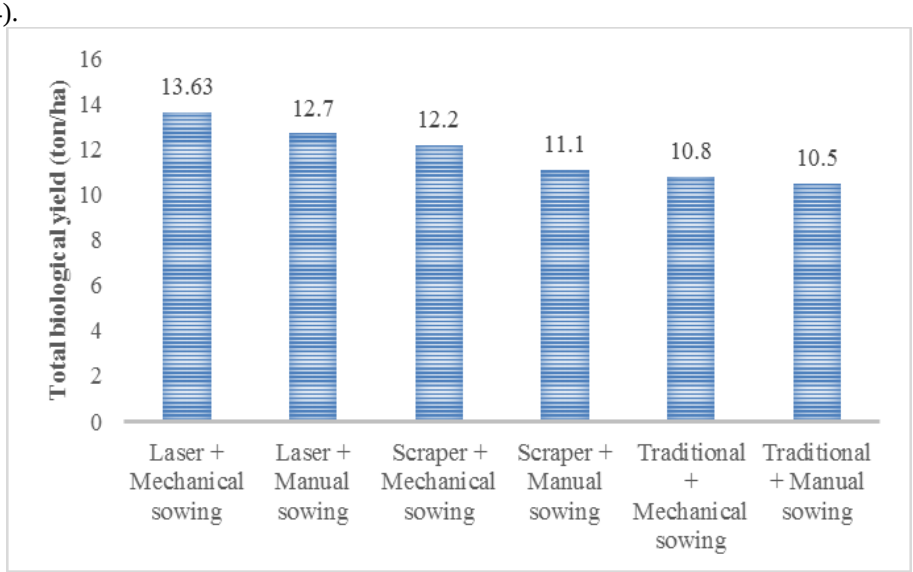

Fig. 4: Two seasons Mean Total biological yield (ton/ha) affected by Different Land Leveling systems and Sowing Methods.(mean followed by the different letter differ significantly according to LSD test

Effect of Different Land Leveling systems and Sowing Methods on Harvesting Index

Land leveling and sowing method have highly significant effect on Harvesting Index while, interaction of land leveling and sowing method showed significant effect on Harvesting Index Table (1). Fig. 5 showed that, as the land leveling changed from laser scraper to tractor and traditional scrapers the harvesting index values decreased at the two sowing methods (mechanical and manual). Collected data of harvesting index indicated that the highest harvesting index of 0.37% was recorded by treatment of laser + mechanical sowing and the lowest one of 0.274% recorded by traditional scraper + manual sowing. From Fig. 5, it could also be seen that as the sowing methods changed from mechanical to manual, the harvesting index decreased by 11.8% at laser scraper, 7.18% at tractor scraper and by 6.16% at traditional. The treatment of laser scraper + mechanical may be considered as best optimized value for harvesting index of the tested parameters, (Fig.5).

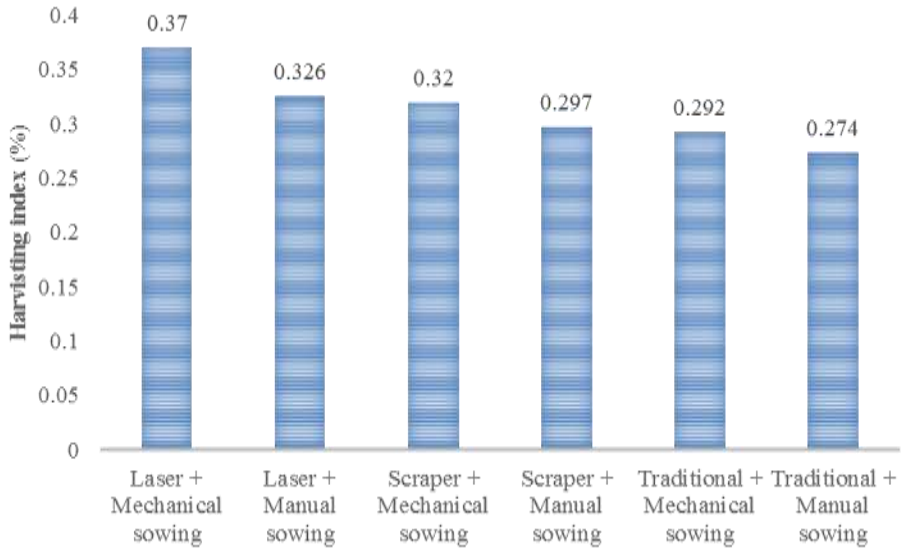

Fig. 5: Two seasons Mean Harvesting Index (%) affected by Different Land Leveling systems and Sowing Methods.(mean followed by the different letter differ significantly according to LSD test

Conclusion

1) The percentage of plant population, plant height, grain yield, total biological yield and harvesting were measured and evaluated under different land leveling implements and different sowing methods.

3) The statistical analysis of data on the effect of study variables on the measured parameters indicated that, the measured parameters were influenced by interaction of different leveling system and sowing methods ($P<0.05$).

3) The treatment of laser leveling implement + mechanical sowing, considered as best optimized value for parameters observed of the wheat crop.

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