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Response of establishment methods on growth, yield and economics of finger millet (*Eleusine coracana* L.) Varieties

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Abstract
During *kharif* season of 2020, a field experimental study was carried out to evaluate finger millet varieties and establishment methods under Prayagraj climatic condition at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). A Randomized Block Design was followed in all of the treatment combinations which were replicated thrice. Among three varieties (GPU 28, ML 365 and Godra OT) and establishment methods (line sowing, broadcasting and transplanting), treatment combination of transplanting + ML 365 recorded significantly higher plant height (106.52 cm), number of total tillers (267.75/m^2), dry matter accumulation (1013.78 g/m^2), grain yield (3.77 t/ha), straw yield (6.59 t/ha), biological yield (10.35 t/ha) and harvest index (37.27%), respectively. It also gave maximum gross returns (Rs. 1,31,963.80/ha), net returns (Rs. 97,824.77/ha) and B:C ratio (2.86).

Keywords: Economics, establishment methods, finger millet, varieties, yield

Introduction
Finger millet (*Eleusine coracana* L.) also known as ragi belonging to Poaceae is an annual herbaceous plant widely grown as a cereal crop in India. It is a major food crop of the semi-arid tropics of Asia and Africa and has been an indispensable component of farming systems (Goron *et al*., 2015) [2]. This crop is generally grown on the moderate hill slope where rice cultivation is not possible. It requires minimum rainfall of around 350-400 mm for successful cultivation but can be grown successfully in the areas receiving rainfall up to 1000 mm. However, well drained loam or clay loam soils are best for cultivation. It can be stored cheaply and has no major pest problem so for a long time (Sarawale *et al*., 2017) [16]. Nutritionally, it has high content of calcium (344 mg/100 g), dietary fiber (15-20%) and phenolic compounds (0.3-3%). In India, it is cultivated over an area of 1.20 million hectares with total production of about 1.99 million tons and productivity of 1656 kg per hectare. Standardization of suitable varieties for a particular location is paramount importance to realize the yield potential of finger millet (Veeraputhiran *et al*., 2009) [19]. The release of high yielding varieties has contributed a great deal towards the improvement of yield in finger millet. The yield of any crop depends on the production potential of the cultivar, climatic, edaphic and management practices to which the cultivar is exposed. Besides varietal selection, methods of sowing is also an important agronomic factor affecting the productivity of crop. Proper sowing method is the important non-monetary input in crop production, which affects the crop growth, yield and quality to greater extent (Sarawale *et al*., 2016) [15]. In Uttar Pradesh, finger millet was found to be a neglected millet crop for the last 20 years. Because of its undesirable taste, low productivity and low monetary income to farmers, the millets are being neglected. Keeping these points in view, an experimental trial was done to find out appropriate varieties and establishment methods which can sustain in Uttar Pradesh soil type and climatic condition.

Materials and methods
A research trial was conducted at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during *kharif* season of 2020 with varieties of finger millet, sown by broadcasting, line sowing and transplanting with spacing of 30 cm x 10 cm. The location is situated at 25.57o N latitude, 87.19o E longitude and at an altitude of 98 m above mean sea level.

Important chemical properties of soil are shown in Table 1.

Table 1: Chemical properties of soil in the experimental field

Particulars	Value
Sand (%)	60 (%)
Silt (%)	20 (%)
Clay (%)	14.4 (%)
Textural class	Sandy loam
pH	7.4
Organic Carbon	0.147 (%)
Available Nitrogen	69.82 (kg/ha)
Available Phosphorus	10.3 (kg/ha)
Available Potassium	213.7 (kg/ha)

The recommended dose of nutrients as 60 kg nitrogen (N), 30 kg phosphorus (P_2O_5) and 30 kg potassium (K_2O)/ha, respectively were used in the experiment. Only fifty per cent of nitrogen and full dose of phosphorus and potassium were applied in all the plots as basal dose. Rest of the fifty per cent of nitrogen were applied after 30 days after transplanting and days after sowing. In broadcasting method of establishment, seeds and fertilizers were dispersed randomly in the experimental plot. In line sowing method, seeds were sown directly and application of fertilizers were done in rows with a definite spacing of 30 cm x 10 cm. Whereas, in transplanting method, 18 days old seedlings were transplanted with a definite row to row and plant to plant pattern of 30 cm x 10 cm with 2 seedlings each. For this, three raised nursery beds were prepared for three finger millet varieties and seeds were sown on beds in a row, so that seedlings can be uprooted easily at the time of transplanting. Plots comprising of broadcasting and line sowing, seeds were sown on 28/06/2020 and similar timing is also considered for seeds sown on nursery beds. Later, transplanting was done on 16/07/2020 to main field. As it is a rainfed crop, no irrigation is needed but after transplanting two irrigations with alternate days were given for better crop establishment. Manually two hand weedings were done at 25 and 50 DAS/DAT with '*khurpi*'. At every 15 days interval, observations such as plant height, number of total tillers/m^2, dry matter accumulation/m^2 and observation of yield at harvest stage were noticed. Based on appropriate experimental design, data generated from the research field were subjected to statistical analysis of variance. Significant was tested by variance ratio (~F-value) at 5% level (Gomez and Gomez, 1984) [4].

Results And Discussion

Growth parameters

The data pertaining to plant height, number of total tillers/m^2 and dry matter production/m^2 of finger millet in accordance with treatment combinations of establishment methods and varieties were depicted in Table 2. The values related to plant height performed significant difference among treatments. However, significantly higher plant height (106.52 cm) was recorded in transplanting + ML 365 followed by treatment combination of transplanting + GPU 28 (104.24 cm), respectively. The reason behind this is because of vigorous growth attained when new roots developed after the transplanting shock. Besides transplanting, varietal selection also attributed the plant height. Similar results were reported by Nandini and *Sridhara* (2019) [5], Patil *et al*. (2018) [8] and *Sarawale et al*. (2016) [15]. Significantly higher number of total tillers/m^2 was noticed in ML 365 variety adopted in transplanting method (257.75/m^2) which were followed by transplanting method + GPU 28 (241.09/m^2). Because transplanted plants could have effectively utilized the available resources such as space, foraging area for root system, light utilization and further enhanced the tiller development. Capacity of tillers also varied with genotypes and its producing ability depends on dry matter production and accumulation in main stem during the early stage of the growth. Similar discussion were also supported by *Gowda et al*. (2018) [3], *Sarawale et al*. (2016) [15], *Raghunatha Reddy et al*. (2020) [20], *Sima Kumari et al*. (2018) [17] and *Raundal* and *Patil Vidya* (2017) [11]. The results of maximum dry matter accumulation were recorded significantly under transplanting + ML 365 treatment combination (1013.78 g/m^2), while at par values were noticed in the treatment combination of transplanting + GPU 28 (973.02 g/m^2). This was due to increased plant height and number of total tillers/m^2 which in turn resulted in higher dry matter accumulation per unit area. It is largely function of photosynthetic surface which had favourably influenced by ML 365 variety. These results are in agreement with the findings of *Sarawale et al*. (2016) [15], *Veeraputhiran et al*. (2009) [19], *Pandiselvi et al*. (2010) [7] and *Triveni et al*. (2018) [18]

Table 2: Effect of establishment methods and varieties on growth attributing parameters of finger millet

Treatments	Plant height (cm)	Number of total tillers/m^2	Dry matter accumulation (g/m^2)
Broadcasting + GPU 28	91.82	137.76	642.34
Line sowing + GPU 28	96.88	203.31	809.22
Transplanting + GPU 28	104.24	241.09	973.02
Broadcasting + ML 365	93.26	142.21	689.68
Line sowing + ML 365	99.16	208.87	855.37
Transplanting + ML 365	106.52	257.75	1013.78
Broadcasting + Godra OT	89.44	124.43	607.23
Line sowing + Godra OT	96.15	155.54	748.49
Transplanting + Godra OT	102.53	210.20	910.61
SEm(±)	0.96	15.11	13.89
CD (P=0.05)	2.88	45.29	41.63

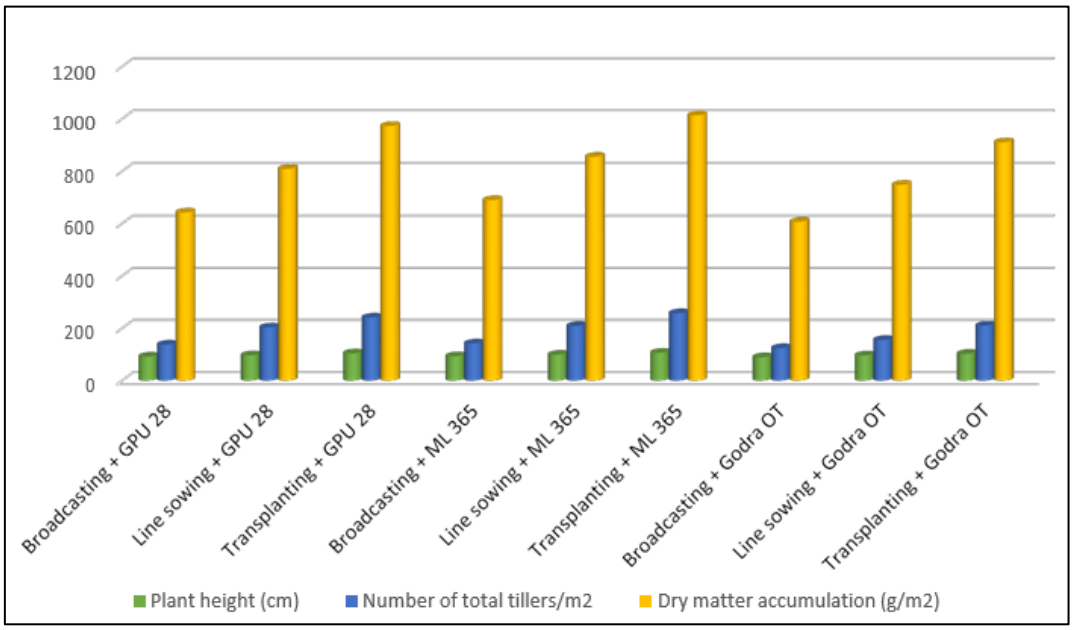

Fig 1: Effect of establishment methods and varieties on growth attributing parameters of finger millet Yield parameters

Data related to yield parameters *viz.* grain yield (t/ha), straw yield (t/ha), biological yield (t/ha) and harvest index (%) were presented in Table 3. The maximum grain yield (3.77 t/ha) was found to be significantly higher in treatment combination of transplanting + ML 365. Whereas, transplanting + GPU 28 variety (3.56 t/ha) was found to be statistically at par with transplanting + ML 365, respectively. Lowest grain yield was recorded with treatment combination of broadcasting + Godra OT (1.73 t/ha). Grain yield under treatment combination of transplanting + ML 365 was produced 87%, 36%, 59%, 26%, 118%, 52% and 15% yield than Broadcasting + GPU 28, Line sowing + GPU 28, Broadcasting + ML 365, Line sowing + ML 365, Broadcasting + Godra OT, Line sowing + Godra OT and Transplanting + Godra OT, respectively. Selection of improved variety and better establishment techniques influenced growth attributes which might have enhanced the grain yield. These results are in confirmatory with the work of *Saha* and *bharti* (2006) [13], *Sarawale et al*. (2017) [16], *Narayan Hebbal et al*. (2018) [6] and *Ahiwale et al*. (2011) [1]. Straw yield was significantly higher (6.59 t/ha) in transplanting + ML 365. However, the treatment combination of transplanting + GPU 28 (6.32 t/ha) was found to be statistically at par with transplanting + ML 365 which were depicted in Table 3. Higher straw yield of ML 365 with transplanting technique may be attributed to higher dry matter accumulation in vegetative parts. Similarly, grain yield correlated positively with straw yield. Lower straw yield of Orissa local variety (Godra OT) may be due to reduced size of photosynthesizing surface which might have caused reduction in growth. These consequently reduced the total straw yield production in broadcasting technique. These results are in agreement with the findings of Gowda *et al*. (2018) [3], Revathi *et al*. (2018) [12] and *Saravanakumar* (2018). The combination of grain and straw yield were conformed to biological yield and recorded maximum in transplanting + ML 365 (10.35 t/ha). The higher grain yield and straw yield were due to increment in growth and yield parameters. Significantly higher harvest index (37.27%) was noticed in transplanting with ML 365 variety which was found to be at par with transplanting + GPU 28 (35.98%), respectively. This was mainly because of increase in grain yield with optimum straw yield which in turn resulted in higher harvest index. These results were in conformity with the findings of *Revathi et al*. (2018) [12] and Praveen Kumar *et al*. (2019) [9].

Table 3: Effect of establishment methods and varieties on yield of finger millet

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Broadcasting + GPU 28	2.01	4.18	6.19	32.48
Line sowing + GPU 28	2.77	5.26	8.03	34.49
Transplanting + GPU 28	3.56	6.32	9.88	35.98
Broadcasting + ML 365	2.36	4.48	6.84	34.43
Line sowing + ML 365	2.98	5.56	8.54	34.89
Transplanting + ML 365	3.77	6.59	10.35	37.27
Broadcasting + Godra OT	1.73	3.95	5.67	30.46
Line sowing + Godra OT	2.48	4.87	7.34	33.74
Transplanting + Godra OT	3.26	5.92	9.18	35.50
SEm(±)	0.08	0.09	0.14	0.70
CD (P=0.05)	0.23	0.27	0.41	2.10

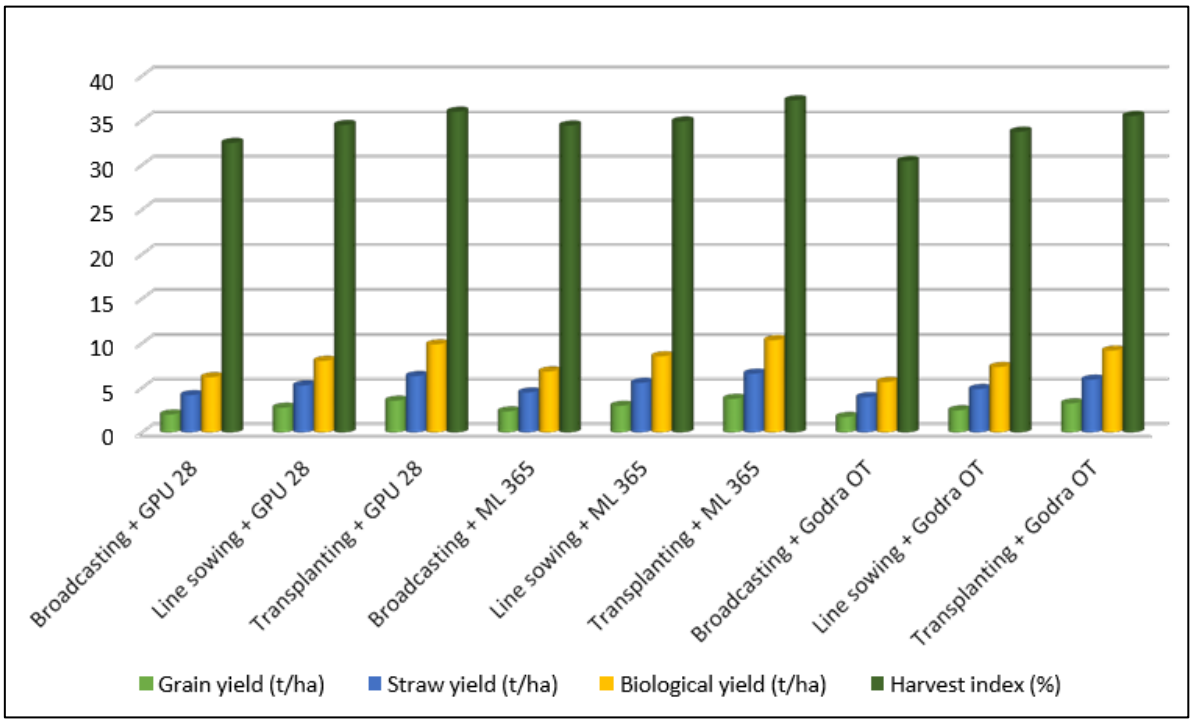

Fig 2: Effect of establishment methods and varieties on yield of finger millet

Economics

Data related to economics *viz*. gross returns (Rs./ha), net returns (Rs./ha) and benefit: cost ratio (B:C) were presented in Table 4. The maximum gross returns (Rs. 1,31,963.80/ha) were noticed in transplanting + ML 365 and minimum gross returns (Rs. 59,188.54/ha) was noticed in the treatment combination of broadcasting method + Godra OT variety, respectively. The highest net returns (Rs. 97,824.77/ha) were recorded in treatment of transplanting + ML 365 and lowest net returns (Rs. 24,798.54/ha) was recorded in broadcasting + Godra OT (local variety), respectively. The treatment combination of transplanting + ML 365 (improved variety) which obtained highest gross returns and net returns led to attain highest B:C ratio (2.86) and lowest B:C ratio (0.72) was obtained in the treatment combination of broadcasting method + Godra OT (local variety). Higher grain yield and straw yield positively correlated with economics. The increased gross returns, net returns and benefit: cost ratio were due to increased grain and straw yield under application of transplanting technique with addition of improved finger millet variety (ML 365). This was in line with the findings reported by *Gowda et al.* (2018) [3], *Revathi et al.* (2018) [12], *Narayan Hebbal et al.* (2018) [6], *Saravanakumar* (2018) [14] and *Raghunatha Reddy et al.* (2020) [20].

From the above study, it is concluded that the finger millet variety ML 365 was found to be more suitable along with transplanting as establishment method which favoured growth and yield. For promoting finger millet production in eastern Uttar Pradesh condition, transplanting method as an establishment technique with ML 365 variety is recommended for this region.

Table 4: Effect of establishment methods and varieties on economics of finger millet

Treatments	Gross returns (Rs. /ha)	Net returns (Rs./ha)	B:C ratio
Broadcasting + GPU 28	68,506.08	34,106.08	0.99
Line sowing + GPU 28	93,840.47	59,584.47	1.73
Transplanting + GPU 28	1,20,133.60	85,994.61	2.51
Broadcasting + ML 365	79,900.61	45,500.61	1.32
Line sowing + ML 365	1,00,991.60	66,735.62	1.94
Transplanting + ML 365	1,31,963.80	97,824.77	2.86
Broadcasting + Godra OT	59,188.54	24,798.54	0.72
Line sowing + Godra OT	84,143.91	49,881.91	1.45
Transplanting + Godra OT	1,10,238.80	76,088.85	2.22

Convulsion

It is concluded that the treatment combination of transplanting method with ML 365 variety was found to be more productive and economically feasible

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