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Effect of Fertility Level, Plant Density and Age of Seedling on Transplanted Pearl Millet (*Pennisetum glaucum*)

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A B S T R A C T

A field experiment was conducted during the *kharif* season of 2018 at the Research Farm, Bihar Agricultural University, Sabour, Bhagalpur, Bihar to find out the effect of fertility level, planting density and age of seedling on transplanted pearl millet under rainfed agro-ecosystem of South Bihar. Experiment was laid out in a factorial randomized block design and replicated thrice. The treatment comprised of three levels of fertility levels *viz.* F_1 (90: 45: 45 kg NPK ha^{-1}), F_2 (120: 60: 60 kg NPK ha^{-1}), F_3 (150 :75: 75 kg NPK ha^{-1}), four combinations of plant population and age of seedling i.e T_1 (15 days old seedling at 50 cm x 20 cm) , T_2 (15 days old seedling at 50 cm x 25 cm), T_3 (20 Days old seedling at 50 cm x 20 cm) and T_4 (20 days old seedling at 50 cm x 25 cm). Results revealed that application of 150:75:75 kg NPK ha^{-1} was recorded significantly grain (3.95 t ha^{-1}) but noted at par with 120:60:60 kg NPK ha^{-1}. Among the levels of plant population and age of seedling, T_3 treatment had significantly higher grain yield (3.95 t ha^{-1}), net return (Rs.71788/ha) and B: C ratio (3.19) but being statistically similar with T_1 treatment. Hence, it may be concluded that to achieving higher crop productivity yield, high yielding hybrids pearl millet cultivars could be grown with 120: 60: 60 kg NPK ha^{-1} under the planting geometry of 50 cm x 20 cm for transplanting of 15 days old or 20 days old seedling for agro-ecosystem of South Bihar.

Introduction

Pearl millet (*Pennisetum glaucum* L.) popularly known as Bajra, cattle millet or bullrush millet is an important coarse grain cereal crop of arid and semi-arid regions of India (Ramesh *et al.,* 2006). It ranks as 6th most important food grains in world and sustaining one third of the world's population (Raily, 2006)). India is the largest producer of pearl millet in area (7.12 m ha) and production (8.06 mt) with productivity of 1132 kg ha^{-1} (Anonymous, 2017). This crop is normally grown as rainfed crop with annual rainfall ranging from 150 to 600 mm.

Thus, nutritional value of pearl millet (11-19 % protein, 60-78% carbohydrates and 3.0-4.6 % fats) offers much scope for development of value-added products in new health conscious consumers especially for diabetic and heart patients (Yadav *et al., 2*011). Pearl millet is generally grown on marginal lands having poor soil fertility of low input management. With the advancement of technology, many pearl millets hybrids are developed and that are responsive to fertilizers besides other good agronomic practices (Kumar *et al., 2*003). Balanced fertilization not only having yield advantages in pearl millet, also increases the quality of produce (Kumar *et al.*, 2019). Nitrogen is a most vital nutrient and performs as a component of many organic compounds viz. proteins, amino acid, nucleotides, enzymes, protoplasm, vitamins, hormones, alkaloids *etc.* It also enhances the utilization of phosphorus and potassium (Prakash *et al.*, 2017)).

Application of nitrogen produces taller plant extending the harvesting period and improved quality of produce like protein and succulence. Phosphorus (P) is a leading limiting factor for plant growth and productivity (Prasad *et al.,* 2017, Prakash *et al.*, 2018) and improves root proliferation that promotes better nutrition of plant (Kumawat *et al.*, 2015;Yadav *et al.*, 2018). Whereas potassium activates a number of enzymes, including synthesis of carbohydrates, provides resistance to the disease and adverse environmental condition (Jeet *et al.*, 2014; Kumar *et al.*, 2018; Kumar *et al.*, 2019). Hence, ensuring the nutritional securities in a given soil for enhancing the yield and yield attributing characters of crop is important factor under the rainfed agro-ecosystem. Plant population is one of the important factors for higher production that determines the optimum plant density. An optimum plant stand enhances the efficiency of pearl millet by exploiting growth factors, which ultimately influences the crop yields. Higher plant density generally increases plant population resulting into inter-crop competition thereby affecting yield but lowering plant density reduce yield drastically. Hence, optimum plant density is utmost to harness the maximum yield potential of crop. Age of seedling bears a great role in establishment of crop and to avoid the root injury shocks during process of transplanting. Keeping these things in view, the present experimentation was carried out.

Materials and Methods

Experiment was carried out during the *kharif* season of 2018 at the Crop Research Farm, Bihar Agricultural university, Sabour, Bhagalpur, which is located at located at the South of river Ganges (25°23'N, 78°07' E and 37.19 m amsl). Soil of the experimental field was sandy loam in texture, slightly alkaline in pH (7.6), low in availability of N (218.9 kg ha^{-1}), medium in available P and medium in availability of K. Experiment was laid out in a factorial randomized block design with three replications and twelve treatment combinations, comprising three levels of fertilizer F_1 (90: 45: 45 kg NPK ha^{-1},), F_2 (120: 60: 60 kg NPK ha^{-1}), F_3(150 :75: 75 kg NPK ha^{-1}) and integrations of the plant population and age of seedling T_1(15 days old seedling at 50 x 20 cm) , T_2 (15 days old seedling at 50 cm x 25 cm), T_3 (20 days old seedling at 50 x 20 cm) and T_4 (20 days old seedling at 50 x 25 cm). Nitrogen application was done in three splits as per the treatments.

Application of $1/3^{rd}$ of N, full dose of P_2O_5 and K_2O were applied as a basal and remaining $1/3^{rd}$ N knee high stage and $1/3^{rd}$ N at panicle initiation stage respectively through Urea, DAP and MOP. As per treatment fertilizers were placed in furrows made by narrow spade (*Kudali*), at a depth of 5 cm and apart from the seed rows by side dressing. The urea, di-ammonium phosphate (DAP) and muriate of potash (MOP) were used as sources for nutrient elements. Full dose of nitrogen was applied in two equal splits i.e. half at sowing and half at three weeks after sowing.

However, the doses (according to treatments) of phosphorus and potassium were applied as basal dressing at the time of sowing. One weeding was done manually at 35 days after sowing during to control weeds and facilitate the good aeration. For biometric observations five plants in net plot were randomly selected and tagged for recording the biometric observations at different stages of crop growth. However, for measuring dry matter accumulation, five plants from the border rows were randomly selected.

Yield attributes and yield were studied before and after harvesting as per investigation required. Crop was harvested when grains are hard enough with nearly 15-20 per cent moisture and plants showed physiological maturity. Harvesting was done by removing earheads first and cutting down the plant later from each plot separately. The earheads after harvesting were sun dried at the threshing floor. Threshing was done thereafter by beating earheads with sticks. The threshed grains were dried in sun to bring the moisture content to 12-14 per cent and then final weights were recorded. The gross return, net returns and benefit: cost ratio of different treatments were worked out on the basis of prevailing market prices. To test the significance, experimental data collected on various aspects of investigation on pearlmillet were statistically analysed with procedure described by Cochran and Cox (1967).

Results and Discussion

Growth attributes

Higher plant height (236.9 cm), leaf area index (3.9), dry matter accumulation (1235.6 g m^{-2}), tillers $hill^{-1}$ (4.2) at harvest were observed under the fertility levels of F_3 (150:75:75 kg NPK ha^{-1}), but being statistically at par with F_2 but superior (Table 1). Fertility level of F_3 (150:75:75 kg ha^{-1}) gave higher tillers $plant^{-1}$ at all the crop growth stages i.e. at 30 DAT (7.09), 60 DAT (6.79) and harvest (4.21), which was statistically at par with F_2 (120:60:60 kg ha^{-1}) but superior over F_1 (90:45:45 kg ha^{-1}).

This might be due to application of nitrogen enhances development of strong cell wall and therefore stiffer straw, which might be resulted into profuse tillering. Higher availability of NPK through balanced fertilization and production of growth promoting substances (Prasad *et al., 2*014; Kumar 2015). Application of nitrogen, phosphorous produces positive significant effect on growth parameters (Jhakar *et al.*, 2011; Mishra *et al.*, 2017). Balanced application of potassium along with N and P_2O_5 not only gave higher yield but also increases quality of economic produces. Plant population and age of seedling affected the growth of pearl millet.

Plant height (238.5) and leaf area index (4.1) was recorded maximum in T_3 (20 days old seedling at 50x20 cm) but statistically at par with the treatment T_1. Significantly higher dry matter accumulation (DMA) recorded with treatment T_3 **(**20 days old seedling at 50 cm x 20 cm) 1260g m^{-2}, which was statistically at par with T_1 (20 days old seedling at 50 cm x 25 m). Plant population and age of seedling affect the number of tillers $plant^{-1}$.

Treatment T_2 produced significantly higher tillers $plant^{-1}$, but statistically at par with T_4, T_3 at 30 DAT, T_1 & T_4 at 60 DAT and T_4. Young seedlings recorded better root growth and facilitated the increased cell division/enlargement due to increased photosynthetic rate subsequently increasing plant height and number of tiller $hill^{-1}$ (Kumar *et al.*, 2017; Prasda *et al.*, 2017).

Table.1 Effect of fertility, plant population and age of seedling on growth parameters of pearl millet

Treatment	Plant height (cm)	DMA (g)	LAI	Tillers hill^{-1} (no.)
Fertility level				
$N_{90}P_{45}K_{45}$	221.92	138.25	3.66	3.53
$N_{120}P_{60}K_{60}$	232.83	150.98	3.76	3.93
$N_{150}P_{75}K_{75}$	236.92	152.90	3.99	4.21
CD (P=0.05)	10.64	6.20	0.24	0.21
Plant population and seedling age				
15 DOS at 50cm x 20cm	234.44	137.72	3.88	3.80
15 DOS at 50cm x 25cm	220.89	156.84	3.52	4.07
20 DOS at 50cm x 20cm	238.56	140.57	4.07	3.73
20 DOS at 50cm x 25cm	228.33	154.38	3.74	3.96
CD (P=0.05)	12.28	7.16	0.28	0.25

Table.2 Effect of fertility, plant population and age of seedling on yield attribute of pearl millet

Treatment	Effective tillers hill^{-1} (no.)	Ear head m^{-2} (no.)	Ear head length (cm)	Ear head dia. (cm)	Ear head wt. (g)
Fertility level					
$N_{90}P_{45}K_{45}$	1.8	15.8	25.1	3.4	51.6
$N_{120}P_{60}K_{60}$	1.9	16.6	26.4	3.6	57.5
$N_{150}P_{75}K_{75}$	2.q	17.8	27.4	3.7	59.9
CD (P=0.05)	0.17	1.2	1.1	0.2	2.9
Plant population and seedling age					
15 DOS at 50cm x 20cm	1.8	17.1	25.8	3.5	54.4
15 DOS at 50cm x 25cm	2.1	15.9	27.3	3.7	60.3
20 DOS at 50cm x 20cm	1.8	17.7	25.5	3.4	53.3
20 DOS at 50cm x 25cm	2.0	16.1	26.6	3.6	57.4
CD (P=0.05)	0.20	1.4	1.3	0.18	3.3

Table.3 Effect of fertility, plant population and age of seedling on yield of pearl millet

Treatment	Test wt. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
Fertility level			
$N_{90}P_{45}K_{45}$	10.17	3.57	7.88
$N_{120}P_{60}K_{60}$	11.42	3.84	8.26
$N_{150}P_{75}K_{75}$	12.17	3.95	8.37
CD (P=0.05)	0.96	0.21	0.37
Plant population and seedling age			
15 DOS at 50cm x 20cm	10.84	3.85	8.29
15 DOS at 50cm x 25cm	12.16	3.62	7.88
20 DOS at 50cm x 20cm	10.52	3.95	8.48
20 DOS at 50cm x 25cm	11.50	3.73	8.04
CD (P=0.05)	1.11	024	0.43

Table.4 Effect of fertility, plant population and age of seedling on economics of pearl millet

Treatment	Gross return (Rs.)	Net return (Rs.)	B:C Ratio
Fertility level			
F_1 ($N_{90}P_{45}K_{45}$)	86012	64793	3.05
F_2 ($N_{120}P_{60}K_{60}$)	91391	68939	3.07
F_3 ($N_{150}P_{75}K_{75}$)	94149	70345	2.96
CD (P=0.05)	4004	4004	NS
Plant population and seedling age			
15 DOS at 50cm x 20cm	92315	69795	3.10
15 DOS at 50cm x 25cm	86660	64196	2.86
20 DOS at 50cm x 20cm	94307	71788	3.19
T_4 (20 DOS at 50cm x 25cm)	88787	66322	2.96
CD (P=0.05)	4624	4624	0.21

Increase in plant height might be due to optimum population attributed to minimum intra-species competition, which might help in proper utilization of natural resources (Kumari *et al., 2*017; Singh *at al*.2017).

Yield attributes

Grain yield of pearl millet was mainly depending on yield attributing characters. Higher yield attributes in treatment may be due to balanced fertilization (Table 2). Thus, all the yield attributes improved and gave significant effect of nutrient application. Application of 150:75:75 kg NPK ha^{-1} produced significantly higher yield attributes. Higher effective tiller $hill^{-1}$ (2.09), ear head m^{-2} (17.80), ear head length (27.34), ear head diameter (3.7), ear head weight (59.9 g) and test weight (12.1 g) were found with fertility level of F_3 (150:75:75 kg NPK ha^{-1}), which was statistically at par with F_2 (120:60:60 kg NPK ha^{-1}). Significantly higher pearl millet grain yield (3.95 t ha^{-1}) recorded with F_3 (150:75:75 kg NPK ha^{-1}) and found at par to F2 treatment.

Application of fertilizer provides to grater and prolonged availability of the nutrient. Increase in grain and straw yields with enhanced N application could be ascribed to increases activity of cytokinin in plants, leads to increased cell-division/elongation which leads to better plant growth, dry-matter production and higher photosynthesis (Kumar *et al.*, 2017b). Thus, an increase in N supply might have increased yield attributing characters which ultimately contributed to increase in yields.

Increased grain yields due to varying levels of nutrients have been reported by Bhuwa and Sharma (2015). Yield attributing traits viz. ear head weight, and test weight were significantly higher in wider spacing. In case of plant population and age of seedling, T_2 (15 days old seedling at 50 cm x 25 cm) exhibited significantly higher values of yield attributing characters viz. ear head length (27.3 cm), ear head diameter (3.7 cm), ear head weight (60.3 gm) and test weight (14.3 gm) over T_1 (15 days old seedling at 50 x 20 cm) however, it was found at par with T_4 (15 days old seedling at 50 x 20 cm).

However, the treatment T_3 was recorded significantly higher head m^{-2} (17.7) over T_2 (15.9) and T_4 (16.2) but was at par with T_1 (17.1). The treatment T_3 was recorded significantly higher grain yield (3.95 t ha^{-1}) (Table 3) and remained at par with T_1 due to closure plant spacing occupied maximum number of plant than wider spacing. It might be attributed to transplanting of pearl millet at optimum spacing of 50 cm x 25 cm with 20 days old seedlings that had ability to establish quickly by absorbing root injury shocks and promoting development of seminal roots as well as favouring proper utilization of natural resources (Singh *et al.*, 2013; Singh *et al.*, 2017; Jeet *et al.*, 2017).

Economics

Significantly higher gross return (Rs. 94149.34 ha^{-1}), net return (Rs. 70345 ha^{-1}) were recorded with F_3 (150:75:75 kg NPK ha^{-1}) and found at par to F_2 (Table 4). Highest gross return (Rs. 94307 ha^{-1}), net return (Rs.71788ha^{-1}) and B: C ratio (3.19) were recorded with T_3, which was statistically at par with T_1 but significant over T_2 and T_4.This might be due to higher yield associated with the respective treatments (Kumar *et al.*, 2015a,b; Kumar *et al.*, 2017a,b; Kumar *et al.*, 2016).

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