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Effect of different tillage and nutrient levels on yield and yield attributing characters of small millets under rainfed conditions

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Abstract
Experiment was conducted during the *Kharif* season 2022 at Research cum Instructional Farm S.G. College of Agriculture and Research Station Jagdalpur, Chhattisgarh in Split split plot design using 18 treatments which was replicated in three times. The experiment findings revealed significant differences between the different tillage, fertility levels and small millet crops. Between the tillage, M1 (Conventional tillage) recorded higher plant growth attributes in terms of plant height, number of effective tillers hill^{-1}, dry matter accumulation, number of grains panicle^{-1}, test weight, harvest index, growth parameters, LAI, crop growth rate, economic yield and stover yield. With records to economics, *viz.*, cost of cultivation, gross return and net return were recorded numerically higher in treatment M1 (Conventional tillage) but M2 (Minimum tillage) was observed highest value of B: C ratio between the tillage. In fertility levels, plant height, number of effective tillers hill^{-1}, dry matter accumulation, growth parameters, LAI, crop growth rate, number of grains panicle^{-1}, economic yield and stover yield were found to be statistically higher in treatment N3 (125% NPK kg ha^{-1}) among all the treatments. Among the small millet crops, crop C1 (Finger millet) showed greater expression in terms of dry matter accumulation at harvest, number of grains panicle^{-1}, economic yield and stover yield. While a greater number of effective tillers, test weight and harvest index were found significantly higher in treatment C2 (Kodo millet). The treatment C3 (Little millet) was recorded significantly taller plant with higher dry matter accumulation at all the growth stages except at harvest.

Keywords: Different tillage, fertility levels, small millets

Introduction
Millets are an essential food grain in the diets of a huge portion of India's people. After rice, kodo millet (*Paspalum scrobiculatum* L.), finger millet [*Eleusine coracana* (L.) Gaertn.] and little millet (*Panicum sumatrense*) are the most important minor grains among the tribes of the Bastar area (Verma and Mishra, 2010) [12]. Millets are important crops in Asia and Africa (Especially in India, Nigeria and Niger), with 97% of millet production in developing countries (McDonough *et al.*, 2000) [6]. Madhya Pradesh has the highest growing area of small millets (84,000 hectares), followed by Chhattisgarh (63,370 hectares) and Uttarakhand (53,000 hectares). Madhya Pradesh (74,000 tons) has higher annual production than Uttarakhand (70,970 tons) and Tamil Nadu (37,340 tons). Pondicherry had the highest productivity (2274 kg ha^{-1}), followed by Telangana (1711 kg ha^{-1}) and Tamil Nadu (1444 kg ha^{-1}) (Kumar *et al.*, 2022) [3].
Soil tillage is one of the key elements influencing soil characteristics and crop output. Tillage provides up to 20% of crop production variables and influences the sustainable use of soil resources through its effect on soil qualities. Reduced tillage has a favourable impact on numerous characteristics of the soil, but excessive and unnecessary tillage activities cause the reverse phenomenon, which is destructive to the soil (Khurshid *et al*., 2006) [2]. Different tillage practices cause changes in soil physical properties, such as bulk density, water holding capacity, pore size distribution, and aggregation. Stratification of soil organic matter and differences in nutrient distribution, conventional tillage can lead to soil microbial communities dominated by aerobic microorganisms. (Mathew *et al*., 2012) [5].

Minimal tillage contributes significantly to soil structure rebuilding by reducing the number of soil interventions and enhancing the quantity of organic material left on the soil surface. When compared to the conventional approach, the content of hydro-stable macro-aggregates increases in all minimal tillage forms - with 0.1-2.2% in the 0-10 cm depth and 4.9-5.2% in the 10-30 cm deep. The minimal tillage approach had little effect on the soil texture. (Rusu *et al.*, 2009) [11].

In India, millets are mostly cultivated in resource-poor soils of the tropics and sub-tropics. Synchronizing nutrient supply with crop demand is essential to maximize yield and fertilizer use efficiency. It has been found that the incorporation of N fertilizer during the seeding stage increased yield as compared to broadcasting of fertilizer. The foliar application of 2% urea produced higher grain and straw yield. Application of fertilizer P @ 125% recommended dose of phosphorus with recommended N, K and FYM in different fertility soils recorded higher grain and straw yield. (Maitra *et al.*, 2020) [4]. Finger millet responds well to N application, since many of the soils in the semi-arid regions of Asia are deficient in N. Studies concerning N management in finger millet are mainly focused on the amount of N applied, timing of application, and varietal responses to N. (Rao *et al*., 1989) [10].

Material and Methods

The experiment was conducted at Instructional cum Research Farm, S.G. College of Agriculture and Research Station, Jagdalpur (C.G.). The experiment in *Kharif* season 2022 was framed in split – split plot design with three replications. The main plot treatment consisted of 2 tillage practices (M) *viz.* M1 (Conventional tillage) and M2 (Minimum tillage), sub plot treatments was 3 fertility levels (F) *viz.* F1 (75% NPK ha^{-1}), F2 (100% NPK ha^{-1}) and F3 (125% NPK ha^{-1}) and sub- sub plot contains 3 small millet crops practices (C) *viz.* C1 (Finger millet), C2 (Kodo millet) and C3 (Little millet). The study aimed to assess the impact of these treatments on the growth and yield of small millets under rainfed conditions. The recommended fertilizer doses for finger millet and kodo millet (60 kg N, 40 kg P_2O_5, 20 kg K_2O ha^{-1}) and (30 kg N, 20 kg P_2O_5, 10 kg K_2O ha^{-1}) for little millet were applied in the experimental plot, 50 per cent nitrogen, 100 per cent phosphorus and 100 per cent potassium were applied as basal dose and the remaining 50 per cent nitrogen was applied in two split doses at the tillering stage and panicle initiation stage of the small millets crop in the form of urea (46%), DAP (18 and 46%) and MOP (60%).

Results and Discussion

Plant height (cm)

Plant height was significantly affected due to different treatment are presented in Table 1. The data shows that treatment M1 (Conventional tillage) recorded significantly taller plant than the treatment M2 (minimum tillage) at 60 DAS, 90 DAS and at harvest but it had found non-significant effect at 30 DAS. It might be due to conventional tillage provide more porosity which enhance the root growth and availability of nutrients from rhizosphere. Similar finding was reported by Nanjappa and Ramchandrappa (2013) [7]. In case of different fertility levels, treatment N3 (125% NPK kg ha^{-1}) observed significantly taller plant at all the growth stages except 30 DAS, but treatment N2 (100% NPK kg ha^{-1}) was found significantly on par at 60 DAS. Smaller plants were recorded in treatment N1 (75% NPK kg ha^{-1}). Taller plants were recorded due to sufficient availability of nutrients during the growth stages which boost the plant hight of small millets. Whereas, in different small millet crops, crop C3 (little millet) observed significantly taller plant at all the growth stages, but which was found on par in treatment C2 (kodo millet) at 30 DAS and smallest plant was recorded in crop C1 (Finger millet). The reason of more plant height of little millet in conventional tillage might be due to favourable condition of root development, better utilization of nutrients among plants as compared to minimum tillage.

Number of effective tillers (hill^{-1})

Number of tillers significantly increases with increase of growth stages are presented in Table 1. Treatment M1 (conventional tillage) produced significantly higher number of tillers per hill at all the growth stages except 30 DAS and lower number of tillers were found in treatment M2 (minimum tillage). It might be due to conventional tillage favour the root growth; hence number of tillers are increased. Similar results were also corroborated by Nanjappa and Ramchandrappa (2013) [7]. In case of different fertility levels, treatment N3 (125% NPK kg ha^{-1}) was recorded significantly highest number of tillers per hill at all the growth stages. While lowest number of tillers per hill was observed in treatment N1 (75% NPK kg ha^{-1}) at 60 DAS, 90 DAS and at harvest but it had found non-significant effect at 30 DAS due to different fertility levels. The reason for maximum number of tillers, might be due to optimum doses of NPK fertilizer application provide to crop for growth and development of tillers in plants. An small millet crops, crop C2 (kodo millet) had recorded significantly higher number of tillers per hill at 60 DAS, 90 DAS and at harvest but which was found similar result with treatment C3 (Little millet) at 60 DAS and lower number of tillers was recorded in C1 (Finger millet) while number of tillers had observed non-significant effect at 30 DAS.

Dry matter accumulation (g plant^{-1})

The data present in Table 1. Treatment M1 (conventional tillage) produced significantly highest dry matter accumulation at all the growth stages and lowest dry matter accumulation was found by treatment M2 (minimum tillage) but it had found non-significant result at 30 DAS. In the case of fertility levels, treatment N3 (125% NPK kg ha^{-1}) recorded significantly higher dry matter accumulation at all the growth stages and low values for accumulation of dry matter was observed in treatment N1 (75% NPK kg ha^{-1}) at all the growth stages. The enhancement in dry matter accumulation with increasing rate of NPK fertilizer was due to better crop growth rate, which gave maximum photosynthates ultimately producing higher biological yield. Whereas, in different small millet crops, crop C3 (Little millet) had found significantly maximum value of dry matter accumulation at 30, 60 and 90 DAS while C1 (Finger millet) was found higher dry matter accumulation at harvest but which was found similar result in treatment C2 (Kodo millet) at 30 DAS and C1 (Finger millet) at 90 DAS.

Leaf area index

Data pertaining to Table 2 revealed that the leaf area index shows significant difference due to different treatments. Treatment M1 (conventional tillage) was recorded highest LAI at all the growth stages than the M2 (minimum tillage) except at 30 DAS but it was found non-significant effect at 30 DAS due to different tillage treatments. Higher leaf area index was found it might be due to conventional tillage provide congenial environment that is the why plant growth was higher and produce more LAI. Significant differences were observed by various fertility levels, it was found significantly highest in treatment N3 (125% NPK kg ha^{-1}) at all the growth stages which had found on par with treatment N2 (100% NPK kg ha^{-1}) at 30 DAS and 90 DAS, while lowest LAI was recorded in treatment N1 (75% NPK kg ha^{-1}) at all the growth stages. Maximum LAI values were observed under treatment N3 (125% NPK kg ha^{-1}) this might be due to increase number of tillers produced maximum number of leaves thus it had produced more leaf area

than the other treatments. In case of small millet crops, treatment C3 produced significantly higher LAI at 30 DAS and 60 DAS than the C2 and C1. At 90 DAS, treatment C2 recorded significantly higher LAI which was found on par with treatment C1. At harvest, LAI did not affect significantly due to different small millet crops.

Crop growth rate (g plant^{-1} day^{-1})

Data pertaining to CGR is presented in Table 2. The data reveals that in different tillage, treatment M1 (conventional tillage) recorded significantly highest CGR value at 30-60 DAS and 90-at harvest than the treatment M2 (minimum tillage) but it had found non-significant effect at 0-30 DAS and 60-90 DAS due to different tillage treatments. In case of different fertility levels, treatment N3 (125% NPK kg ha^{-1}) recorded higher CGR value than the other treatments. While lowest CGR value found in treatment N1 (75% NPK kg ha^{-1}). Significant differences were observed by various small millet crops on CGR and it was observed highest in treatment C3 (little millet) at 0-30 DAS, C2 (kodo millet) at 30-60 DAS and C1 (finger millet) at 60-90 DAS and 90-at harvest, but treatment C1 (finger millet) was observed significantly on par at 30-60 DAS.

Number of grains panicle^{-1} and Test weight (g)

The data recorded on number of grains per panicle and test weight are represented in Table 2. The data shows that both the yield attributes character *i.e.* number of grains per panicle and test weight were recorded non-significant but numerically highest value was found on number of grains per panicle and test weight in treatment M1 (conventional tillage). In case of fertility levels, treatment N3 (125% NPK kg ha^{-1}) observed significantly higher value of number of grains per panicle and lowest number of grains per panicle was observed in treatment N1 (75% NPK kg ha^{-1}). Test weight had found non-significant effect due to different fertility levels but numerically maximum test weight was recorded in treatment N2 (100% NPK kg ha^{-1}). As regards to small millet crops, crop C1 (Finger millet) was obtained maximum number of grains per panicle and lowest number of grains per panicle was recorded in treatment C2 (Kodo millet). While in case of test weight, it had found highest value in treatment C2 (Kodo millet) and lowest test weight was obtained in treatment C3 (Little millet).

Economic yield (q ha^{-1}), Stover yield (q ha^{-1}) and Harvest index (%): Table 3 shows that significant differences in grain yield, stover yield and harvest index. The data reveals that Treatment M1 (conventional tillage) produced significantly highest grain and stover yield than the treatment M2 (minimum tillage). The reason for more grain and stover yields of small millet crops might be due to conventional tillage provide porous field which help to absorb more nutrient and water for producing a greater number of plants per meter square produced a greater number of tillers. Comparable studies were supported by Anon. (2008) [1], Prasad *et al.* (2016) [9] and Pradhan *et al.* (2011) [8]. Harvest index had found non-significant due to different tillage treatments but numerically higher harvest index value was recorded in treatment M2 (minimum tillage). As regards to fertility levels, treatment N3 (125% NPK kg ha^{-1}) produced significantly higher grain and stover yield and lowest grain and stover yield was found in treatment N1 (75% NPK kg ha^{-1}) while, in case of harvest index, highest value of HI in treatment N1 (75% NPK kg ha^{-1}) but it had found similar results to the treatment N2 (100% NPK kg ha^{-1}) and lowest HI values were recorded in treatment N3 (125% NPK kg ha^{-1}). In case of small millet crops, crop C1 (finger millet) recorded maximum grain yield and stover yield and in harvest index, treatment C2 (kodo millet) was found significantly highest value of HI and lowest value of grain yield, stover yield and harvest index were recorded in treatment C3 (little millet). Similar result was also found by Nanjappa and Ramchandrappa (2013) [7].

Economics

Effect of different treatments on economics are presented in Table 3. The data reveals that in different tillage methods, treatment M1 (Conventional tillage) recorded numerically higher cost of cultivation, gross return, net return. Whereas, B:C ratio was recorded highest value in treatment M2 (minimum tillage). Similar result was also reported by Vijaymahantesh (2012) [13] and Nanjappa and Ramchandrappa (2013) [7]. As regards to fertility levels, treatment N3 (125% NPK kg ha^{-1}) observed highest value of cost of cultivation, gross return, net return and B:C ratio followed by N2 (100% NPK kg ha^{-1}) and minimum cost of cultivation, gross return, net return and B:C ration were found in treatment N1 (75% NPK kg ha^{-1}). In case of different small millet crops, crop C1 (Finger millet) observed higher cost of cultivation, gross return, net return and B: C ratio followed by treatment C2 (Kodo millet) and lower cost of cultivation, gross return, net return and B:C ratio was recorded in treatment C3 (little millet).

Table 1: Effect of different tillage, fertility levels and small millet crops on plant height (cm), number of effective tillers (hill^{-1}) and dry matter accumulation (g plant^{-1}) at different growth stages

Treatment	Plant height (cm)				No. of effective tillers (hill^{-1})				Dry matter accumulation (g plant^{-1})			
	At 30 DAS	At 60 DAS	At 90 DAS	At harvest	At 30 DAS	At 60 DAS	At 90 DAS	At harvest	At 30 DAS	At 60 DAS	At 90 DAS	At harvest
Tillage												
M1: Conventional tillage	44.2	76.02	101.04	103.94	1.13	3.55	3.67	3.67	0.31	2.99	5.24	13.88
M2: Minimum tillage	40.16	63.68	83.83	84.53	1.09	2.65	2.76	2.69	0.29	2.17	3.74	10.92
SEm±	0.79	1.87	2.4	1.95	0.03	0.07	0.09	0.05	0.01	0.05	0.1	0.19
CD at 5%	NS	11.55	14.78	12.01	NS	0.4	0.52	0.33	NS	0.3	0.62	1.14
CV %	9.81	13.92	12.09	10.79	11.48	8.44	12.2	7.66	10.53	9.88	11.7	7.77
Fertility levels												
N1: 75% NPK kg ha^{-1}	41.22	63.62	87.27	88.89	1.09	2.8	2.9	2.83	0.28	2.23	3.79	9.81
N2: 100% NPK kg ha^{-1}	42.19	70.92	92.36	94.08	1.1	2.98	3.07	3.11	0.29	2.48	4.43	12.35
N3: 125% NPK kg ha^{-1}	43.13	75	97.69	99.73	1.14	3.52	3.67	3.6	0.33	3.03	5.25	15.03
SEm±	0.77	1.78	1.25	1.32	0.02	0.05	0.07	0.06	0.01	0.06	0.08	0.32
CD at 5%	NS	5.78	4.07	4.29	NS	0.16	0.21	0.2	0.02	0.19	0.25	1.04
CV %	7.82	10.78	5.14	5.97	7.84	5.12	7.71	7.14	10.53	9.57	7.36	10.96
Crops												
C1: Finger millet	33.05	50.84	75.53	78.54	1.03	1.72	2.15	2.05	0.26	1.99	4.53	20.39
C2: Kodo millet	45.32	70.67	82.06	84.27	1.11	3.83	4.12	4.13	0.31	2.09	3.93	10.91
C3: Little millet	46.33	85.21	115.52	115.52	1.13	3.66	3.26	3.26	0.32	3.55	4.76	4.76
SEm±	0.76	1.6	1.44	1.46	0.02	0.08	0.07	0.08	0.01	0.05	0.14	0.3
CD at 5%	2.22	4.67	4.19	4.27	NS	0.22	0.22	0.23	0.02	0.13	0.41	0.88
CV %	7.67	9.71	5.91	6.63	6.63	8.06	8.7	9.13	10.53	7.45	13.26	7.77

Table 2: Effect of different tillage, fertility levels and small millet crops on leaf area index, CGR (g plant^{-1} day^{-1}), number of grains panicle^{-1} and test weight (g) at different growth stages

Treatment	Leaf area index				CGR (g plant^{-1} day^{-1})				No. of grains panicle^{-1}	Test weight (g)
	30 DAS	60 DAS	90 DAS	At harvest	0-30 DAS	30-60 DAS	60-90 DAS	90-At harvest		
Tillage										
M1: Conventional tillage	0.47	1.11	1.41	1.26	0.01	0.0896	0.075	0.3055	586.56	3.09
M2: Minimum tillage	0.45	0.85	1.29	1.05	0.0098	0.0627	0.0522	0.2486	553.11	3.02
SEm±	0.01	0.01	0.02	0.03	0	0.002	0.005	0.006	7.54	0.05
CD at 5%	NS	0.08	0.1	0.18	NS	0.011	NS	0.04	NS	NS
CV %	9.8	6.48	6.19	13.4	0.01	0.0896	0.075	0.3055	6.88	7.95
Fertility levels										
N1: 75% NPK kg ha^{-1}	0.37	0.84	1.13	0.95	0.0094	0.065	0.0518	0.2186	537.06	2.99
N2: 100% NPK kg ha^{-1}	0.48	0.97	1.4	1.14	0.0098	0.073	0.0648	0.2757	565	3.2
N3: 125% NPK kg ha^{-1}	0.52	1.13	1.52	1.38	0.0104	0.0905	0.0742	0.3368	607.44	3.16
SEm±	0.02	0.02	0.04	0.04	0	0.002	0.003	0.012	8.1	0.06
CD at 5%	0.05	0.06	0.14	0.11	0	0.006	0.009	0.039	26.37	NS
CV %	13.85	7.24	13.45	12.83	0.0094	0.065	0.0518	0.2186	6.03	8.21
Crops										
C1: Finger millet	0.36	0.62	1.38	1.13	0.0084	0.0581	0.0846	0.5288	1138.58	3.03
C2: Kodo millet	0.46	0.76	1.44	1.12	0.0103	0.0592	0.0614	0.2329	146.89	4.58
C3: Little millet	0.53	1.51	1.16	1.16	0.0105	0.0108	0.0401	0.0401	360.78	1.39
SEm±	0.01	0.01	0.04	0.04	0	0.002	0.005	0.011	7.42	0.04
CD at 5%	0.03	0.04	0.12	NS	0	0.005	0.015	0.033	21.66	0.11
CV %	6.93	5.61	12.39	12.83	0.0084	0.0581	0.0846	0.5288	5.52	5.17

Table 3: Effect of different tillage, fertility levels and small millet crops on economic yield (q ha^{-1}), stover yield (q ha^{-1}), harvest index (%) and economics

Treatment	Yield (q ha^{-1})			Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C Ratio
	Economic yield (q ha^{-1})	Stover yield (q ha^{-1})	HI (%)				
Tillage							
M1: Conventional tillage	21.93	41.57	33.41	22295	75864	53569	2.27
M2: Minimum tillage	17.53	33.74	34.49	15395	60235	44840	2.73
SEm±	0.19	0.86	0.41				0.03
CD at 5%	1.2	5.31	NS				0.2
CV %	5.12	11.87	6.24				6.69
Fertility levels							
N1: 75% NPK kg ha^{-1}	15.56	28.95	36.18	18098	53341	35244	1.9
N2: 100% NPK kg ha^{-1}	20.01	36.72	33.83	18845	68995	50150	2.57
N3: 125% NPK kg ha^{-1}	23.62	47.3	31.84	19592	81813	62221	3.04
SEm±	0.39	0.96	0.72				0.06
CD at 5%	1.25	3.11	2.36				0.2
CV %	8.27	10.76	9.05				10.51
Crops							
C1: Finger millet	32.84	59.22	33.55	19444	120466	101023	4.91
C2: Kodo millet	15.43	27.83	36.27	19324	47675	28351	1.52
C3: Little millet	9.09	22.62	30.16	16687	29315	12628	0.8
SEm±	0.26	0.73	0.56				0.05
CD at 5%	0.76	2.14	1.63				0.15
CV %	5.59	8.26	6.98				8.48

Conclusion

On the basis of a one year study during Kharif 2022, The experiment on the effect of different Tillage on yield and Economics of small millet crops concluded that: Between the tillage, treatment M1 (Conventional tillage), exhibited better expression in respect of crop growth and yield and yield attributing characters, GR and NR as compared to treatment M2 (Minimum tillage) but B: C ratio was found highest in treatment M2 (Minimum tillage). Economics, *i.e.*, cost of cultivation, gross return, net return and B: C ratio, were significantly higher in treatment M1 (Conventional tillage).

Among the different fertility levels, treatment N3 (125% NPK kg ha^{-1}) showed greater expression in terms of crop growth parameters, yield attributing characters and yield as compared to treatments N1 (75% NPK kg ha^{-1}). However, treatment N2 (100% NPK kg ha^{-1}) was also recorded as significantly superior to treatment N1 (75% NPK kg ha^{-1}).

Among the small millet crops, crop C1 (Finger millet) showed greater expression in terms of dry matter accumulation at harvest, days to 50% flowering, days to maturity, number of grains panicle^{-1}, economic yield and stover yield. While a greater number of effective tillers was found in treatment C2 (Kodo millet) and treatment C3 (Little millet) was recorded significant taller plant among the all small millet corps.

Economics, *i.e.*, cost of cultivation, gross return, net return and B: C ratio, were significantly higher in treatment M1 (Conventional tillage). Treatment N3 (125% NPK kg ha^{-1}) had the highest COC, GR, NR and B: C ratio among all the fertility levels. Finger millet (C1) showed higher COC, GR, NR and B: C ratio as compared to little millet (C3).

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