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Response of P_2O_5, K_2O and seed rate on grain yield of pearl millet (*Pennisetum glaucum* L.) fodder variety Bajra 2011

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Abstract

Response of P_2O_5, K_2O and seed rate on grain yield of Pearl millet variety 'Bajra 2002' was studied in field experiment during kharif seasons of 2015 and 2016. Fifteen management practices such as three P_2O_5 and K_2O levels and five seed rates were imposed with three replication using split plot design. Parameters included plant height, stem diameter, tiller/m², head/m², head/plant, 1000 grain weight, number of grains/head and seed yield kg/ha. Fertilizer and seed rate treatments had significant effect on plant height, stem diameter head/m² and grain yield/ha. P_2O_5 and K_2O showed no significant effect on head/plant, tiller/m² 1000 grain weight and number of grain/head. The highest grain yield production (4211.8kg/ha) was recorded in the combination of 3.75kg/ha seed rate and fertilizer dose of 57-60-60 NPK kg/ha. The highest grain yield from pearl millet crop was obtained by the fertilizer dose of 57kg N + 60kg P_2O_5/ha while statistically similar but economical grain yield was obtained with the fertilizer dose 57kg N + 40kg P_2O_5 /ha.

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Introduction

Pearl millet (*Pennisetum glaucum* L.) is the sixth most important cereal crop in the world after rice, wheat, maize, barley and sorghum (Singh *et al.*, 2003). Pearl millet grain has good nutritional value and it contains 11-19% protein, 60-78% carbohydrates and 3.0-4.6% fat and also has a good amount of phosphorus and iron. In Pakistan, it is widely grown as rain-fed cereal crop in the arid and semi-arid regions covering 476000 hectares with grain production of 293000 metric tonnes (FAO, 2011). It can be grown in areas where rainfall is not sufficient (200–600mm year^{-1}) for the cultivation of maize and sorghum crops (Reddy *et al.*, 2016). The increased population pressure on land has caused sub-division of larger tracts of agriculture farmlands into individual small parcels of human settlements thereby reducing the land area under arable agriculture.

The soils having low inherent fertility are considered as the most important constraint to food security (Bationo *et al.*, 1998). The main cause of fertility depletion in such soils is the imbalance caused by nutrients that are not commonly replaced after their removal (Gichuru *et al.*, 2003). Sanchez *et al.* (1997) have reported an estimated depletion rate of 660 kg N/ha, 75kg P/ha and 450kg k/ha from about 200 million hectares of cultivated lands of 37 *African* countries in the past 30 years nutrient. Under continuous cropping system inherently infertile soils require external input of fertilizers and materials for maintaining fertility and productivity (Nyathi and Campbell, 1995). Land degradation manifested in the form of soil fertility depletion is considered as the root cause of declining fertility under small holdings (Stoorvogel and Smaling, 1990; Smaling *et al.*, 1997) and nutrient imbalance on large scale farms (Nandwa and Bekunda, 1998).

Productivity enhancement is essential to cater the needs of increasing population. It is hypothesized that better management of nutrients and water supply can play a role in maximizing yield per unit area and catering the needs of the increased population pressure. Grain yield of pearl millet is affected greatly by the seeding rate and the supply of nutrients but the information on the optimum and economical dose of P_2O_5 and K_2O, for higher grain yield and better quality of pearl millet in the rain-fed region, is lacking. Therefore, the present investigation was conducted to study the effect of P_2O_5 and K_2O on grain yield and quality; and to determine the optimum and economic dose for P_2O_5 and K pearl millet crop.

Material and methods

Experiment Area and Planting Material

The research was conducted in field area of Fodder Research Institute, Sargodha and planting material was obtained from national research stations to study the effect of P_2O_5, K_2O and seed rate on yield of pearl millet.

Application of Fertilizers and Seed Rate

Five levels of seed rates i.e. 2.5, 3.75, 5.0, 6.25 and 7.5 kg/ha and three levels of NPK fertilizer @ 57-20-20, 57-40-40 and 57-60-60kg/ha were investigated under the study. The fertilizer doses of P and K as per treatment and 1/3 N were added as basal during seed bed preparation and the remaining 2/3 N was applied 21 days after sowing with the first irrigation. Other agronomic recommended practices such as weeding, hoeing, irrigation etc were carried out uniformly to all the treatments.

Growth Parameter Studies

All the observations on agronomic parameters, such as plant height, stem diameter, number of heads per plant, number of tillers per meter square and number of heads per meter square were recorded at the maturity stage of the crop. Ten heads from each plot were collected, threshed and grains were counted to calculate average number of grains per head and were weighed to find out 1000-grain weight. After harvesting and threshing all the plots separately the grains were weighed and on the basis of plot size grain yield in t/ha was calculated.

Statistical Analysis

The study was conducted for two years in experiments having three replications and the results were discussed as combined effect of the two years studies. The study was conducted in split plot design with fertilizer in the main plots and seed rate rates in the sub-plots.

Results and discussion

Fertilizer doses, seeding rates and their interactions showed significant effect on some of the growth parameters of pearl millet. Increase in the fertilizer doses of P_2O_5 and K_2O increased the plant height, number of heads/m^2 and grain yield while decreased the stem diameter. The effect of P_2O_5, K_2O and seeding rate on different growth parameters and yield are presented and discussed separately.

Plant Height

According to the results fertilizer levels and seeding rate and the interaction of both the treatments affected the plant height significantly. Increase in the fertilizer doses of the fertilizer resulted in an increase in the plant height. The maximum plant height at crop maturity (229.33cm) was recorded in the treatment given 57-60-60kg NPK ha^{-1} followed by 220.6 cm plant height having fertilized @ 57-40-40kg NPK ha^{-1} against the lowest plant height (218.33cm) recorded with 57-20-20Kg NPK ha^{-1}. Increase in seed rate of Pearl millet resulted in a significant increase in the plant height. A continuous trend of increase in the plant height was recorded throughout the range of the seeding rates tested under the study. Seeding rates of 2.5, 3.75, 5.0, 6.25 and 7.5kg/ha resulted in 190.11, 215.44, 226.56, 236.44 and 2445.22cm respectively (Table 1). All the seeding rates differed significantly for their effect on plant height. Snider *et al.* (2012) have reported similar results of increase in the plant height at higher seed rates. The higher seed rate, having higher plant population, stimulates internode elongation and increases plant height (Schmitt and Wulff, 1993).

The effect of interaction of the seeding rates and fertilizer doses of P and K had a significant effect on plant height. The effect of fertilizer levels at lowest seeding rate was non-significant while the fertilizer doses differed significantly at all the other higher seeding rates. Maximum plant height (251.0cm) was recorded in the treatment combination of 57-60-60kg NPK ha^{-1} fertilizer and 7.5kg/ha seeding rate. The second group of highest plant height i.e. 245, 243.33 and 241.33cm was recorded in the treatment combinations 6.25 kg seed + 57-60-60kg NPK ha^{-1}, 7.5kg seed + 57-40-40kg NPK ha^{-1} and 7.5kg seed + 57-20-20kg NPK ha^{-1}. Similar results have been reported from earlier studies of Bothe *et al.* (2000), testing a range of 0-75kg/ha P_2O_5, resulting in maximum plant height using the highest P_2O_5 dose of 75Kg/ha. The higher plant height due to higher P levels is considered to be due to its essential constituent of plant tissue plays a positive role in stem elongation (Kummar and Chandra, 2008; Shahid *et al.,* 2009). Similarly, Adel and Thomas (1994) reported increase in plant height at higher K levels than at lower K regime as K improves the growth and development of the plants in addition to improving the nutrient uptake and efficiency.

Stem Diameter

Stem diameter was affected by seeding rate and fertilizer level in the study conducted for two years. Increase in the seed rate from 2.5kg /ha to the highest seed rate 7.5kg/ha, tested under the study, the stem diameter decreased significantly while increase in the fertilizer doses of P_2O_5 and K_2O resulted in an increase in the stem diameter.

The maximum stem diameter 1.42cm was recorded at the lowest seeding rate having significantly higher stem diameter than recorded in all the other seed rates. The lowest stem diameter (1.20cm) was recorded in the treatment sown with the highest seed rate (7.5Kg ha^{-1}). The fertilizer dose of 40:40kg P and K ha^{-1} resulted in the maximum diameter while the higher and lower doses of P and K resulted in significantly lower plant diameter (Table 1).

Interaction of seed rates and fertilizer doses on stem thickness/diameter were significant for their effect on the stem diameter. The stem diameter was reduced by increasing seed rate or decreasing the P and K fertilizer doses in general but the reduction in the stem diameter at higher seed rates was less prominent where higher P and K fertilizers were applied. The study reveals that a higher seed rate, or plant population, caused decrease in stem diameter due to interplant competition (Schmitt and Wulff, 1993; Van der Werf *et al.*, 1995). Taller plants resulting from a higher seed rate or plant population have thin and slender stems that are more prone to lodging (Kashiwagi *et al.*, 2008; Venato and Kindiger, 2008) hence higher seed rates are not recommended.

Table 1, Effect of seed rate and fertilizer doses of P_2O_5 and K_2O on plant characters, yield contributing parameters and grain yield*.

Treatments (Fertilizer doses/Seed rate/Interaction)	Plant height (cm)	Stem diameter (cm)	No. of tillers per m^2	No. of heads per m^2	No. of heads per plant	1000 grain weight (gm)	No. of grains per head	Seed yield (kg/ha)
Fertilizer								
F1: 57-20-20 NPK kg/ha	218.33C	1.3033C	54.264	38.733AB	0.753	8.918	1269.33	3369.7B
F2: 57-40-40 NPK kg/ha	220.60B	1.3333A	54.198	38.400B	0.745	9.402	1262.79	3505.2AB
F3: 57-60-60 NPK kg/ha	229.33A	1.3153	53.998	39.333A	0.742	9.48	1270.39	3642.5A
Spacing								
S1: 2.5 kg/ha	190.11E	1.4222A	27.333E	23.22D	0.8544A	11.364A	1802.0A	4056.6B
S2: 3.75 kg/ha	215.44D	1.3878B	40.000D	33.00C	0.8422A	10.268AB	1638.8B	4211.8A
S3: 5.0 kg/ha	226.56C	1.3211C	54.333C	42.00B	0.7678B	8.729BC	1278.0C	3709.7C
S4: 6.25 kg/ha	236.44B	1.2600D	68.333B	48.444A	0.6944C	8.622C	870.6D	2940.0D
S5: 7.50 kg/ha	245.22A	1.1956E	80.778A	47.444A	0.5756D	7.274C	748.4E	2610.0D
Interaction								
F1xS1	189.67I	1.4167B	28.00	24.00	0.87	11.36	1796	3954.00
F1xS2	213.00H	1.3900C	39.00	31.67	0.86	10.526	1649.7	4086.00
F1xS3	218.67G	1.3133E	54.33	40.67	0.746	8.326	1276	3630.00
F1xS4	229.00E	1.2500G	69.33	49.33	0.706	7.70	876.6	2793
F1xS5	241.33BC	1.1467I	80.66	48.00	0.583	6.68	748.33	2384
F2xS1	189.00I	1.4100B	27.00	23.33	0.86	12.36	1805.00	4093
F2xS2	212H	1.3833C	40.66	34.33	0.85	11.103	1630.00	4249
F2xS3	223.33F	1.3333D	54.00	41.33	0.76	8.80	1279.00	3739
F2xS4	235.33D	1.2800F	68.33	47.33	0.693	7.85	851.66	2873
F2xS5	243.33B	1.2600FG	81.00	45.66	0.563	6.90	748.33	2566
F3xS1	191.67I	1.4400A	27.00	22.33	0.833	12.32	1805.00	4120
F3xS2	221.33FG	1.3900	40.33	33.00	0.816	11.153	1636.66	4299
F3xS3	237.67CD	1.3167DE	54.66	44.00	0.796	8.796	1279.00	3757
F3xS4	245.00A	1.2500G	67.33	48.66	0.683	8.10	883.30	3153
F3xS5	251.00A	1.1800H	80.67	48.66	0.580	7.10	748.66	2882

* The means within a factor of the column or the interaction means within a column followed by a letter in common do not differ significantly at 5% level.

Although the study indicated reduction in the stem thickness but coupled with higher doses of P and K the effect was compensated. Xiang *et al.* (2012) reported that plant height and stem diameter increased initially but the effect decreased with increasing the amount of P and K application. The maximum stem diameter (0.86cm) and (0.91cm) was reported at the level of 17Kg P_2O_5 and 75Kg K_2O ha^{-1} respectively. Increase in K application increased the stem diameter, lowered the plant height and reduced the lodging rate and the results are in conformity with the findings of Xiang *et al.* (2012). A combination of fertilizer @ 40Kg P_2O_5 + 40Kg K_2O ha^{-1} and 2.5Kg ha^{-1} seed was found better than the other combinations as regards stem diameter.

Increase in P_2O_5 and K_2O, through the range of their doses tested, resulted in significant increase in the seed yield/ha, number of heads/m^2, 1000 grain weight, number of grains/head however these characters were affected negatively with increase in the seed rate. Similar results were reported by Alpha *et al.* (2007). The highest number of heads/m^2 (39.33) and seed yield (3642.5kg/ha) were recorded where P_2O_5 and K_2O was applied a@ 60-60kg /ha while 40-40kg/ha P and K also gave statistically similar results for the two traits. The study indicted 40kg/ha P_2O_5 as the optimal dose for maximum plant vigour and efficient nutrient uptake giving better results for number of heads/m^2 and seed yield while further increase in the P dose affected the plant growth. These results are in agreement with many other workers (Xiang *et al.*, 2012; Pauline *et al.*, 2010; Kamara *et al.*, 2008; and Aise *et al.*, 2011).

The study revealed that 40kg/ha K_2O produced the best results as regards the seed yield, 1000 grain weight, number of heads/m^2 and number of grains/head. Similar results have been reported by Sale and Campbell (1986) mentioning increased K dose resulting in better yield traits and seed yield. The study emphasizes the role of P and K in enhancing the growth of pearl millet, reducing the lodging rate and increasing the yield of pearl millet. Seeding rate significantly affected 1000-grain weight, number of grains/head and number of heads/plant.

The lowest seed rate (2.5kg/ha) was found to be the best for these yield contributing traits. The results of 3.75kg/ha seed rate were found at par with 2.5kg/ha seed rate as regards number of head/plant, number of heads/m2 and 1000-grain weight. As the seeding rate was increased from lower seed rate (2.5kg/ha) to higher seed rate, up to 7.5kg/ha, the 1000-grain weight, number of grains/head, number of heads/plant decreased significantly. Although several yield contributing traits were recorded to be better by using 2.5kg/ha seed, the best yield was obtained by 3.75kg/ha seed. This may be explained as a combination of the yield contributing traits of individual plant and the plant population.

The results of this study are supported by the findings of Fernandez *et al.* (2012) who reported that lower plant population produced a greater number of heads/plant, highest 1000-grain weight, and greatest number of seeds/head. Karchi and Rudich (1966) have reported the contribution of number of seeds/head towards seed yield. Significant increase in the number of tillers/m^2 and number of heads/m^2 were recorded by increasing the seeding rate.

Significantly highest number of tiller/m^2 was observed at seed rate 7.5kg/ha which was followed by seeding rate 6.25kg/ha (Table 1). The highest number of heads/m^2 (48.4) was recorded by 6.25kg/ha seed rate followed by statistically similar number of heads/m^2 (47.4) in 7.5kg/ha seeding rate. Fertilizer levels also showed significantly effect on number of heads/m^2. It was recorded that fertilizer level 60-60kg/ha P_2O_5 and K_2O was significantly different from 40-40kg/ha P_2O_5 and K_2O for number of heads/m2. The result of number of heads/m^2 have no significant effect on grain yield of pearl millet that was supported by (Mascagni and Bell, 2005).

Conclusion

It is concluded that fertilizer level of N:P:K @ 57:40:40kg/ha produced significantly higher grain yield of pearl millet combined with 3.75kg/ha seeding rate. The increase in the number of heads/plant, stem diameter, 1000-grain weight and number of grains/head because the seed rate higher than 3.75kg/ha had no positive effect on grain yield. Significant decrease in productivity is probably caused due to morphological changes resulting in taller plant with thinner stems that are more prone to lodging. The study suggests that seeding rate 3.75kg/ha with fertilizer dose of N:P:K @ 57:40:40 kg/ha may give maximum grain yield of pearl millet.

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