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THE EFFECT OF SEEDING RATE AND ROW SPACING ON WHEAT AND SPACING ON SWEET CORN PERFORMANCE (PRODUCTIVITY) UNDER RAINFED AND IRRIGATED CONDITIONS

by

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Introduction

Wheat (Triticum spp.) and corn (Zea mays L.) are the most important cereal crops all over the world.Wheat world production increased from 454 million metric tons in 1983 to 510 million metric tons in 1988 and corn world production increased from 421 million metric tons in 1981 to 458 million metric tons in 1987 (FAO, 1988). The leading countries in wheat production are: USSR, USA, Canada and Australia. The leading countries in corn production are USA, Brazil, USSR, Mexico and Yugoslavia.

Wheat and corn are the main field crops in many parts of the developed and developing countries because they are directly or indirectly provide a large portion of human sustenance. They are by far the most important source of carbohydrate for man and they are a comparatively cheap source of calories.

High yielding varieties of wheat and corn requires proper management for optimum growth and grain production. For successfull prodction of cereal crops, factors like use of suitable varieties, optimum plant density and row spacings, improved cultural practices, proper seeding rate and irrigation are considered to be major factors. A good variety of wheat and corn with optimum plant density and row spacing produce optimum number of plants per unit area.

The main objective of the present investigation was to study the performance of wheat and corn as affected by seeding rate and row spacing under rainfed and irrigated conditions.

Review of Literature

The yield, yield components and other agronomic characteristics of wheat and corn plants are the function of many factors. Regardless of its genetic constitution, plant actual yield can be greatly influenced by environmental factors. Man can manipulate some of these factors to the advantage of crop species grown under specific climatic conditions. Two important production factors are the seeding rate and row spacing. The main objective of this study is to determine the performance of wheat and corn as affected by seeding rate and row spacing under rainfed and irrigated conditions. The review of literature should be delt within four main parts as follows:

A) Effect of seeding rate on wheat.

B) Effect of plant density on corn.

C) Effect of row spacing on wheat.

D) Effect of spacing on corn.

A) Effect of Seeding Rate on Wheat:

Meddleton et al. (1964) studied the effect of seeding rate and row width on yield and components of yield in winter barley and they found that decreasing the rate of seeding decrease the number of fertile heads per unit area, but increased the number of seeds per head as measured by the weight of grain per 100 heads. The weight of 1000-seeds and test weight per bushel were not affected significantly. Dubey and Lal (1970) concluded that the relative tillering capacity of semi-dwarf and standard wheat change with plant density or spacing.

Larter et al. (1971) found that average grain yield of triticale from rates in excess of 100 kg/ha were not significantly different from those obtained at 100 kg/ha rate. Average yield of wheat were highest from the two lowest seeding rate (25 and 50 kg/ha). Significant reduced yields were obtained from rates of 100 kg/ha and above. As seeding rate increased, the kernel weight decrease while protein was unaffected.

Miletic (1972) found that high plant density adversely affected tillering and number of spike/plant, but number of seeding rate had the dominant effect on number of spike/m^2, which in turn had dominant effect on grain yield/unit area. Ali-Khan (1973) showed that present practice of planting 55 kg/ha (approximately 250,000 plants/ha) in rows of 15 cm apart is satisfactory. Very little or no advantage could be gained by increasing seeding rate. However, Ruzzkowski et al. (1973) compared 15 winter wheat varieties grown at 400, 600 or 800 plants/m^2. They found that grain yield decrease in most cases with increasing plant density, but the effect varied with variety. The yield decrease was associated with the decrease in tillering and number of spikelets per spike.

Pendleton and Dungan (1960) studied four wheat varieties under six seeding rates. They found that the four varieties differently responded to the seeding rate and they considered that seeding rate had marked effect on number of fertile tillers produced per plant. Ballatore et al. (1975) studied the effect of 80, 120, 160, 200 and 240 kg seeds/ha on biological performance and yield of three durum wheat cultivars and found that increasing sowing rate decrease tillering, 100 grain weight, number of grains/spike and yield/spike. High sowing rates increased number of shrivelled grains and straw yields. Grain yields increased with increasing sowing rate upto 160 kg/ha.

Singh and Sharma (1976) indicated that increasing seeding rate from 75 to 125 kg/ha increase stand density, but decreased weight and number of grain per spike. Kamel et al. (1978) observed that seeding rate significantly affected plant height, tillers number per plant, grain number per plant, grain weight per plant and 1000 grain weight. The optimum seeding rate was 71.4 kg/ha. Tillers number/m^2 and grain yield per hectar were increased with increasing seeding rate up to 143 kg/ha. Puri and Qualset (1978) showed that 1000-grain weight tends to decrease with increasing seeding rate from 50 to 100, 200 and 300 seeds/m^2 at row spacing of 30 cm apart. Grain yield/ha and number of tillers/plant increase with increasing seeding rate.

Bishnoi (1980) studied the effect of two row spacing (12.5 and 25 cm) and three seeding rates (50, 70 and 100 kg/ha) for two growing seasons on the performance of Arthur 71 wheat. He found that difference in forage yield due to row spacing and seeding rate were highly significant. Seeding rate of 75 and 100 kg/ha produced significantly more forage, whereas seeding rate of 50 kg/ha was adequate for grain yield.

Ciha (1983) showed that increasing seeding rates for spring wheat with late seeding dates didn't influence grain yield. Greater seeding rates may increase yield when environmental factors cause a reduction in tillering. Obeidat et al. (1984) indicated that yield was significantly increased by higher seeding rates (169 kg/ha). Roth et al. (1984) concluded that seeding rate for soft red winter wheat in South

Eastern USA is about 100 kg/ha in Pennsylvania, grain yield was not increased by more seeding rate than 168 kg/ha.

Frederick and Marshall (1985) showed that seeding rate above 101 kg/ha increase grain yield significantly in only three out of eight in northern eastern USA. Hagras (1985) indicated that the highest seeding rate (75 kg grain/fad) gave higher values of grain and straw yield, harvest index and number of spike/m^2. El-Ghareib and El-Monoufi (1988) showed that grain and straw yield increased with increasing seeding rates, this mostly due to higher number of plants per unit area, higher number of tillers and subsequently higher number of spikes in dense population.

Basilious and Mosaad (1988) indicated that 60 kg seeds/Fad had significantly higher biological, grain and straw yields than 40 kg seeds/fad in 1986/87 season. Meanwhile, number of spikes/plant and grain yield/plant were significantly higher under 40 kg seeds/Fad than that of 60 kg seeds/Fad. Jonhson et al. (1988) reported that the increase in seeding rates increase the number of spikes per square meter and weight per kernel, but decrease the number of kernel per spike.

Rajput et al. (1989) reported that the medium seeding rate of 62 to 71 kg/ha was found to perform better in the production of wheat grain. The lowest seeding rate (45 kg/ha) produces the highest 1000 grain weight.

B) <u>Effect of Plant Density on Corn</u>:

Dungan et al. (1958) stated "as long as the yield per acre increased with mounting population, the weight of ears per plant declined linearly, but when the population passed the optimum for maximum yield per acre, the grain production per plant drop sharply:. They also reported the highest grain yield was obtained at the 20,000 plants per acre and with average ear weight of 0.45 bound per plant.

Grime and Musik (1960) reported that the plant population ranging from 56,000 to 224,000 plants per acre. In some instance, didn't materially influence yields. However, a population approching 100,000 plants per acre, under optimum irrigation produced maximum or near maximum yield in all years.

Colville (1962) reported that all traits increased or decreased with increasing plant population rate except shelling percentage and yield. With these exceptions, all factors were statistically correlated with population rate. None of the factors was correlated with yield of the curve linear response of the yield to the population rate.

Robinson et al. (1964) working with grain sorghum under conditions of abundant moisture, found no effect on yield of population ranging from 64,000 to 312,000 plants per acre. Stickler (1964) found that under irrigation, highest yields were obtained with either 20,000 or 24,000 plants per acre. None irrigation corn yielded best at 16,000 plants per acre. Zui et al. (1966) pointed out that the optimum population ranged between 20,000 and 72,000 plants per acre, and 1000 to 600 cm^2 per plant in rows 1 m apart.

Rutger et al. (1967) reported that the highest silage dry matter yields were obtained at 80,000 plants but were not statistically higher than at 70,000 plants per ha. Bryant and Blazer (1968) also found that silage yields from two varieties were increased when the population was increased from 39,500 to 98,800 plants per ha. Fairbourn et al. (1970) found that the dry matter production increased with increase in plant population. Dry grains per plant and the ratio of dry shelled grains to the total dry matter decreased as plant population increased.

Brown et al. (1970) reported that increasing plant population from about 50,000 to 100,000 plants per ha didn't increase yield except in irrigated D- X L 65. Yield decreased with increased population in above range for non irrigated P 309 B. Stivers et al. (1971) reported that the average grain yields of the 69,000 plants per ha population were 2.3% lower than those of the 54,000 population in the 11 locations year traits. Andrew and Peck (1971) found that in the favourable environments, first planted, irrigated, yields increased with population upto 60,000 plants/ha, while in unfavourable environments, late and non irrigated, yields were highest at the low population. Gummins and Dobson (1973) found that as population increased from 49,000 to 86,000 plants/ha at the Predmont location, ear content decreased from 55 to 45 percent and stalk content increased from 27 to 32 percent. This resulted in significantly lower (IVDMD) (Invitro Dry Matter Digestability) at 86,000 than 68,000 plants/ha. In the Mountains as the population increased from 30,000 to 74,000 plants/ha, less change in ear (57 to 53 percent) and stalk (16 to 18 percent) content was observed with no change in (IVDMD) with varying population.

Alessi and Power (1974) reported that average grain yields increased from 2,000 to 3,070; 3050; 2,960; 2,680 kg/ha with progressive increases in population from 20,000 to 30,000, 40,000, 60,000 and 74,000 plants/ha. Number of barren stalks increased and ear weight decreased with increase plant population. Optimum plant population for grain and forage ranged from 30,000 to 40,000 plants/ha.

C) Effect of Row Spacing on Wheat:

Kinra et al. (1963) indicated that wide row spacing would tend to increase light intensity between rows and cause reduction in plant height. However, increasing row spacing to 14 inch also increased the inter-plant competition. Row spacing had no consistent effect on lodging or test weight. Yield was reduced as in row spacing increased in all cases. Large decrease occured between the 11 and 14 inch spacing. Percent of protein increased with increase in row spacing.

Meddleton (1964) found that there was no significant difference in yields in 8 and 19 inch rows. Toussain and Hettinga (1966) reported that grain yields increase with decrease row spacing; compared with standard 22 cm rows, wheat grown in 11 cm row yielded 11% more grain with irrigation and 8% more without in extremely dry year, 1964. Yield increased yield 54 - 73% in wet year 1965. Irrigation had practically no effect on grain yield and the increase due to decrease row spacing.

Benatsson (1972) found that spring wheat and barley grain yield were highest for rows 10 cm apart and decreased by 0.6% for each cm increased in row spacing. The two crops depend similarly, but wheat responded slightly better than barley to 13 cm row spacing.

Ali-Khan (1973) found that the yield difference due to row spacings and seeding rates were significant at both locations. Higher yields were recorded at 15 cm row spacing with higher seeding rate. He concluded that a row spacing of 15 cm is well suited for seeding equipment and is also benificial for weed control. Plants in narrow rows are also less susceptible to lodging as they support each other against high winds.

Cholick (1978) studied the effect of seeding rate and row spacing on winter wheat cultivars. He found that row spacing had no effect on grain or bushle weight. Number of tillers/unit area was inversely related to row width. Bishnoi (1980) studied the effect of two row spacing (12.5 and 25 cm) and three seeding rates (50, 75 and 100 kg/ha) for two growing seasons on performance of Arthur 71 wheat. He found that grain yields were higher at 12.5 cm row spacing than at 25 cm row spacing for wheat.

Oliveira and Bego (1981) working on a red Latosol at cascavel wheat cv. PAT 7219 and at palotina cv. Nambu which sown in rows of 15, 25 and 35 cm apart and 50, 75, 100, 125, 175 or 200 viable seeds/m. They found that spacing of 15 cm gives high test grain yield at both sites. Hagras (1981) reported that the highest sowing rate in rows of 30 cm apart gave the highest grain and straw yields of 14.13 Ardeb and 6.30 kg/Fad, respectively. Grain and straw yields were significantly increased from 6.30 Ardeb and 3.16 kg/Fad with no N to 15.64 Ardeb and 7.76 kg.Fad with 90 kg N/Fad. Crude protein percentage of grain increased with increasing rate of N, increasing sowing rates and at wider spacing.

Ahmed et al. (1984) conducted field trail on wheat grown at row spacings of 22.5, 45 or 60 cm in sandy clay loamy soil at Faisalabad, Pakistan. They concluded that the wide row spacing significantly increased grain yields.The increase in row spacing increased the 1000-grain weight, but decreased the number of grain per spike. Roth et al. (1984) found that a narrow row spacing (0.13 m) yielded an average increase of 7.5%. Frederick and Marshall (1985) reported that an increase for grain yield in Pennsylvania, averaging 8.2% in the 0.13 m row spacing compared to 0.18 m. The most favourably yield component by narrow row spacings was the increase in tillering per unit area.

Joseph et al. (1985) reported that a narrow row spacing (0.10 m) produced grain yields of wheat of 0.6 to 0.8 mg/ha greater than those produced by 0.20 m spacing in the MidAtlantic Coastal plain region. Thus, a significant yield advantage was obtained by reducing row spacing, while maintaining a constant plant density.

Saradon et al. (1988) reported that the tiller mortality was greater at high plant density and in tall cultivars. The number of fertile spikelets/spike was the yield component which most adversely by plant density. Dry matter distribution at harvest was not affected by plant density. Earlier senscence of plants at higher density was partially compensated for by a greater carbohydrate translocation to grain.

Jonhson et al. (1988) found that the grain yield of soft red winter wheat in the south east USA can be increased significantly by narrow row spacing and high seeding rate. Narrow row spacing gave a 7 to 8% increase in grain yield.

Rajput et al. (1989) indicated that wheat yield was not reduced to a significant extend by increasing the row spacing from 20 to 25 cm.

D) Effect of Spacing on Corn:

Haynes and sayre (1956) found that the highest yields occured at closer within row spacings than those which usually give maximum yields at closer between row spacings. Differences in within row spacing from 1 to 4 inches had little effect on total plant weight per acre, but the closer spacings within this range increased the stover:ear ratio. Brown and Shrader (1959) found that the ptimum row spacing was 10 or 20 inches in 1954 and 40 inches in 1955 under extreemly drought condition. Within row competition was considered important in influencing grain and forage yields. They pointed out that wide row spacing and low population are desirable in drought years since individual plant size is less in wide than in narrow rows and less vegetative development would generally mean more moisture available during grain development. Stickler and Laude (1960) found little difference in yield from 20 or 40 inch row spacing with weed growth prevented. Yield was drastically reduced in narrow spaced rows without weed control.

Hoff and Mederski (1960) found that equidistant planting (18.5 inch rows) out yielded 42 inch row by 7 to 10 bushels per acre. They emphasized the role of individual plant competition in contributing to increase grain yield in narrow rows. Porter et al. (1960) found that increased shading of the soil surface will reduce weed growth, but it may promote the development of insect and diseases organisms. Pendleton and Seif (1961) evaluated 20, 30 and 40 inches rows at vary plant population with brachytic-2 hybrid. Highest yields were obtained with 30 inches row. Narrow rows required slightly higher plant populations for maximum yield than did 40 inch rows. Colville and Burnside (1963) found mean yield of 146 and 91 bushel per acre, for corn planted in 20 X 20 and 40 X 40 inches spacing with 15.680 plants per acre. Atrazine gave acceptable weed control in the narrow rows. Bond et al. (1964) found that under condition of abundant moisture supply highest yield were obtained from narrow row spacings (10" and 20"), where under limited moisture supply wider row spacing (40") was preferable. Stickler (1964) suggested that yield advantages in narrow rows (20 to 30 inches) probably resulted from more ears per 100 plants (more multiple eared plants and fewer barren plants) rather than from more net photosynthesis and higher grain yield.

Zui et al. (1966) found that increased intra row plant spacing also resulted in higher head weights consequently, under dryland conditions higher yields are ob-tainable by combining narrower rows with increased intra row seedling spacing. Burnside et al. (1964) reported that narrow row spacings (10" and 20") as compared with wider row spacings (30 and 40") increased lodging, forage yield, sorghum population and sorghum heads per acre and decreased weed yields, sorghum height, head per plant, individual head weight, seed moisture and weight of 100 seeds.

Bryant and Blazer (1968) found that the proportion of stalk to total dry weight of two hybrids was the smallest from 53 cm. The weight of the total corn plant, averaged for two hybrids at all populations, decreased slightly with each increase in distance between rows. However, Lutz and Jones (1969) concluded that higher yields with the 40 cm spacing may be attributed, at least in part, to increase in available light energy and to reduce evaporation of water from the soil because of increase shading. They also reported that increase in silage yields from reducing the distance between rows.

Fairbourn et al. (1970) concluded that the system of planting corn in double row of 0.3 m apart with water shades up to 1.8 m wide between the double rows, when compared to a uniform row spacing of 0.5 or 1.2 m, apparently didn't significantly increase water use by evapotranspiration as defined or reduced yield. Brown et al. (1970) reported that the yields from 102 cm row at Calhoun were approximately 2,000 kg/ha lower than that of 51 cm row at comparable populations. The difference in yield due to row width was not great at the Plains. Increasing plant popula-tion in 102 cm row from 27,000 to 62,000 plants per ha raised yields by about 3000 kg/ha at the Plains. There was no effect of within row spacing at Calhoun. Stiver et al. (1971) found that dry matter yields of the 51 cm row were 5.0% higher than those of the 102 cm rows that yielded 15,089 kg/ha. Yields from 76 cm row were intermediate, 3.4% greater than from 102 cm rows.

Gummins and Dobson (1973) reported that in the piedmont, yield was not significantly different for early and late maturity hybrids, significantly higher in 51 than 102 cm rows (11.9 vs 11.3 MT/ha), and in the mountains yields were not significantly different for row spacing.

Alessi and Power (1974) concluded that spacing plants wider apart within a given row spacing tended to produce bigger ears per stalk than plants spaced closer together. Also found that narrow row spacing is of little benefit for dry land corn production. Generally, a lack of available water during grain formation and filling is the factor limiting corn production in the Great Plains. Krall et al. (1977) found that grain yields consistently decreased as the variability of spacing increased at the two of the three locations. They also reported that a survey of within row variability in plant spacing in fields in three Kansas countries indicated that planting precision could increase yield 200 to 1,200 kg/ha without changing planting rate.

Ramirez et al. (1979) reported that seed yields increase with decrease in row width and where generally highest in rows 0.8 m apart with 60,000 plant/ha. Sayfikar (1980) indicated that grain yields were significantly higher in narrow rows where was not limited. Light interception tends to decrease with increase in row spacings. Row orientation had no effect on grain yield.

Materials and Methods

<u>Wheat</u>:

In order to evaluate the effect of seeding rate and row spacing and their interaction on wheat yield, two experiments were conducted at the University Research Farm in Jubeiha under rainfed and at University Research Farm in Jordan Valley under irrigated conditions. Jubeiha site lies on a latitude of 32^{o} 01' north and a longitude of 35^{o} 52' east with an elevation of 980 m above sea level, while Jordan Valley site lies on a latitude of 32^{o} 12' north and a longitude of 35^{o} 37' east with an elevation of 350 m below sea level.

In 1990/1991 growing season, (Petra) a wheat variety was grown in both locations under three different seeding rates of 10, 12 and 14 kg/dunum[(1)] and three different row spacing of 20, 25 and 30 cm apart. The experiment was split plot design with three replications. The seeding rate considered as the main plots, while the row spacing considered as subplots. The fertilizers used for both locations (Jubeiha and Jordan Valley) consisted of 20 kg/dunum of ammonium sulphate (21% of N) and 15 kg/dunum of tripple phosphate (45% P_2O_5), were applied at planting.

Each subplot consisted of four rows and each row was 2.5 m long. Seeds for each row were weighted according to the seeding rate and planted by hand in well prepared soil on October 22 in Jordan Valley and October 30 in Jubeiha (Soil analysis- Appendix 1).

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(1) Dunum = 1000 m^2.

The plots were hand weeded when necessary. Ten plants were randomly labelled early in the growing season in each subplot. At maturity they were harvested and kept seperately in plastic bags for individual plant values. Data were recorded for each plant seperately, then mean of individual values were subjected to statistical analysis. The traits studied on individual plants were as follows:

1. Number of fertile tillers: A tiller was considered to be fertile if it contained grain in the spike.
2. Number of grain per spike: This was recorded by counting the number of grains produced from each spike.
3. Grain yield per spike (g): This was obtained by threshing and weighting grains from each spike.
4. Length of the spike (cm): The value obtained from measuring the distance between the base of spike to its tip.
5. Plant height (cm): The length of the main tiller from the soil surface to the tip of the ear without the awns.

In 1990/1991 growing season, the two central rows were harvested. Harvesting was done by cutting the plant culms at the soil surface on June 24 and April 15, 1991 for Jubeiha and Jordan Valley Stations, respectively. Then plants from each subplot were kept seperately in well areated plastic bags. Data were recorded on subplot basis and converted to Kg/dunum. The following traits were recorded:

1. Biological yield (kg/dunum): Total vegetative growth above the ground.
2. Grain yield (kg/dunum): Grains from each subplot were cleaned and weighted.

3. 1000-kernel weight (g): 500 kernels were randomly counted from the yield of each subplot, weighted and was multiplied by 2 to get the 1000-kernel weight.
4. Harvest Index: This value was obtained by dividing weight of cleaned grain of each subplot over the bundle weight of the subplot.
5. Protein percentage: Nitrogen percentage was determined in grain from each subplot by the Kjeldahl Method, the factor 6.25 was used to convert nitrogen percentage to protein percentage.

Statistical analysis which included analysis of variance, mean seperation according to the least significant difference (LSD) at 5% level and correlations between characteristics mentioned earlier for both locations were conducted in the computer center at the University of Jordan by employing the statistical method described by Little and Hills (1975).

Corn:

To evaluate the effect of within row plant spacing and row spacing and their interaction on corn yield, two experiments were conducted at the University Research Farm in Jordan Valley on October, 1990 and March, 1991, with spacing of 20, 30 and 40 cm in 20, 30 and 40 cm rows, at plant populations of 25,000, 16,666, 12,500, 16,660, 11,111, 8333 and 12,500 plants/dunum, respectively.

In both growing seasons, sweet corn Jubilee F_1 hybrid variety was grown at the university research farm in Jordan Valley on sand loam soil and were conducted under irrigation. Irrigation interval and amount were regulated to maintain optimum moisture availability. The experiment was laid out in a split plot design and replicated three times. The within row plant spacings were randomly assigned to main plot and row width were assigned to subplots. Each plot consisted four rows, each row were consisted six plants.

Seeds were hand planted, three seeds per position and plants were thinned to one per position when they are approximately 15 cm tall. The experimetal sites were fertilized at the planting time. All plots recieved a surface broadcast application of 20 kg/dunum of Ammonium sulphate (21%N), and 15 kg/dunum of tripple super phosphate (46% P_2O_5) and was spread by hand on surface of each plot.

Hand weeding was practicedwhen necessary. Five guarded plants were randomly labelled early in the growing season in each subplot. At maturity, they were harvested and kept seperately in plastic bags for individual plant values. Data were recorded for each plant seperately, then the mean of individual score was subjected to statistical analysis. The traits studied on individual plants were as follows:

1. Ear weight per plant (gm): The value resulted from weighting the total ear weight of five plants.
2. Grain yield per ear (gm): This was obtained by threshing and weighing the grains for each plant.
3. Number of ears per 100 plants: Ears were counted by dividing the total number of ears by the total number of plants and multiplying by 100.
4. Plant height (cm): The height of the main stem at the maturity was considered as equivalent to the plant height.

5. Stem diameter (cm): The value resulted from taking stem diameter by caliper.

In both growing seasons, the two central rows at maturity were harvested. The other two rows were left and considered as guard rows in order to prevent edge effect. Harvest was done by cutting the plant stem at the soil surface. Measurements were recorded on plot basis and converted to kg/dunum. The following traits were recorded:

1. Biological yield (kg/dunum): Total vegetative above the ground.
2. Grain yield (kg/dunum): Grain from each subplot were cleaned and weighed.
3. Weight of 1000-seeds (gm): 500 grains were randomly counted from the yield of each subplot, weighed and the weight was multiplied by 2 to get 1000 grain weight.

Data for each trait measured were subjected to analysis of variance according to the method for split plot design as out laid by Little and Hills (1975). The differences were tested for significance using the Least Significant Differences (LSD).

Results

Wheat:

A. Jubeiha:

The analysis of variance showed no significant interaction between seeding rate and row spacing for all characteristics studied in 1990/91 growing season (Table 1). Therefore, only means of main treatments are presented in table 2.

Biological yield was affected by both seeding rate and row spacing. However, only row spacing gave significant differences. Seeding rate of 12 kg/du gave highest biological yield. The decrease in row spacing led an increase biological yield. Biological yield being highest (576 kg/du) for 20 cm as compared to (434 kg/du) for 25 cm and (350 kg/du) for 30 cm, respectively.

Grain yield was highest when seeding rate was 12 kg/du, but it was not significantly different from that of the other rates. Row spacing significantly affected grain yield. The 20, 25 and 30 cm row spacings had grain yields of 176,140 and 109 kg/du, respectively. The two wider row spacings had signifi- significantly lower grain yield than narrow rows.

Lowest seeding rate (10 kg/du) produced the highest 1000-kernel weight which was statistically similar with that of 12 kg/du. The highest weight of 1000-kernels might be the result of the thinner population and higher spike length which favoured the better formation of grains. Row spacings of 20, 25 and 30 cm had 1000-kernel weight of 40.68, 42.31 and 46.49 g, respectively. The 1000-kernel weight on wider row spacings were significantly higher than those of narrow row spacings.

Table 1: Analysis of variance (mean squares) for yield, yield components and other characteristics of wheat grown at Jubeiha in 1990/91 growing season.

Source of variance	Degree of freedom	Biological yield (kg/du)	Grain yield (kg/du)	1000-kernel weight (g)	Number of fertile tillers	Number of Kernels/ spike	Kernel weight/ spike (g)	Spike length (cm)	Plant height (cm)	Harvest index	Protein percent (%)
Block	2	92484.926	4872.511	6.238	0.005	107.434	1.598**	0.028	84.179**	0.010**	0.554*
Seeding rate	2	26083.165	7079.438	45.794*	0.100	83.308	0.188	0.270	8.984	0.008	1.229**
Error A	4	21709.232	1944.255	4.607	0.071	20.362	0.042	0.170	2.573	0.000	0.040
Row spacing	2	117260.823**	10031.705**	0.836**	1.161**	128.324**	0.601**	0.849**	66.695**	0.001	2.721**
Interaction	4	5827.910	283.482	5.365	0.153	4.159	0.032	0.021	3.344	0.003	0.065
Error B	12	4195.186	632.483	3.095	0.132	3.852	0.026	0.057	6.921	0.002	0.057

*, ** significant at 5 and 1% level of probability, respectively.

Table 2: Effects of seeding rates and row spacings on yield, yield components and other characteristics of wheat grown at Jubeiha in 1990/91 growing season.

Treatment	Biological yield (kg/du).	Grain yield (kg/du)	1000-kernel weight (g)	Number of fertile tillers	Number of Kernels/ spike	Kernel weight/ spike (g)	Spike length (cm)	Plant height (cm)	Harvest index	Protein percent (%)
Main treatment Seeding rate (kg/dunum)										
10	391.80 a	112.03 a	45.40 a	2.79 a	45.28 a	3.47 a	6.04 a	63.67 a	0.28	12.65 a
12	490.40 a	167.47 a	43.19 ab	2.69 a	40.89 a	3.23 a	5.75 a	63.04 a	0.34	12.40 a
14	478.56 a	147.18 a	40.89 b	2.58 a	39.43 a	3.21 a	5.73 a	61.71 a	0.32	11.95 b
Sub treatment Row spacing (cm)										
20	576.22 a	176.53 a	40.68 b	2.30 b	45.22 a	3.04 c	6.11 a	64.45 a	0.30 a	12.90 a
25	434.09 b	140.30 b	42.31 b	2.74 a	42.60 b	3.31 b	5.91 a	64.27 a	0.32 a	12.31 b
30	350.44 c	109.84 c	46.49 a	3.04 a	37.78 c	3.56 a	5.51 b	59.67 b	0.32 a	11.80 c

In each column and within each treatment, means followed by same letter are not significantly different at 5% level of probability according to the Least Significant Differences (LSD).

The minimum seeding rate produced the maximum number of fertile tillers. It was observed that the lowest the seeding rate, the highest the number of fertile tillers. This probably due to wider spacing and consequently less competition which favoured tillering and resulted in the production of more fertile tillers. The row spacing of 30 cm gave the highest and significantly different number of fertile tillers compared to other two spacings.

Number of kernels per spike didn't differ significantly at the different seeding rates, though seeding rate of 10 kg/du produced more kernels per spike as compared to that produced at seeding rate fo 12 and 14 kg/du. The 20, 25 and 30 cm row spacings had number of kernels per spike of 45, 42 and 37, respectively. The two wider rows had significantly lower number of kernels per spike than the narrow rows.

Kernel weight per spike was almost equal at the different seeding rates. However, highest weight was obtained at the lowest seeding rate. Row spacings of 20, 25 and 30 cm had kernel weight of 3.04, 3.31 and 3.56 g, respectively. Kernel weight per spike increased with increasing row spacing.

Spike length was shorter under high seeding rate. Spike length decreased when seeding rate increased from 10 to 14 kg/du. No significant differences were found between seeding rates. 20, 25 and 30 cm row spacing had spike length of 6.11, 5.91 and 5.51 cm, respectively. The two narrower row spacings had significnatly higher spike length than the wider row spacings.

Seeding rate of 10 kg/du produced maximum plant height which was not significantly different from other seeding rates used. Row spacing of 20, 25 and 30 cm had plant height of 64, 64 and 59 cm, respectively. The two narrower row spacings had significnatly higher plant height than the wider row spacings.

Data indicated that both seeding rate and row spacing in-significantly affected harvest index. Harvest index increased as seeding rate increased. However, this increase was not linear with seeding rates.

Protein percentage was significantly affected by both seeding rate and row spacing. Seeding rates of 10, 12 and 13 kg/du has protein percentage of 12.65, 12.40 and 11.95%, respectively. The two lowest seeding rates had significantly higher protein percentage than the higher seeding rate. Protein percentage declined significantly with increasing row spacing. Grain from 20 cm spacing consistently had significantly higher protein content than grain from 25 and 30 cm spacings.

B. Jordan Valley:

Analysis of variance showed no significant interaction for all characteristics studied in 1990/91 growing season (Table 3). Therefore, only means of main treatments are presented in table 4.

Biological yield was not significantly affected by seeding rate. Yield for seeding rates of 10, 12 and 14 kg/du were 580, 650 and 532 kg/du, respectively. Row spacing had significant effect on bio-logical yield. The average yields were 718, 598 and 446 kg/du for row spacing of 20, 25 and 30 cm,

Table 3: Analysis of variance (mean squares) for yield, yield components and other characteristics of wheat grown at Jordan Valley in 1990/91 growing season.

Source of variance	Degree of freedom	Biological yield (kg/du)	Grain yield (kg/du)	1000-kernel weight (g)	Number of fertile tillers	Number of Kernels/ spike	Kernel weight/ spike (g)	Spike length (cm)	Plant height (cm)	Harvest index	Protein percent (%)
Block	2	163621.991	7013.634	7.441	0.103	127.389	2.202**	0.012	141.188**	0.011	0.219
Seeding rate	2	31572.809	2054.781	46.714	0.168	87.196	0.241	0.086	12.218	0.000	1.674*
Error A	4	32630.291	6209.498	8.989	0.143	33.112	0.068	0.381	3.782	0.003	0.155
Row spacing	2	166982.803*	10163.028*	97.041**	0.254	75.593**	0.844**	1.120**	133.330**	0.003	2.737**
Interaction	4	5176.006	1495.546	2.139	0.337	27.517	0.043	0.146	4.114	0.002	0.078
Error B	12	19436.408	1476.945	5.102	0.511	9.822	0.042	0.096	4.089	0.002	0.088

*, ** significant at 5 and 1% level of probability, respectively.

Table 4: Effects of seeding rates and row spacings on yield, yield components and other characteristics of wheat grown at Jordan Valley in 1990/91 growing season.

Treatment	Biological yield (kg/du)	Grain yield (kg/du)	1000-kernel weight (g)	Number of fertile tillers	Number of Kernels/ spike	Kernel weight/ spike (g)	Spike length (cm)	Plant height (cm)	Harvest index	Protein percent (%)
Main treatment Seeding rate (kg/dunum)										
10	580.44 a	172.18 a	49.59 a	3.60 a	49.56 a	4.06 a	7.05 a	82.18 a	0.30 a	11.76 a
12	650.14 a	184.79 a	47.81 ab	3.56 a	44.44 a	4.02 a	6.54 a	81.87 a	0.29 a	11.53 a
14	532.34 a	154.70 a	45.07 b	3.34 a	43.52 a	3.76 a	6.86 a	80.02 a	0.25 a	10.93 b
Sub treatment Row spacing (cm)										
20	718.33 a	202.78 a	44.73 b	3.37 a	48.46 a	3.63 c	7.23 a	84.99 a	0.28 a	11.99 a
25	598.09 a	173.17 ab	46.61 b	3.44 a	46.68 a	3.96 b	7.06 a	81.76 b	0.29 a	11.33 b
30	446.51 b	135.72 b	51.12 a	3.65 a	42.79 b	4.24 a	6.55 b	77.32 c	0.31 a	10.85 c

In each column and within each treatment, means followed by same letter are not significantly different at 5% level of probability according to the Least Significant Differences (LSD).

respectively. From these averages, one can conclude that there was no significant diff-erences between 20 and 25 cm row spacing. 20 cm row spacing produced the highest yield.

Seeding rate exhibited no significant effects on grain yield. The average grain yields were 172, 184 and 154 kg/du for seeding rates of 10, 12 and 14 kg/du, respectively. Row spacing of 20, 25 and 30 cm had grain yields of 202, 173 and 135 kg/du, respectively. Grain yield decreased with increasing row spacings. There was a definite increase in grain yield with narrow row spacing.

Weight of 1000-kernels decreased with increase seeding rate. However, the highest weight was obtained at the lowest seeding rate. It was observed that there was progressive increase in 1000-kernel weight as row spacing increased from 20 to 30 cm. The increase in 1000-kernel weight was probably as a result of enhanced production of photosynthesis due to wider spacing which ultimately favoured better development of wheat kernels.

Number of fertile tillers was almost equal at the different seeding rates. However, highest number of fertile tillers was obtained at the lowest seeding rate. Number of fertile tillers increased as the row become wider. The greatest increase was usually at 30 cm spacing. No significant differences were found between row spacings.

Data show that number of kernels per spike (Table 4) decreased as seeding rate increased from 10 to 14 kg/du. However, the lowest seeding rate gave the highest number of kernels per spike. Row spacing of 20, 25 and 30 cm had number of kernels per spike of 48, 46, 42, respectively. The two narrow row spacing had significantly higher number of kernels per spike than wider row spacing.

A decrease in kernels weight per spike was observed as seeding rate increase. Lowest seeding rate (10 kg/du) produced the highest kernels weight per spike. Kernels weight per spike differ significantly at different row spacing. Kernels weight increased significantly by an increase in row spacing. The highest values occured at 30 cm row spacing.

Data revealed that spike length was significantly influenced by the various row spacing treatments. There was general increase in spike length with decreasing row spacing up to 20 cm compared to the other spacings. Seeding rate of 10 kg/du produced maximum spike length which was not significantly different from other seeding rates used.

Plants were taller under lower seeding rate. Seeding rate of 10 kg/du produced maximum plant height. Plant height decreased when seeding rate increased from 10 to 14 kg/du. Row spacing of 20, 25 and 30 cm had plant height of 84, 81 and 77 cm, respectively. Plant height on the two wider row spacings were significntly lower than those of narrow row spacing.

Harvest index was lowered by increasing seeding rate above 10 kg/du. However, it was not affected by seeding rate. Harvest index increased with increased row spacing.

Seeding rate of 10, 12 and 14 kg/du had protein percentage of 11.76, 11.53 and 10.93%, respectively. Protein percentage decreased significantly with increasing seeding rate from 12 to 14 kg/du. Row spacing of 20, 25 and 30 cm had protein percentage of 11.95, 11.33 and 10.85%, respectively. The two wider row spacings significantly lower protein percentage than the narrow rows.

Correlations:

Simple correlations were calculated among yield and yield other traits in 1990/91 growing season in both locations:

A. Jubeiha:

Results of the correlation coefficients among yield and some other traits are presented in Table 5. Biological yield was significantly and possitively correlated with grain yield and plant height. Biological yield was significantly and negatively correlated with 1000-kernel weight, kernel weight per spike and number of fertile tillers. No correlations were found between biological yield and number of kernels per spike and spike length.

Grain yield was possitively correlated with plant height and negatively correlated with 1000-kernel weight and number of fertile tillers. No correlat-ions were found between grain yield and number of kernels per spike and spike length.

1000-kernel weight was possitively correlated with number of fertile tillers. No correlations were found between 1000-kernel weight and number of kernels per spike, spike length and plant height.

No associations existed between number of fertile tillers and number of kernels per spike, spike length and plant height. Number of kernels per spike was possitively correlated with spike length and plant height. Spike length was found to be posssitively correlated with plant height.

Table 6: Correlation coefficients among yield and some other yield traits for wheat grown at Jordan Valley in 1990/91 growing season.

Yield components	Grain yield	1000-kernels weight	Weight of kernels/spike	No. of fertile tillers	No. of kernels/spike	Spike length	Plant height
Biological yield	0.91499**	-0.20676	-0.23746	-0.02570	0.38727*	0.46146*	0.65788**
Grain yield		-0.15410	-0.24276	0.00699	0.42292*	0.55185**	0.54796**
1000-kernel weight			0.36937	0.44698*	-0.26291	-0.26709	-0.28410
Weight of kernels/spike				0.08355	0.10323	-0.14076	-0.48949**
Number of fertile tillers					-0.02475	-0.22313	-0.10693
Number of kernels per spike						0.42896*	0.39248*
Spike length							0.50450**

*, ** significant at 5 and 1% level of probability, respectively.

Corn:

(October 1990):

For all characteristics, the analysis of variance is given in Table 7.

Means of the main treatments namely within row plant spacing and row spacing for all traits studied, and for combination treatments (interactions) are presented in Table 8 through 11.

The effect of within row plant spacing and row spacing on biological yield are presented in Table 8. Within row plant spacing and row spacing had effect on biological yield. Within row plant spacing of 20, 30 and 40 cm had biological yield of 3545, 2913 and 1778 kg/du, respectively. The two narrow within row spacing gave significantly higher biological yield than wider spacing. All differences among biological yield due to row spacing were highly significant. The average biological yield for plants in 20, 30 and 40 cm rows were 3458, 2710 and 2067 kg/du, respectively. The interaction between within row plant spacing and row spacing was significant.

The effect of within row plant spacing and row width on grain yield are also presented in Table 8. The average grain yield for plants spaced at 20, 30 and 40 cm within row plant spacing were 359, 297 and 142 kg/du, respectively. There was no difference between the average grain yield for the at within row plant spacing of 20 and 30 cm. However, plants grown at 20 cm spacing had higher grain yield than plants grown at 30 and 40 cm. All differences among grain yield due to row width, as averages of within row spacing were highly

Table 7: The analysis of variance (Mean squares) for yield, yield components and other characteristics of corn grown at Jordan Valley in October 1990.

Source of variation	Degree of freedom	Biological Yield (kg/du)	Grain Yield (kg/du)	Weight of 1000-seeds (g)	Ear weight per plant (g)	Grain yield per ear (g)	No. of ears per 100 plants	plant height (cm)	Stem diameter (cm)
Block	2	26410.811	12637.124	167.863	32.031	9.063	1558.950*	28.858	0.190
Within row plant spacing	2	7213217.680**	108428.430**	141.189	188.583	277.204	1607.781*	391.771	0.111
Error (A)	4	399772.928	6111.370	46.573	126.776	271.964	221.274	203.580	0.128
Row spacing	2	4358298.095**	96043.012	1298.425**	156.403*	13.868	444.875	1741.660**	0.123
Interaction	4	480360.201*	6831.359**	662.540*	140.060*	65.596	344.927	193.301	0.074
Error (B)	12	124586.758	2239.617	186.175	33.605	36.206	388.290	77.362	0.054

*, ** significant at 5 and 1% level of probability, respectively.

Table 8: Effect of within row plant spacing and row spacing on the biological and grain yields of corn grown at Jordan Valley in October 1990.

Within row Plant spacing (cm)	Biological yield				Grain yield			
	Row width (cm)			Mean	Row width (cm)			Mean
	20	30	40		20	30	40	
20	4015.5 a	3818.2 a	2802.3 b	3545.37 a	470.6 a	345.03 b	263.2 bc	359.62 a
30	4091.1 a	2662.7 b	1985.5 cd	2913.14 a	443.0 a	245.13 c	149.7 de	279.30 a
40	2268.2 bc	1651.7 cd	1415.6 d	1778.50 b	197.7 cd	146.17 de	83.67 e	142.53 b
Mean	3458.3 a	2710.52 b	2067.8 c		370.5 a	245.44 b	165.53 c	

Comparable means followed by the same letters are not significantly different at 5% level of probability according to the Least Significant Differences (LSD).

significant. The average grain yield for plants in 20, 30 and 40 cm rows were 370, 245 and 165 kg/du, respectively. There was a significant difference within row plant spacing by row width interaction, indicating there was association between the effect of within row plant spacing and row width on grain yield.

Weight of 1000-seeds was almost equal at the different within row plant spacing (Table 9). The highest weight of 1000-seeds was obtained at the narrowest within row plant spacing. Weight of 1000-seeds differences, as averaged of row spacing were significant. The average weight of 1000-seeds for plants grown at 20, 30 and 40 cm rows were 152, 143 and 128 gm, respectively. The two narrow row spacing have significantly higher weight of 1000-seeds than the wider row spacing. The interaction between within row plant spacing and row spacing was significant.

The effect of within row plant spacing and row spacing on ear weight per plant are presented in Table 9. Ear weight per plant didn't differ significantly at different within row plant spacing. Though, plants grown at 20 cm within row spacing produce the highest ear weight per plant compared with those grown at 30 and 40 cm. Row width of 20, 30 and 40 cm had the ear weight of 61.44, 56.61 and 53.14 gm, respectively. Ear weight per plant decreased with increasing row spacing. Interactions were found between within row plant spacing and row width.

Grain yield per ear as affected by within row plant spacing and row spacing are shown in Table 10. Within row plant

Table 9: Effect of within row plant spacing and row spacing on the weight of 1000 seeds and ear weight per plant of corn grown at Jordan Valley in October 1990.

Within row plant spacing (cm)	Weight of 1000 seeds (gm) Row width (cm)			Mean	Ear weight per plant (gm) Row width (cm)			Mean
	20	30	40		20	30	40	
20	141.5 ab	150.13 ab	144.30 ab	145.32 a	57.8 ab	55.3 bc	62.2 ab	58.46 a
30	163.27 a	147.83 ab	111.50 c	140.80 a	66.8 a	65.6 ab	50.0 cde	60.79 a
40	151.43 ab	131.70 bc	129.13 bc	137.42 a	59.7 abc	48.93 de	47.2 e	51.96 a
Mean	152.00 a	143.20 a	128.30 b		61.44 a	56.61 ab	53.14 b	

Comparable means followed by the same letters are not significantly different at 5% level of probability according to the Least Significant Differences (LSD).

Table 10: Effect of within row plant spacing and row spacing on grain yield per ear and number of ears per 100 plants of corn grown at Jordan Valley in October 1990.

Within row plant spacing (cm)	Grian yield/ear (gm)			Mean	Number of ears/100 plants			Mean
	Row width (cm)				Row width (cm)			
	20	30	40		20	30	40	
20	40.57 ab	42.20 ab	48.53 a	43.53 a	91.33 b	97.20 b	88.80 b	92.44 b
30	42.80 ab	40.40 ab	35.37 bc	39.52 a	135.97 a	111.07 ab	99.87 b	115.63 a
40	34.67 bc	35.87 bc	28.10 c	32.88 a	91.53 b	97.20 b	88.83 b	92.52 b
Mean	39.48 a	39.45 a	37.33 a		106.28 a	101.82 a	92.50 a	

Comparable means followed by the same letters are not significantly different at 5% level of probability according to the Least Significant Differences (LSD).

spacing and row width had no effect on grain yield per ear. There was a general increase in grain yield per ear with increased in within row plant spacing. No significant differences were found between within row plant spacings. The 20, 30 and 40 cm of row spacing had the grain yield per ear of 43, 35 and 32 gm, respectively. Grain yield per ear decrease with increase in row spacing. No significant differences were found between row spacing.

Number of ears per 100 plants appears to be one of the largest contributing factor in determining the yield response of corn to rate and method of planting. The number of ears per 100 plants (Table 10) increased significantly with increased within row plant spacing upto 30 cm spacing. Within row spacing greater than 30 cm spacing, the number of ears per 100 plants decreased. Row spacing of 20, 30 and 40 cm had the number of ears per 100 plants of 106, 101 and 92, respectively. No significant differences were found between row spacing.

Mature plant height as affected by within row plant spacing and row width are shown in Table 11. Row plant spacing had no effect on plant height, however, plant height was greater at 30 cm than at the other within row plant spacing. No significant differences were found between within row plant spacing. Plant height as averages of row spacing were significant. The average plant height for plants in 20, 30 and 40 cm rows were 154, 146 and 127 cm, respectively.

Stem diameter was almost equal at the different within row plant spacing (Table 11). However, the highest stem diameter was obtained at 40 cm within row plant spacing compared to

Table 11: Effect of within row plant spacing and row spacing on plant height and stem diameter of corn grown at Jordan Valley in October 1990.

Within row plant spacing (cm)	Plant height (cm)			Mean	Stem diameter (cm)			Mean
	Row width (cm)				Row width (cm)			
	20	30	40		20	30	40	
20	147.47 bc	144.30 bc	135.77 cde	142.51 a	2.47 ab	2.07 b	2.20 ab	2.24 a
30	169.23 a	153.30 b	125.87 de	149.47 a	2.10 b	2.23 ab	2.07 b	2.13 a
40	147.17 bc	140.97 bcd	120.70 e	136.28 a	2.53 a	2.40 ab	2.13 ab	2.36 a
Mean	154.62 a	146.19 a	127.44 b		2.37 a	2.23 a	2.13 a	

Comparable means followed by the same letters are not significantly different at 5% level of probability according to the Least Significant Differences (LSD).

other spacings. Row width of 20, 30 and 40 cm had stem diameter of 2.37, 2.23 and 2.13 cm, respectively. No significant differences were found between row spacing.

(March 1991):

Data for all characteristics collected were submitted to analysis of variance and results are summarized in Table 12.

Means of the main treatments namely within row plant spacing and row spacing for all traits studied and for combination (interactions) are presented in table 13 through 16.

Biological yield was affected by both within row plant spacing and row spacing (Table 13. The average biological yield for plants spaced at 20, 30 and 40 cm within rows were 4375, 3540 and 2183 kg/du, respectively. There was no differences between the average biological yield of plant grown within row plant spacing of 20 and 30 cm. However, plants grown at 40 cm within row plant spacing significantly had lower biological yield than plant grown at 20 and 30 cm.

All differences among biological yield due to row spacing were highly significant. The average biological yield for plants in 20, 30 and 40 cm row were 3842, 3388 and 2868 kg/du, respectively. The two wider rows have significantly lower biological yield than narrower rows. Interaction between within row plant spacing and row width was observed for biological yield.

Data on grain yield as influenced by within row plant spacing and row spacing are presented in Table 13. Within row plant spacings influenced grain yield significantly. Grain yields were higher with 20 cm within row spacing mainly as a

Table 12: The analysis of variance (Meansquares) for yield, yield components and other characteristics of corn grown at Jordan Valley in March 1991.

Source of variation	Degree of freedom	Biological Yield (kg/du)	Grain Yield (kg/du)	Weight of 1000-seeds (g)	Ear weight per plant (g)	Grain yield per ear (g)	No. of ears per 100 plants	plant height (cm)	Stem diameter (cm)
Block	2	33556.409	82655.281	174.545	117.717	18.521	1397.103*	51.403	0.336
Within row plant spacing	2	11013518.965**	1105378.545*	211.327	268.538	447.168	1712.303*	559.696	0.161
Error (A)	4	558241.903	87922.968	39.169	251.894	405.141	103.249	273.665	0.159
Row spacing	2	2138258.307**	213944.600**	2775.485**	68.696	175.634	245.286	271.905	0.267
Interaction	4	624513.404*	34132.225	168.894	230.715**	117.082	441.026	280.545	0.087
Error (B)	12	182704.960	12819.405	57.024	43.556	54.506	515.864	108.543	0.082

*, ** significant at 5 and 1% level of probability, respectively.

Table 13: Effect of within row plant spacing and row spacing on the biological and grain yields of corn grown at Jordan Valley in March 1991.

Within row Plant spacing (cm)	Biological yield			Mean	Grain yield			Mean
	Row width (cm)				Row width (cm)			
	20	30	40		20	30	40	
20	4461.7 ab	4772.9 a	3892.1 bc	4375.5 a	1272.0 a	1082.7 a	1101.6 a	1152.11 a
30	4545.7 ab	3328.6 cd	2747.5 de	3540.6 a	1116.7 a	765.2 b	584.5 bc	822.12 ab
40	2520.5 ef	2064.7 ef	1965.9 f	2183.7 b	547.5 cd	458.9 cd	348.3 d	451.59 b
Mean	3842.6 a	3388.7 b	2868.5 c		978.74 a	768.54 b	678.13 b	

Comparable means followed by the same letters are not significantly different at 5% level of probability according to the Least Significant Differences (LSD).

result of increased the number of plant population per unit area. The row width of 20, 30 and 40 cm had grain yield of 978, 768 and 678 kg/du, respectively. Grain yields were significantly greater at 20 cm than at wider row spacing. There was no significant interaction between within row plant spacing and row spacing.

Weight of 1000-seeds as affected by within row plant spacing and row spacing are presented in Table 14. Within row plant spacing and row spacing had no effect on weight of 1000-seeds. The average weight of 1000-seeds for plants grown at 20, 30 and 40 cm within row plant spacing were 161, 154 and 152 gm, respectively. There was no differences between the average weight of 1000-seeds of plants grown at 20 and 30 cm and 40 cm. However, plants grown at 20 cm had higher weight of 1000-seeds than plants grown at 30 and 40 cm. The average weight of row spacing of 20, 30 and 40 cm rows were 137, 158 and 172, respectively. Seeds weight on wider row spacing was significantly higher than those on the narrow row spacing. Interaction between within row plant spacing and row width combination exhibited no significant on the weight of 1000-seeds.

Within row plant spacing and row spacing had no effect on ear weight per plant (Table 14). Data showed that the ear weight per plant under various within row plant spacing didn't vary much. However, within row spacing of 30 cm spacing produce the maximum ear weight per plant than other within row plant spacings. Row spacing had no effect on ear weight per plant. The row width of 40 cm row produced the maximum ear weight per

Table 14: Effect of within row plant spacing and row spacing on the weight of 1000 seeds and ear weight per plant of corn grown at Jordan Valley in March 1991.

Within row plant spacing (cm)	Weight of 1000 seeds (gm) Row width (cm)			Mean	Ear weight per plant (gm) Row width (cm)			Mean
	20	30	40		20	30	40	
20	148.93 b	163.00 a	173.47 a	161.80 a	61.10 c	69.13 bc	83.53 a	71.26 a
30	128.60 c	164.13 a	171.80 a	154.84 ab	74.50 ab	81.93 a	69.47 bc	75.30 a
40	135.97 bc	147.47 b	173.00 a	152.48 b	66.60 bc	61.23 c	65.63 bc	64.45 a
Mean	137.83 c	158.53 b	172.76 a		67.40 a	70.77 a	72.88 a	

Comparable means followed by the same letters are not significantly different at 5% level of probability according to the Least Significant Differences (LSD).

plant. Other row spacings are appeared equally in producing ear weight per plant. The interaction between within row plant spacing and row spacing are significant.

Within row plant spacing exhibited no significant effects on grain yield per ear (Table 15). Grain yield per ear decreased with increasing within row plant spacing. The 20 cm within row plant spacing produced more grain yield per ear than did 30 and 40 cm. No significant differences were found between within row plant spacing. The 20, 30 and 40 cm row spacing had the grain yield per ear of 43.8, 49.3 and 52.7 gm, respectively. Grain yield per ear increased with increasing row spacing. The interaction between within row plant spacing and row spacing was absent.

The effect of within row plant spacing and row spacing on number of ears per 100 plants are also shown in Table 15. Within row plant spacing influenced the number of ears per 100 plants significantly. The highest number of ears per 100 plants was obtained at 30 cm within row plant spacing. Narrower or wider within row plant spacing reduced number of ears per 100 plants. Row spacing had no effect on number of ears per 100 plants. However, it was observed that there was an increase in number of ears per 100 plants as the distance of rows was increased from 20 to 40 cm. No significant differences were found between row spacing.

Results of mature plant height as affected by within row plant spacing and row spacing are presented in Table 16. Within row plant spacing and row width had no effect on mature plant height. The average plant height for plant spaced at 20, 30 and

Table 15: Effect of within row plant spacing and row spacing on grain yield per ear and number of ears per 100 plants of corn grown at Jordan Valley in March 1991.

Within row plant spacing (cm)	Grian yield/ear (gm)			Mean	Number of ears/100 plants			Mean
	Row width (cm)				Row width (cm)			
	20	30	40		20	30	40	
20	45.47 bc	52.77 b	67.37 a	55.20 a	110.67 b	122.20 ab	130.53 ab	121.13 b
30	47.57 bc	50.53 bc	50.53 bc	49.54 a	152.83 a	141.70 ab	136.07 ab	143.53 a
40	38.53 c	44.83 bc	40.20 bc	41.19 a	102.67 b	122.00 ab	130.50 ab	118.39 b
Mean	43.86 b	45.38 ab	52.70 a		122.06 a	128.63 a	132.37 a	

Comparable means followed by the same letters are not significantly different at 5% level of probability according to the Least Significant Differences (LSD).

Table 16: Effect of within row plant spacing and row spacing on plant height and stem diameter of corn grown at Jordan Valley in March 1991.

Within row plant spacing (cm)	Plant height (cm)			Mean	Stem diameter (cm)			Mean
	Row width (cm)				Row width (cm)			
	20	30	40		20	30	40	
20	163.87 b	180.57 ab	188.6 a	177.68 a	2.70 ab	2.60 ab	3.03 a	2.78 a
30	188.03 a	191.77 a	175.0 ab	184.53 a	2.33 b	2.77 ab	2.90 a	2.67 a
40	163.67 b	176.20 ab	167.7 b	169.18 a	2.83 ab	3.00 a	2.97 a	2.93 a
Mean	171.86 b	182.84 a	177.1 ab		2.62 b	2.75 ab	2.57 a	

Comparable means followed by the same letters are not significantly different at 5% level of probability according to the Least Significant Differences (LSD).

40 cm within row plant spacing were 177.6, 185.9 and 169.1 cm, respectively. There was no significant differences between the average plant height grown at different within row plant spacing. However, 30 cm within row plant spacing had higher plant height than did other within row plant spacing. Row spacing of 20, 30 and 40 cm had plant height of 171.8, 182.8 and 177.0 cm, respectively. Wider row spacing showed increased plant height.

Table 16 also showed the results of stem diameter as affected by within row plant spacing and row spacing. There was a general increase in stem diameter with increase in the distance within row plant spacing. No significant differences were found between within row plant spacing. The average stem diameter for plants spaced at 20, 30 and 40 cm rows were 2.62, 2.75 and 2.57 cm^2, respectively. The stem diameter increased with increasing in row spacing.

Correlations:

Simple correlations were calculated among yield and other traits in 1990 and 1991 growing seasons in Jordan Valley.

October 1990:

Results of the correlation coefficients among yield and other traits are presented in Table 17. Biological yield was significantly and possitively correlated with grain yield, weight of 1000 seeds, ear weight per plant, grain yield per ear and plant height. No correlations were found between biological yield and number of ears per 100 plants and stem diameter.

Grain yield was significantly and possitively associated with weight of 1000 seeds, ears weight per plant plant, grain yield per ear and plant height. No correlations were found between grain yield and number of ears per 100 plants and stem diameter.

Weight of 1000 seeds was possitively correlated with ears weight per plant and plant height. No associations were found between weight of 1000 seeds and grain yield per ear, number of ears per 100 plants and stem diameter.

Ear weight per plant was significantly and possitively correlated with grain yield per ear and plant height. No correlations were found between ears weight per plant and number of ears per 100 plants and stem diameter.

Grain yield per ear was significantly and possitively correlated with plant height. No associations were found between grain yield per ear and number of ears per 100 plants and stem diameter.

Number of ears per 100 plants was significnatly and possitively associated with plant height.

No correlations were found between plant height and stem diameter.

March 1991:

Results of the correlation coefficients among yield and other traits are presented in Table 18.

Biological yield was significantly and possitively correlated with grain yield and plant height. No correlations were found between biological yield and weight of 1000 seeds, ears weight per plant, grain yield per ear, number of ears per 100 plants and stem diameter.

Table 18: Correlation coefficients among yield and other yield traits of corn grown at Jordan Valley in March 1991.

Yield traits	Grain yield	1000-kernels weight	Ears weight per plant	Grain yield per ear	No of ears/ 100 plants	Plant height	Stem diameter
Biological yield	0.86694**	-0.15035	0.28577	0.34288	0.17112	0.40946*	-0.32162
Grain yield		-0.15251	0.46523*	0.56914**	0.17689**	0.41778*	-0.34997
1000-kernels weight			0.21703	0.25754	0.02251	0.09500	0.40647*
Ears weight per plant				0.80229**	0.33969	0.72269**	-0.13700
Grain yield per ear					0.10483	0.64894**	-0.06407
Number of ears per 100 plants						0.48156*	0.11285
Plant height							-0.08536

* , ** = Significant at 5 and 1% levels of probability, respectively.

Grain yield was significantly and possitively correlated with ears weight per plant, grain yield per ear, number of ears per 100 plants and plant height. No correlations were found between grain yield and weight of 1000 seeds and stem diameter.

Weight of 1000 seeds was significantly and possitively correlated with stem diameter. No associations were found between weight of 1000 seeds and ears weight per plant, grain yield per ear, number of ears per 100 plants and plant height.

Ear weight per plant was significantly and possitively correlated with grain yield per ear and plant height. No correlations were found between ears weight per plant and number of ears per 100 plants and stem diameter.

Grain yield per ear was significantly and possitively correlated with plant height. No correlations were found between grain yield per ear and number of ears per 100 plants and stem diameter.

Number of ears per 100 plants was possitively correlated with plant height. No correlations were found between plant height and stem diameter.

Discussion

Wheat:

Grain yield levels in Jubeiha location were lower than those in Jordan Valley.

A. Jubeiha:

Differences among grain yield of the different seeding rates were not significantly through raising seeding rates from 10 to 12 kg/du. Lack of effect of seeding rate on increasing grain yield statistically was a result of intra competition among plants for light, minerals and water.

Biological yield per dunum increased with increasing seeding rates. This mostly due to the higher number of plants per unit area and subsequently higher number of spikes in dense populations. These results are in general agreement with those obtained by Ghareib and El-Monoufi (1988).

Plants at low seeding rates were produced more fertile tillers, large number of kernels per spike and higher kernels weight per spike, though the letter was not statistically significant. The results obtained from this study were in agreement with the results obtained by Hagras (1985). Seeding rate didn't influenced plant height and spike length. Protein percentage was decreased by increasing seeding rate. Similar results were obtained by Kinra et al. (1963).

Harvest index decreased when seeding rate increased. These results are in agreement with those obtained by Gharieb and El-Manoufi (1988).

Differences in biological and grain yields due to row spacing were significant. Narrow spacing significantly increase both biological and grain yields over the 25 and 30 cm spacing. Similar results were reported by Johnson et al. (1988), who concluded that a significant yield advantage was obtained by reducing row spacing which maintained a constant plant density. Number of kernels per spike, plant height and spike length were increased by reducing row spacing. This was in agreement with the results of Rajput et al. (1989). Increasing row spacing increased 1000-kernel weight but decreased number of kernels per spike. Similar result was obtained by Ahmed et al. (1984). Increase row spacing produced the maximum number of fertile tillers. This is probably due to consequently less competition which favoured tillering and resulted in more production of fertile tillers. These results are very similar to those obtained by Rajput et al. (1990). Protein percentage increased with decreasing row spacing. This is in close agreement with results reported by McGinnies (1970).

Biological yield was possitively correlated with grain yield and plant height. Correlation between biological yield and 1000-kernel weight and number of fertile tillers were negative. Correlation of grain yield was similar under all treatments for biological yield, plant height, 1000-kernel weight and number of fertile tillers. Correlation between 1000-kernel weight and number of fertile tillers was consistent and possitive. Number of kernels per spike was possitively correlated with plant height and spike length. Spike length was highly associated with plant height.

B. Jordan Valley:

Seeding rate results were similar to those obtained in

Jubeiha. No differences were observed for either biological and grain yields (Table 4).

Increased seeding rate gave lower values of 1000-kernel weight. This result may be due to the larger number of kernels produced from the unit area with high seeding rate and therefore, a compensation effect is expected. Similar results were obtained by Ghareib and El-Manoufi (1988). Meanwhile, number of kernels per spike, kernel weight per spike and number of fertile tillers were higher under low seeding rate of 10 kg/du comapre to the higher seeding rate. Seeding rate had no significant effect on plant height and spike length. Similar result was obtained by Obeidat (1980). Protein percentage was decreased by increasing seeding rate (Table 4).

Grain yield differences due to row spacing were significant (Table 4). Generally, grain yield in 20 cm row spacing was some what higher than those in the other two spacing.

In biological yield differences due to row spacing, higher biological yield was recorded at 20 cm row spacing. Similar results were reported by Ali-Khan (1973).

Number of Kernels per spike, plant height and spike length were increased by reducing row spacing. Meanwhile, increasing row spacing increase 1000-kernel weight and number of fertile tillers but decreased number of kernels per spike. Similar results were obtained by Rajput et al. (1989). Protein percentage increased with decreasing row spacing (Table 4).

Biological yield was possitively correlated with grain yield, number of kernels per spike, spike length and plant height. No correlations were found between biological yield and 1000-kernel weight and number of fertile tillers.

Grain yield was possitively correlated with number of kernels per spike, spike length and plant height. No correlations were found between grain yield and 1000-kernel weight and number of fertile tillers.

1000-kernel weight was possitively correlated with number of fertile tillers. No correlations were found between 1000-kernel weight and number of kernels per spike, spike length and plant height.

Number of kernels per spike was possitively correlated with spike length and plant height.

Corn:

1990/1991 season:

Grain yields in the first growing season (October 1990) were lower than those of the second growing season (March 1991). This mainly due to the low temperature as the season progressed (Appendix 2).

October 1990:

Differences among biological and grian yields at different within row plant spacings were significant. Biological and grain yields were greater with the narrower within row plant spacings, suggesting that the low temperature was not severe enough to completely over come within row plant spacing effects in the first growing season. Similar results were obtained by Brown et al. (1970) and Krall et al. (1977) who reported that grain yields consistently decreased as the variability of spacing increased.

Plants at a narrower within row plant spacing produced large number of grain per ear and had heavier ears and seeds though the letter was not statistically significant. Similar result was obtained by Haynes and Sayre (1958). Number of ears per 100 plants increased with increasing within row plant spacing from 20 to 30 cm (Table 10). Whereas, plant height and stem diameter were not affected.

Row spacing was significantly difference from each other as measured by corn biological and grain yields, in which all row spacing were compared. Meaningfully and significant biological and grain yields increased of 20 over 30 and 40 cm rows. The results obtained were in agreement with the results obtained by Bryant and Blazer (1968), and Stivers et al. (1971) who reported that percentage increase in dry matters with narrow rows were similar to those of grains. Weight of 1000-seeds and ears weight per plant were increased by reducing row spacing. Similar result was obtained by Gummins and Dobson (1973) who reported that advantage can be obtained by using narrower rows with high plant populations, especially if plant stress occurs from sub optimum climatic conditions.

Row spacing didn't affect grain yield per ear and number of ears per 100 plants (Table 10). Plant height was reduced with increasing row spacing, whereas, stem diameter was not affected. Similar result was obtained by Colville (1962).

Biological yield was possitively correlated with grain yield and weight of 1000 seeds, ear weight per plant, grain yield per ear and plant height.

Correlation of grain yield was similar under all treatments for biological yield, weight of 1000 seeds, ear weight per plant, grain yield per ear and plant height.

Ear weight per plant waa possitively correlated with grain yield and plant height. No correlations were found between ear weight per plant and number of ears per 100 plants.

Number of ears per 100 plants was possitively correlated with plant height. No correlations were found between plant height and stem diameter.

March 1991:

Higher field capacity and favourable summar temperature resulted in higher yield in the March 1991 as compared to the October 1990.

Biological and grain yields increased with reduction of within row plant spacing. These results indicated that under the conditions studied, yield superiority is mainly due to the size of the plant population, where each plant is provided with specific growing area. Similar result was obtained by Krall et al. (1977).

Weight of 1000-seeds was reduced with increasing within row plant spacing, whereas, ears weight per plant were not affected (Table 14).

Within row plant spacing didn't affect grain yield per ear but affect the number of ears per 100 plants. The within row plant spacing of 30 cm produced the maximum number of ears per 100 plants. Similar result was obtained by Haynes and Sayre (1959). Increase within row plant spacing reduced plant height but increase stem diameter, though the letter was not statistically significant (Table 16).

Differences in biological and grain yields due to row spacing were significant. Narrower row spacing (20 cm) significantly increase both biological and grain yields over 30 and 40 cm row spacing. Similar results were reported by Sayfikar (1980) and Stickler and Loude (1960) who found that yields were reduced in narrow rows when weed growth was not controlled. Weeds were effectively controlled by hand in this experiment and therefore, weeds were not contributed to differences in biological and grain yields among row spacing.

Increasing row spacing increased weight of 1000-seeds and ears weight per plant. Similar result was obtained by Alessi and Power (1974) who reported that spacing plants wider apart within a given row spacing tended to produce larger ears per stalk than plants spaced closer together.

Row spacing didn't affect grain yield per ear and number of ears per 100 plants. 40 cm rows produced more ears per 100 plants and grain yield per ear than did 20 and 30 cm rows. Similar result was obtained by Stickler (1964).

Plant height and stem diameter increased the proportion to row width. Indicating that the increase in plant height and stem diameter is mainly function of size and shape of planting area provided (Table 16).

Biological yield was possitively correlated with grain yield and plant height. No correlations were found between biological yield and weight of 1000 seeds, grain yield per ear, number of ears per 100 plants and stem diameter.

Grain yield per plant was possitively correlated with ear weight per plant, grain yield per ear, number of ears per 100 plants and plant height. Weight of 1000 seeds was possitively correlated with stem diameter.

Ear weight per plant was possitively correlated with grain yield per ear and plant height. No correlations were found between ear weight per plant and number of ears per 100 plants.

Summary and Conclusion

Wheat:

Two experiments were conducted at the University Campus in Jubeiha under rainfed and University Research Farm in Jordan Valley under irrigated conditions during 1990/91 growing season to study the effect of seeding rate and row spacing on yield and yield components of durum wheat variety "Petra".

Both locations in the 1990/91 growing season, the durum wheat variety "Petra" was planted at three seeding rates and three row spacings. The design of the experiments was split plot, with seeding rate being main plots while the row spacing were randomly assigned to the subplots.

Seeding rates for both locations were 10, 12 and 14 kg/dunum. The row spacings were 20, 25 and 30 cm rows. The main results obtained could be summarized as follows:

1. Seeding rate didn't affect biological and grain yields statistically at both locations. However, the trend was that the higher biological and grain yields were obtained by increasing seeding rate. Seeding rate statistically affected one or two out of the ten characteristics studied at Jubeiha and Jordan Valley in 1990/91, respectively.

2. Row spacing statistically affected biological and grain yields in both locations. Biological and grain yields increased as the row spacing became narrower. Row spacing statistically affected 9 or 8 out of the ten characteristics studied at Jubeiha and Jordan Valley in 1990/91 growing season, respectively.

3. Interactions between seeding rate and row spacing were not significant for all characters studied at Jubeiha and Jordan Valley in 1990/91 growing season.

Several recommendations could be drown from the present investigation, especially to wheat grower at Jubeiha and Jordan Valley areas:

1. For Petra variety, seeding rate used to be 12 kg/du, for Jubeiha and Jordan Valley, respectively.
2. Row spacing used to be 20 cm suggesting that wider row spacing technology can be adapted without any risk of reduction in yield, and allowing easy and free working of intertillage device for effective weed control.
3. A combination of 12 kg/du seeding rate and 20 cm row spacing is important for increasing grain yield.
4. In general, similar experiments should be carried out in different areas representing the wide range of environmental conditions prevailing in Jordan. So, reliable results and recommendations could be achieved.

<u>Corn</u>:

Two experiments were conducted at the University Research Farm in Jordan Valley under irrigated conditions during 1990 and 1991 growing seasons to study the effect of within row plant spacing and row spacing on yield and other yield traits of corn.

In both growing seasons, sweet corn Jubilee F_1 hybrid variety was grown at within row plant spacings of 20m 30 and 40 cm in 20, 30 and 40 cm rows. The design of the experiment was split plot, with within row plant spacings being main plots,

4. In general, similar experiments should be carried out in different areas representing the wide range of environmental conditions prevailing in Jordan, so, reliable results and recommendations could be achieved.

الملخص العربي

القمح: تم اجراء تجربتين في كل من منطقة الجبيهه في الحرم الجامعي تحت ظروف الزراعة المطرية (الجافة) والتجربة الثانية وضعت في محطة البحوث الزراعية في منطقة الاغوار تحت نظام الزراعة المروية وذلك في الموسم الزراعي ١٩٩٠/١٩٩١ . واستعملت معدلات البذار والمسافات لدراسة تاثير هذه العوامل على انتاجية القمح . اما معدلات البذار التي تم استعمالها فهي : ١٠ ، ١٢ و ١٤ كغم/دونم ، بينما كانت المسافات الزراعية بين الخطوط ٢٠ ، ٢٥ و ٣٠ سم بين السطر والذي يليه ، على التوالي ، وهي تفسر المسافات بين النباتات في السطر الواحد . وكان الصنف المستعمل هو (بترا) .

لم تظهر النتائج أي تاثير معنوي على الانتاج البيولوجي وكذلك على انتاج البذور وكانت هذه النتيجة في كلا الموقعين الا ان النتائج اظهرت ان هناك دلائل على زيادة الانتاج بزيادة معدلات البذار .

لقد اظهرت النتائج ان المسافات لها تاثير معنوي على الانتاج البيولوجي وعلى انتاج البذور . وكان ذلك في كلا الموقعين تحت الزراعة المروية او الجافة . زاد الانتاج كلما قلت المسافة بين السطور حيث اعطت اقل المسافات اعلى انتاج .

لم تشر النتائج لوجود تفاعل بين المسافات ومعدلات البذار للصفات المدروسة في الجبيهه تحت ظروف الزراعة المطرية وكانت النتائج تسير في نفس الاتجاه في منطقة الاغوار .

الذرة الصفراء: تم اجراء تجربتين للذرة ايضا في محطة البحوث الزراعية في منطقة الاغوار للموسم الزراعي ١٩٩٠/١٩٩١ تحت ظروف الزراعة المروية . وكان الصنف المستعمل في كلا التجربتين هو صنف الهجين (جبيلي) . كانت المسافات بين السطور هي : ٢٠ ، ٣٠ و ٤٠ سم بين السطور ، على التوالي في الموسم الزراعي ١٩٩٠/١٩٩١

وذلك لدراسة تأثير المسافات بين السطور على التاجية البذرة .

اشارت النتائج الى انه يوجد تأثير معنوي على الانتاج البيولوجي وانتاج البذور ، حيث زاد الانتاج كلما قلت المسافة بين السطور ، وكان ذلك في كلا التجربتين كما ان النتائج اظهرت تفاعلا معنويا بين مسافات السطور والمسافات في السطور وكان ذلك واضحا في التجربتين .

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Appendix 1: Some physical and chemical properties of Jubeiha and Jordan Valley soils.

	Jubeiha	Jordan Valley
pH	8.25	7.8
$CaCO_3$	13.71	19.8
Organic Matter %	0.71	0.9
Clay %	54.85	17.53
Silt %	27.43	22.82
Sand %	17.72	59.65
Class	Clay	Sand Loamy

Appendix 2: The average temperature during 1990 and 1991 growing seasons in Jordan Valley.

Month	Temperature (°C)	
	1990	1991
January	--	14.8
February	--	15.5
March	17.5	19.5
April	22.5	24.0
May	26.8	27.3
June	30.4	30.7
July	32.7	31.6
August	32.5	30.3
September	30.7	30.6
October	28.2	28.4
November	23.5	--
December	18.7	--

LIST OF ABBREVIATIONS

Word or sentence	Abbreviation
And others	et al.
Centimeter	cm
Degree centigrade	C^o
Dunum	du
Gram(s)	gm
Hectar	ha
Inch	"
Kilogram(s)	kg
Meter	m
Millimeter	mm
Per	/
Percent	%