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IMPACT OF DIFFERENT NPK LEVELS AND SOWING METHODS ON MAIZE GROWTH, YIELD, AND QUALITY CHARACTERISTICS

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ABSTRACT

Crop management practices are crucially important to increased yield and quality. This research study was planned to investigate the effects of different levels of NPK and sowing methods on maize. Results showed that different NPK levels and sowing methods significantly affected the growth and yield traits of maize ($p<0.05$). The better results for plant height (cm), leaf area index, cob length (cm), grains per cob, 1000-grain weight, grain yield (kg ha-1), protein content (%) total sugars (%) and starch (%) were recorded when crop-fertilized NPK with 150-120-120 kg ha^{-1}. However, all these parameters were marginally different compared to NPK rate of 120-90-90 kg ha-1, except for plant height (cm). This treatment produced significantly higher grain yield and quality traits of maize compared to lower and control treatment. Minimum values for plant height (cm), leaf area index, cob length (cm), grains per cob, 1000-grain weight, grain yield kg ha^{-1}, protein content (%), total sugars (%) and starch (%) were noted in the control treatment. In case of sowing methods, ridge sowing produced maximum plant height (cm) , leaf area index, 50% days to tasselling and yield contributing characters like cob length (cm), grains cob^{-1}, 1000-grain weight (g) and grain yield (kg ha-1) of maize as compared to broadcasting and drilling sowing methods. But sowing methods did not significantly affected the quality characteristics of maize, particularly protein content (%), total sugars (%) and starch (%). Among different sowing methods, ridge sowing method produced the maximum grain yield kg ha^{-1} of maize as compared to drilling and broadcasting. Considering the results comprehensively, the NPK rate of 120-90-90 kg ha^{-1} under ridge method would be the best management practice for maize cultivation:

Keywords: Maize, Fertilizer, Sowing methods, Yield, Growth

INTRODUCTION

Maize is a staple food crop in Pakistan after wheat and rice (Khan *et al*., 2021). The area of maize under cultivation in Pakistan is 0.974 million hectares for grain production, yielding 3.707 million tons of grain per year with an average yield of 3805 kg ha^{-1} (GOP, 2022-2023). Maize was the first cereal crop in the world to be classified based on production and yield (Paredes *et al.*, 2014). Throughout the world and Pakistan, maize is a high-yielding cereal crop (FAOSTAT, 2020), where human population is increasing rapidly and food supplies are outstripped (Memon *et al*., 2011; Ullah *et al*., 2011). Among the agro-management practices, fertilizer application and sowing methods are crucial factors for enhancing maize growth and yield in modern agriculture (Pimental *et al*., 2005). Successful maize production depends on the proper fertilizer application to enhance the production to overcome the shortage of food and feed for humans and livestock consumption. Maize crops required a well-balanced nutrient quantity of N, P and K for achieving the highest grain yield (Bekele *et al*., 2022). Being an exhaustive crop, it depletes soil nutrients more rapidly. Among all nutrients, N is one of the most important factors for worldwide maize production (Rhezali and Lahlali, 2017).The management of nitrogen in maize production is of major concern because it is an essential component for growth and development (Blumenthal *et al*., 2008). Nitrogen is an essential nutrient and is needed in large amounts in intensive agriculture systems to achieve high crop yields (Winkler *et al.*, 2002). The judicious application of phosphorus fertilizer is an important factor for sustainable agriculture in Pakistan's in cereals-based system (Anonymous, 2006). In many parts of the world, phosphorus is the most important nutrient for agriculture (Shrestha *et al.*, 2016). Potassium is a third macronutrient that is necessary for plant growth (Gebrselassie, 2016). Potassium performs vital function in various physiological processes, such as protein synthesis, water and nutrient transportation, carbohydrate metabolism, photosynthesis, nitrogen utilization, promotion of early growth, and enhancing resistance against pests and diseases. (Yawson *et al*., 2011). Maize absorbs in large quantities of potassium after

nitrogen, so potassium fertilizers are needed in large amounts for maize crop. (Niehues *et al*., 2004). NPK fertilizers significantly impact plant growth, development and yield, providing the necessary growth nutrients for better cell function, cell division, and improvement of vigorous growth (Fashina *et al*., 2002). NPK fertilizer plays an important role in increasing maize yields (Ashgar *et al*., 2010). Cultural practices also have a significant effect on the growth and yield of maize (Latif *et al*., 2001). The sowing method is another important factor in improving maize yields (Belachew and Abera, 2010). Sowing is a method by which the crop is sown in the field to achieve the desired distribution and arrangement of the plants. In Pakistan, maize was sown using different sowing methods such as flat sowing, ridge sowing, and raised bed sowing. While the soil and climatic conditions of Pakistan favor for maize production, inappropriate sowing methods fundamentally decrease maize production. A proper sowing method helps maintain optimal plant populations and allows plants to use light and other input sources evenly and efficiently (Quanqi *et al*., 2008). Inappropriate methods of sowing significantly reduce maize production (Bakht *et al.*, 2011). In-proper sowing method results in unfertile plants and their size remains small, the crop become more vulnerable to pests, diseases and lodging, lowering yield per unit area (Liu and Yong, 2008). Ridge sowing produces a higher yield than other sowing methods (Abdullah *et al*., 2008).

MATERIALS AND METHODS

Field research was conducted during the 'Kharif' (summer) season of 2017-2018 at the Student Experimental Farm, Department of Agronomy, Sindh Agriculture University, Tandojam. Pakistan. The experimental design was RCBD (factorial) with three replications. The net plot size was 3 m wide x 5 m long (15 m^2). There were five NPK treatments (F_1= Control**,** F_2= 75-30-30 kg NPK $ha^{-1,}$ F_3 =100-60-60 kg NPK ha^{-1}, F_4= 120- 90-90 kg NPK ha^{-1}, F_5 = 150-120-120 kg NPK ha^{-1}) and three sowing methods (M_1 = Broadcasting, M_2 = Drilling, M_3 = Ridge). The land was ploughed, followed by clod crushing and leveling to achieve good seedbeds. The fertilizer source of nitrogen was urea, Phosphorus in the form of di-ammonium and Potassium as Sulphate of Potash. All fertilizer doses were applied according to the treatments. The maize variety Akbar was sown with different sowing methods. All the recommended management practices for the maize crop were done throughout the growing season except treatments. The canal water was applied to irrigate the crop when required. Harvesting was done manually with a hand sickle implement.

Data collection methods: Days to reach 50% tasselling were determined by calculating the number of days from sowing to reach 50% tassels in each subplot. Plant height was observed with a measuring tap on randomly selected plants in each plot. Leaf area index was determined using the following formula: Leaf area $plant^{-1}$ / Ground area $plant^{-1}$ (m^{-2}). The average grain number of cob^{-1} was calculated from the five cobs randomly selected from each plot. From each treatment, the randomly selected 1000 grain were weighed on top-loading digital balance, and yield per hectare was calculated from grain yield per plot and recorded. Protein content was determined according to the Kjeldahl method described by (Isaac and Johnson, 1976). For nitrogen determination, the grain was oven-dried for 72 hours (Gostar, 24060, Iran). The starch % of the grain was determined according to the method of (Juliano, 1969). Total sugar % was calculated according to the Anthron method of Riazi *et al.* (1985).

Statistical analysis: The collected data were statistically analyzed using Statistics 8.1 computer software. The LSD test was applied to determine the effects of fertilizer rates and sowing methods on maize growth, yield and quality characteristics at *p*-value 0.5%.

RESULTS

Plant height (cm): Plant height was significantly affected by NPK levels and sowing methods (Table-1). Plants fertilized with NPK levels @ 150-120-120 kg ha-1 gained highest plant height (199.66 cm), followed by NPK @120- 90-90 kg ha^{-1} with plant height (189.45 cm). However, the smallest plant height (71.98 cm) was noted under the control treatment. Moreover, the response of plant height to different sowing methods was also significant. The maximum plant height (173.39 cm) was recorded using the ridge sowing method, followed by the drilling method with a plant height of (160.49 cm). However, the lowest plant height (151.11 cm) was noted under the broadcasting sowing method

Days to 50% tasselling: The observed results indicated that the data on days to 50% tasselling was significantly varied in response to NPK levels and sowing methods throughout the growing seasons (Table-1). The data showed that a maximum number of days to 50% tasselling (57.57) were recorded with the application of NPK @120- 90-90 kg ha^{-1}. However, further increases of NPK@ 150-120-120 kg ha-1 rates showed non-significant response to days to 50% tasselling and minimum days to 50% tasselling (47.39) were recorded in the control treatment. In the case of sowing methods, early days to 50 % of tasseling 51.10 were observed in the broadcasting sowing method followed by 53.72 days to 50% tasselling in drilling methods. Late days to 50% tasselling (56.31) were recorded in the ridge sowing method.

Leaf area index: Application of various NPK levels and sowing methods significantly affect the leaf area index of maize grown for grain (Table -1). Among the tested NPK levels, application of NPK @120-90-90 kg ha^{-1} recorded a greater leaf area index (9.52) and

further increased rates of NPK@ 150- 120-120 given the non-significant effect on leaf area index. The lower value of the leaf area index (3.41) was observed in control plots, whereas no fertilizers were applied. LAI also showed a significant response to sowing methods, the ridge sowing method has a maximum leaf area index of (8.56) followed by (6.52) in the drilling sowing method. The lower leaf area index values (5.48) were recorded in the broadcasting sowing method

Table 1. Growth traits of maize crop as affected by NPK levels and sowing methods

NPK (Kg ha^{-1})	Plant Height (cm)	Days to 50% tasselling	Leaf area index
00	78.98 e	47.39 d	3.41 d
75- 30-30	168.36 d	51.94 c	4.96 c
100-60-60	178.87 c	53.57 b	6.72 b
120- 90-90	189.45 b	57.49 a	9.52 a
150-120-120	199.66 a	58.16 a	9.58 a
SE=	2.58120	0.6781	0.1451
LSD (0.05)	5.28731	1.3890	0.1124
Sowing methods			
Broadcasting	151.11 c	51.10 c	5.48 c
Drilling	160.49 b	53.73 b	6.52 b
Ridge	173.39 a	56.31 a	8.56 a
SE=	1.9994	0. 5253	0.1124
LSD= 0.05	2. 2474	1. 0759	0.2303

Note: Different letters indicate significant differences at $p< 0.05$.

Yield parameters: The data on yield parameters are presented in (Table- 2). From the results, it can be seen that the maximum grains per cob (353), 1000 grains weight (94.12 g), grain yield (4062 kg ha^{-1}) was found with the application of NPK @ 120-90-90 kg ha^{-1}, further increase in NPK rates 150-120-120 kg ha^{-1} showed non-significant response to these traits. The minimum number of grains per cob (127), weight of 1000 grains (24.71 g), and grain yield (1299 kg ha^{-1}) were found in the control treatment. The sowing method was also significant. The highest grains per cob (304.33), weight of 1000 grains (260.47 g), and grain yield (3511 kg ha^{-1}) were found in the plots where maize was sown on ridges followed by drill sowing with 293.47 grains per cob, weight of 1000 grains (239.28 g) and grain yield (3389 kg ha-1) and the lowest grains per cob (261.87), weight of 1000 grains (229.45 g) and grain yield (3278 kg ha^{-1}) were recorded in the sowing method.

Table 2. Yield traits of maize crop as affected by NPK levels and sowing methods

NPK (Kg ha^{-1})	Grains per cob	1000 grains weight (g)	Grain yield (kg ha^{-1})
00	127 d	24.71 d	1299 d
75- 30-30	281 c	62.30 c	3682 c
100-60-60	311 b	89.13 b	3859 b
120- 90-90	353 a	94.12 a	4062 a
150-120-120	359 a	94.33 a	4070 a
SE=	2.9410	2.6769	45.275
LSD (0.05)	6.0243	2.7166	92.742
Sowing methods			
Broadcasting	261.87 c	229.45 c	3278 c
Drilling	293.47 b	239.28 b	3389 b
Ridge	304.33 a	260.47 a	3511 a
SE=	2.2781	35.070	35.070
LSD= 0.05	4.6664	71.838	71.838

Note: Different letters indicate significant differences at $p< 0.05$.

Quality parameters: Table -3 shows that sowing methods did not significantly influence the grain quality parameter of maize, but all these quality traits were significantly influenced by NPK levels. The maximum protein content of (10.43%) starch (69-55%) and total sugar (3.03 %) was observed with the application of NPK @ 120-90-90 kg ha-1, further increase in NPK rates 150-120-120 kg ha-1 showed non-significant response to these traits. Control treatment resulted in 8.12, 61.91, and 2.57 % of protein, starch and total sugar, respectively. It was observed that higher values of maize quality traits viz., protein content (9.65, 9.59 %), starch (66.64,66.55%) and total sugar (2.85, 2.83 %) were found under ridge and drilling sowing methods as compared to broadcasting sowing method but the differences did not reach the level of significance

Table 3. Quality characters of maize as affected by NPK levels and sowing methods.

NPK (Kg ha^{-1})	Protein content (%)	Starch (%)	Total sugars (%)
00	8.12 d	61.91 c	2.57 d
75- 30-30	9.14 c	64.46 b	2.74 c
100-60-60	9.69 b	66.30 b	2.81 b
120- 90-90	10.43 a	69.55 a	3.03 a
150-120-120	10.48 a	70.08 a	3.04 a
SE=	0.1642	1.0164	0.0222
LSD (0.05)	0.3363	2.0820	0.0455
Sowing methods			
Broadcasting	9.47	66.50	2.80
Drilling	9.59	66.55	2.83
Ridge	9.65	66.64	2.85
SE=	0.1272	0.7873	0.0172
LSD= 0.05	Ns	NS	NS

Note: Different letters indicate significant differences at $p< 0.05$.

DISCUSSION

In present study, five different NPK levels and three sowing methods were used to enhance the production of grain and quality of maize crop. It is found that the application of NPK @ 120-90-90 kg ha^{-1} significantly improved all the growth and yield traits of maize, A proper supply of NPK fertilizers significantly increased the growth, yield and quality traits of maize. The application of inorganic fertilizers improves crop yields as the elements in such fertilizers are easily accessible to use by crops compared to organic fertilizers, similar findings are also noted by Ashgar *et al*. (2010). NPK fertilizer significantly increases maize grain yields. NPK fertilizers have a significant impact on plant growth, development and yield, providing the necessary growth nutrients for better cell function, cell division, improvement vigorous growth (Fashina *et al*., 2002). The optimal use of NPK fertilizer boosted the maize crop's growth and yield characteristics; thus, the appropriate dose of NPK is critical for maize production (Asghar *et al*., 2010). Grain yield was increased by applying higher levels of NPK fertilizer (Jayaprakash *et al*., 2010). The increase in grain yield is due to the application of NPK (Alias *et al.,* 2003). Relevant results were also found by (Mousavi *et al*., 2019) that NPK fertilizers significantly affected the quality parameters of maize crops. The starch quality, oil content, protein content, and grain yield were improved with the application of NPK fertilizer (Bilgin *et al*., 2010). NPK fertilizers enhance the quality of maize grains by positively influencing their protein and starch content. NPK fertilizers rates not only increase grain yield but also improve grain quality in terms of protein (Rehman *et al*., 2011). As far as sowing methods are concerned, ridge sowing produced significantly better growth and yield traits than drilling or broadcasting. These results were in conformity with those reported by (Bakht *et al*., 2006; Belachew and Abera, 2010; Gul *et al*., 2015; Kashif *et al*., 2018). The total grain yield, harvest index, and percentage of shelling were higher in ridge sowing with an excess of nitrogen. In most parts of the world, broadcast sowing is the predominant method of farming, but this method has resulted in inefficient use of elementary sources (Savita *et al*., 2010). Agronomical and phenological traits were significantly higher under ridge sowing methods than in other trench and flat sowing methods. Ridge-sowing crops produced high yields because the roots have access to nutrients and water (Kumar and Chawla, 2015). The sowing method does not significantly affect the quality characteristics of maize. viz. Protein content, starch and total sugars. Previous research also shows that ridge, broadcasting and drilling sowing methods did not affect the quality traits of maize. Many researchers (Rehman *et al*., 2011; Jaspal, 2015, Kaur, 2013: Amandeep and Mahesh, 2017) observed that different sowing methods did not significantly impact the quality traits of maize. Maize is a very important grain crop as well as well it is also used for feeding animals as forage. Fast-growing human populations need more grains. Conclusively, our research experiment results revealed that the commonly grown maize variety "Akbar" sown on ridges with NPK level @120-90-90 kg ha^{-1} showed better performance in terms of grain yield and quality characteristics.

CONCLUSIONS

The results of the present investigation showed that application of NPK @ 120-90-90 kg ha^{-1} produced significantly higher grain yield and quality traits of maize as compared to other treatments. Among different sowing methods, ridge sowing method produced maximum grain yield of maize as compared to drilling and broadcasting, whereas quality parameters were not influenced significantly by different sowing methods, So, it can be concluded that maize may be grown on a ridge with the application of NPK @ 120-90-90 kg ha^{-1} for higher productivity and profitability.

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