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EFFECT OF PLANTING METHODS, SEED DENSITY AND NITROGEN PHOSPHORUS (NP) FERTILIZER LEVELS ON SWEET CORN (*Zea mays* L.)

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Abstract
A field experiment was conducted to evaluate the effect of planting methods, seed density and nitrogen phosphorus (NP) fertilizer levels on emergence m^{-2} growth and grain yield of sweet corn. The fertilizer and interaction of fertilizer x seed density had significant negative effect with increasing level while seed density had a positive effect with increased density on emergence per m^2. Increased seed density significantly reduced plant growth which increased with application of higher fertilizer dose. The grain yield was improved by ridge planting methods, increased seed density and increased fertilizer levels. The highest grain yield (3,553.50 kg ha^{-1}) of sweet corn plants was recorded in ridge planting method with highest NP fertilizer level of 300:150 kg ha^{-1} and 4 seeds $hill^{-1}$. The lowest grain yield (3,493.75 kg ha^{-1}) of sweet corn was observed in flat sowing planting method with 120:75 NP level and 2 seeds $hill^{-1}$ seed density. The ridge planting rank first then furrow and flat planting methods on basis of grain yield per hectare. The sweet corn plant yield was high with 4 seeds $hill^{-1}$ compared with 2 seeds $hill^{-1}$.

Keywords: Grain yield, NP fertilizer levels, planting methods, seed density, *Zea mays* L.

INTRODUCTION
Among the modern agro-management practices planting method, seed density and nitrogen application technique is imperative for boosting up of emergence, growth and production of sweet corn. Considerable work has been reported on these aspects but efforts are still required to improve these techniques for getting maximum yield. In this regard critical review of past studies was studied for conducting a planned research. Brown [1958] while doing corn cultivation trial showed a slight benefit from splitting the ridges. He further found that there is difference between ridge and flat cultivation. Ridge method showed more

performance than flat. Okigbo [1973] while undertaking an experiment on corn development and yield under flat and ridge sown conditions reported that corn on ridges produced more ears per plant. Leyenaar and Hunter [1977] in field trials on corn cv. Composite-4 grown on sandy loam soil in flat, ridged or furrowed in both cropping seasons reported that stover yield were the highest at thinning, mid silk and harvesting stages where corn was sown in flat beds. Grain yield were 3.59, 3.47 and 2.66 tons ha^{-1} with flat, furrowed and ridged beds respectively. While Gupta *et al*. [1979] conducted trials with corn and sorgham grown on black clay soils in the rainy season of 1976 and 1977 on ridges or flat bed and reported that corn and sorghum grown on ridges yielded 14-106 % and 6-59% respectively more on flat beds because of better aeration of soil. Ridging also improved with rainfall during growing season. Ridging also improved seedling emergence as well as plant fresh weight. Sharma and Admu [1984] planted corn cv. sweet corn on hill form at seed densities 2 seeds $hill^{-1}$ and 4 seeds $hill^{-1}$ in rows 90 cm apart. They concluded that number, weight of cobs and grains per cob were highest at 2 seeds $hill^{-1}$. Majid *et al*. [1986] studied the effect of different sowing methods e.g. line sowing, furrow sowing and ridge sowing on corn yield and yield components. They concluded that maximum 1000 grain weight (205 gm), Plant height (191.5 cm) and grain yield was obtained with ridge sowing. Elmaeni and Ersahookie [1987] reported that treatment ridge with deep plowing, out yielded other treatments producing corn grain or yield of 7.37 and 11.9 tons ha^{-1} for spring and autumn, respectively. At the shallow plowing depth, on the ridges grain yields were 3.19 and 7.7 tons ha^{-1} respectively. Shallow plowing with the furrows in the spring and autumn gave 3.16 and 7.3 tons grain ha^{-1} respectively. Hutchison *et al*. [1988] raised corn cv. Pioneer 3165 at 3 seed densities and given 3 rates of nitrogen. Grain yield obtained were 2.48, 2.90 and 3.18 tons ha^{-1} at seed densities of 2, 3 and 4 $hill^{-1}$. Yield with 100, 150 and 230 kg N ha^{-1} were 2.17, 2.29 and 3.06 tons ha^{-1}. Plant height at maturity was not significantly affected by N rate and seed density. Arain *et al.* [1989] reported that corn cv. Sarhad white, Sarhad yellow and Akber were given 50, 100 or 150 kg N ha^{-1} with 60 kg P ha^{-1} or no fertilizer. Plant height and number of grain per ear increased with NP up to 110 kg N + 60 kg P ha^{-1}. Further increase in N rates decreased plant height and grains per ear. Average grain yield was highest with 100 kg N + 60 kg P. Akber produced the tallest plant (194 cm) with highest grains per ear (371) and the highest grain yield of 3.56 tons ha^{-1}. Chaudhry *et al.* [1989] conducted an experimental work in 1981-84 at Rawalpindi on the effects of 90+40 or 46+30 kg +P ha^{-1} and plant population of 55,000 or 110,000 plants ha^{-1} on corn cv. Faisal and local cultivar were determined and concluded that Faisal gave more grains ear^{-1}, highest 1000 grain weight and higher yields in all treatments. The maximum yield of 2.99 tons ha^{-1} was obtained from cv. Faisal with 92 kg N at 40 kg P at the lower density compared with 1.95 tons ha^{-1} from local cultivar. Keeping in view the above finding, the present study was undertaken to determine the effect of planting method, seed density and different levels of nitrogen and phosphorus on grain yield of sweet corn.

MATERIALS AND METHODS

The proposed study to evaluate the effect of planting methods, seed density and NP fertilizer on hill planted sweet corn (*Zea mays* L) was carried out in 1996-97

at agricultural farm located at NWFP Agricultural University Peshawar, Pakistan, The area lies approximately between latitudes 24 and 37^{o}N and Longitude 61 and 76^{o}E. The average minimum temperature was 25^{o}C and average maximum temperature 37^{o}C with day length of 11-2 hrs. It occurs in semi arid climate zone of Pakistan. The native vegetation is mixture of trees, shrubs and grasses. The soil is invariable calcareous silt and clay sediments. The organic matter is quite low average about 0.5% in the surface horizons. The experiment was laid out in RCB with split plot design. Main plot was divided into 96 subplots (5x5 m) of planting method. Row to row distance was 60 cm and hill to hill 20 cm. The factors evaluated in experiment were three planting methods (flat, furrow, and ridge planting), two seeding densities (2 or 4 seeds hill^{-1}) and four NP fertilizer levels (120:75, 200:100, 250:125 and 300:150 NP kg ha^{-1}). The seed obtained from the farm of NWFP Agriculture University, Peshawar.

All the phosphorus and half dose of nitrogen were applied at sowing surface of each subplot and re-ploughed for thorough mixing of the fertilizers. For flat sowing hand hoe was applied at row distance of 60 cm while for furrow and ridge plots farm ridger was used adjusted at 60 cm, furrow to furrow and ridge to ridge. In case of furrow the seeding was done at bottom of furrow and in ridges seeding was done at the top of the ridge. The remaining half of nitrogen was applied with second irrigation by placements to all the treatments according to plan. All necessary practices were kept uniform to all treatments. Emergence m^{-2}, plant height and grain yield per hectare were recorded, and statistically analyzed.

Data on the emergence m^{-2} was recoded after full emergence of young seedling with meter rod placed 5 times in each subplot, seedling were counted and converted into seedling m^{-2} as

$$\text{Emergence per square meter} = \frac{1\text{x No. of seedling m}^{-1}\text{ row}}{\text{Row length x row width}}$$

Plant height (cm) of 10 tagged plants at random per row from subplot was recorded at maturity for the calculation of average plant height. Measurements were recorded from the soil surface to the tip of plant. Grain yield after harvesting the cobs were husked, dried and threshed. Grain weight was recoded on basis of subplot and converted in kg ha^{-1}. The data collected were statistically analyzed using analysis of variance techniques. Least significant test was applied to check the significance among treatment means.

RESULTS AND DISCUSSION

The data recorded in Table 1 indicates that increased seed density of sowing four seeds per hill increased emergence per square meter. The seed density of 4 seeds per hill has increased emergence up to 112% than two seeds hill^{-1}. The planting method did not affected emergence, however, fertilizer and interaction of fertilizer with seed density has significant effect on emergence. Highest emergence of 40.0 seedling m^{-2} was observed at 200:100 NP kg ha^{-1} with seed density of 4 seeds hill^{-1} while lowest emergence of 16.9 seedling m^{-2} was noticed at seed density of 2 seeds hill^{-1}. Increased seed density has adjusted better emergence at this fertilizer level. However, increased seed density has reduced plant height (Table 2). With low level of NP fertilizer plant height was lower than other levels of NP fertilizers. Ridge planting method increased plant height

compared with flat and furrow methods. This result is in conformity with Majid *et al.* [1986] who concluded that maximum plant height was obtained with ridge sowing method.

Table 1: Emergence per square meter as affected by planting method, seed density and NP fertilizer levels of corn.

NP levels kg ha^{-1}	Seed density (seeds hill^{-1})	Planting method			Mean
		Flat	Furrow	Ridge	Density x Fertilizer
120: 75	2	18.0	17.0	17.2	17.4 de
	4	36.2	34.2	35.3	35.3 c
200:100	2	18.0	19.0	19.0	18.7 d
	4	42.0	37.5	40.5	40.0 a
250: 125	2	17.2	16.5	17.0	16.9 e
	4	38.0	35.2	37.5	37.0 b
300: 150	2	19.2	18.0	18.3	18.5 d
	4	38.5	36.0	38.5	37.7 b
		Method x Fertilizer			
120:75		27.1	25.6	26.2	26.3 c
200:100		30.0	28.4	27.2	29.3 a
250:125		27.6	25.8	27.8	26.9 c
300:150		28.8	27.0	28.4	28.1 b
		Method x Density			
	2	18.1	17.6	17.8	17.9 b
	4	38.7	35.8	38.0	37.5 a
	Mean	28.4	26.7	27.9	

Data in a row/column with same subscript letter are significantly different at 5% level probability using LSD test. LSD value for fertilizer, seed density and their interaction at 5% level = 1.05, 2.57 and 1.48 respectively.

Table 2: Plant height (cm) as affected by planting method, seed density and NP fertilizer levels of sweet corn.

NP levels kg ha^{-1}	Seed density (seeds hill^{-1})	Planting method			Mean
		Flat	Furrow	Ridge	DensityxFertilizer
120: 75	2	159.5	165.2	173.2	166.0
	4	157.5	160.0	174.0	163.8
200: 100	2	164.5	170.2	178.5	171.1
	4	161.7	165.5	177.2	168.1
250: 125	2	166.7	171.5	180.0	172.7
	4	160.0	164.5	177.7	167.4
300: 150	2	166.5	172.5	180.5	173.0
	4	159.7	165.7	178.0	167.8
		Method x Fertilizer			
120:75		158.5	162.6	173.6	164.9 b
200:100		163.2	167.8	177.8	169.6 a
250:125		163.3	168.0	178.8	170.8 a
300:150		163.1	169.0	179.2	170.4 a
		Method x Density			
	2	164.4 c	169.8 b	178.0 a	170.7 a
	4	159.7 d	163.9 c	176.7a	166.8 b
	Mean	162.0 b	166.8 b	177.4 a	

Data in a row/column with same subscript letter are significantly different at 5% level probability using LSD test. LSD value for planting method, fertilizer, seed density and interaction of method x density at 5% level = 7.707, 4.57, 1.86 and 2.28 respectively.

Results presented in Table 3 show that corn grain yield of sweet corn plants was significantly affected by planting methods, seed density, fertilizer and the interaction of planting methods and seed density while the interaction and other variables of seed density and fertilizer had not significantly affected grain yield. The highest grain yield 3,553.50 kg ha^{-1} of sweet corn plants was recorded in ridge planting method with highest NP fertilizer level of 300:150 kg ha^{-1} and 4 seeds $hill^{-1}$. While the lowest grain yield 3,493.75 kg ha^{-1} of sweet corn was measured in flat sowing planting method with 120:75 NP level and 2 seeds $hill^{-1}$ seed density. Based on grain yield per hectare, the ridge planting ranked first followed by furrow and flat planting methods. The sweet corn plants yield was better by planting 4 seeds $hill^{-1}$ than 2 seeds $hill^{-1}$.

Grain yield is function of integrated effect of all individual components (emergence and growth), interaction between the genetic make up and agronomic practices, which may be positive or negative such as fertilizer application and seed density. The increased seed density has increased emergence but has reduced plant height. These results are in conformity with the observations of Hutchison *et al.* [1988] and Jaffar *et al.* [1988].

Table 3: Grain yield (kg ha^{-1}) as affected by planting method, seed density and NP fertilizer levels of sweet corn.

NP levels kg ha^{-1}	Seed density (seeds $hill^{-1}$)	Planting method			Mean Density x Fertilizer
		Flat	Furrow	Ridge	
120: 75	2	3493.7	3506.5	3528.5	3509.6
	4	3508.2	3517.2	3542.5	3522.6
200:100	2	3499.5	3517.2	3542.5	3516.7
	4	3514.5	3523.2	3567.2	3528.5
250: 125	2	3494.5	3508.5	3529.0	3510.6
	4	3509.7	3518.7	3534.5	3521.0
300: 150	2	3493.2	3507.2	3529.5	3510.0
	4	3511.0	3519.7	3553.5	3521.4
			Method x Fertilizer		
120:75		3501.0	511.8	3535.5	3516.1 b
200:100		3507.0	3518.6	3542.2	3522.6 a
250:125		3502.1	3513.5	3531.7	3515.9 b
300:150		3502.1	3513.5	3531.5	3515.7 b
			Method x Density		
	2	3495.2 e	3508.8 d	3531.0 b	3511.7 b
	4	3510.8 d	3519.8 c	3539.4 a	3523.4 a
	Mean	3503.0 c	3514.3 b	3535.2 a	

Data in a row/column with same subscript letter are significantly different at 5% level probability using LSD test. LSD value for planting method, fertilizer, seed density and interaction of method x density at 5% level = 5.99, 2.30, 5.65 and 2.82 respectively.

The grain yield obtained by present study is higher than the average yield of corn yield of Pakistan, which has been reported 1457 kg ha^{-1} [Anonymous 1995-1996] and 1790 kg ha^{-1} [Govt. of Pakistan 2003]. However, this yield is much lesser than reported by Lang *et al.* [1956] and Rasheed *et al* [2004]. In a study on corn concerning the relation between density of population and different levels of nitrogen supply, it was found that higher the level of nitrogen, the greater would be the plant population required for achieving maximum yield. With a low supply of nitrogen the maximum yield of grain was 4720 kg ha^{-1}, which was obtained with a population of 3 plants per m^{-2}; with a medium nitrogen level, the maximum

yield was 5,800 kg ha^{-1}, obtained with 4 plant m^{-1}; with a high nitrogen level, the highest yield was 7430 kg ha^{-1} which required a density of 5 plants m^{-1}. At low levels of nutrient-supply, dense population may have specific adverse effects on crop plants. In the present study both NP were applied but yield remain below than the yield obtained by Lang *et al*. [1956]. It may be competition of space, aeration and light among plants. Higher emergence rate was recorded with 4 seeds $hill^{-1}$ but low plant height and number of grain per cob were calculated than 2 seeds per hill. Razzaq [1998], and Elmaeni and Ersahookie [1987] reported that treatment ridge with deep plowing, out yielded other treatments producing corn grain or yield of 7.37 and 11.9 tons ha^{-1} for spring and autumn, respectively. At the shallow plowing depth, on the ridges grain yields were 3.19 and 7.7 tons ha^{-1} respectively. Shallow plowing with the furrows in the spring and autumn resulted in the production of 3.16 and 7.3 tons grain ha^{-1} respectively that is much higher than previous record. This record yield on ridge with deep plowing needs demonstration and dissemination to increase yield of corn in Pakistan and world.

CONCLUSION

The ridge plant method and increased density with suitable fertilizer application increased yield of maize. The average yield of Pakistan is low due to lack of adaptation of ridge planting method, low plant density per square meter and inefficient fertilizer application techniques.

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