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Effect of maize-based cropping systems on, growth, yield attributes and yield of maize in Jamtara district of Jharkhand

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Abstract
The aim of this work was to study effect of maize-based cropping systems on, growth, yield attributes and yield of maize in Jamtara District of Jharkhand. The experiment was consisted of 9 treatments T_1-Maize - fallow, T_2-Maize - wheat, T_3-Maize (Green cob) - toria - wheat, T_4-Maize (Green cob) - toria - chickpea, T_5-Maize - pea - Greengram, T_6-Maize - linseed - Greengram, T_7-Maize - lentil - Greengram, T_8-Maize - chickpea - Greengram and T_9-Maize - potato - Greengram with three times replications in Randomized Block Design. The following indicators were evaluated growth parameters (plant height), yield parameters (number of grain rows cob^{-1}, number of total grains cob^{-1} and cob weight (g), yields (Grain, cob and stover) as well as shelling percentage and harvest index. The results show that the cropping systems influenced all the elements studied except the plant height and test weight. The superiority of inclusion of pules crops in maize-based cropping system was performed better the cereals crop. The pooled data showed highest green cob yield (10584 kg/ha), green stover yield (15040 kg/ha) was recorded in Maize (Green Cob)-Toria- Chickpea, where cob yield (7894 kg/ha), and stover yield (10840 kg/ha), shelling (37.70%), and harvest index (89.09%) was found maximum under Maize-Pea-Greengram cropping system.

Keywords: Maize, cropping system, yields, shelling% and harvest index

1. Introduction
In India, maize plays a vital role in ensuring food security and supporting the livelihoods of millions of farmers due to its high productivity, wide adaptability, and diverse end uses, Understanding the response of maize yield attributes and yield under different maize-based cropping systems is therefore essential for developing efficient and sustainable crop production systems due to sustaining maize productivity under increasing pressure on land resources and declining soil fertility remains a major challenge. Maize (*Zea mays* L.) is a major cereal crop in India and an important component of the *Kharif* cropping system, especially in eastern states of Jharkhand because its required small amount of water, supports crop variety and provides cash for farmers (Otieno, H. M. (2019) [6]. In year 2024-25, maize occupied over 2.3 lakh ha in Jharkhand, contributing notably to the state's coarse cereal production profile, with area under maize cultivation increasing from previous years' estimates of around 2.08 lakh ha during 2022-23 reflecting its rising importance in the region's agriculture (Singh, U. (2021) [11]. At the district level, Jamtara is among the maize producers in the state having accounted for roughly 33.5 thousand tonnes of maize production in last years, with variation in production across seasons. Maize is one of the most important cereal crops globally, serving as a major source of food, feed, and industrial raw material (Sanodiya, P *et al* 2024) [9].
Yield attributes such as cob length, number of grains per cob, and test weight are major contributors to maize yield and are significantly influenced by cropping system management (Shivay, Y. S *et al* 2002) [10]. Variations in residue incorporation, nutrient availability, and soil moisture regimes under different maize-based cropping systems can markedly affect these yield-determining parameters**.** Continuous monocropping of maize often leads to nutrient depletion, pest build-up, and reduced productivity, whereas diversified maize-based cropping

systems can improve yield stability and sustainability (Abdulkadir *et al* 2025) [1]. In this context, the present investigation was undertaken to evaluate the effect of different maize-based cropping systems on yield attributes and yield of maize. The study aims to identify suitable cropping sequences that enhance maize productivity while maintaining soil health and long-term sustainability under prevailing agro-climatic conditions.

Cropping system diversification, particularly maize-based cropping systems, has emerged as an effective strategy to enhance crop productivity, optimize resource use efficiency, and improve soil health (Ansari *et al* 2023) [2]. Inclusion of legumes, and oilseeds, crops in maize-based cropping sequences can influence nutrient availability, soil physical properties, and biological activity, thereby affecting the growth and yield performance of the succeeding maize crop (Kumar *et al* 2025) [5]. Maize-based cropping systems play a crucial role in improving crop productivity and sustainability by enhancing nutrient cycling, soil physical conditions, and biological activity (Kumar *et al* 2025) [5]. Inclusion of legumes or diversified crop sequences in maize-based systems has been reported to improve nitrogen availability, resource use efficiency, and overall system productivity, thereby positively influencing growth and yield of the succeeding maize crop (Rao and Reddy, 2017; Singh *et al.*, 2020) [8].

2. Martial and Method

The fixed layout field experiment was conducted during rainy, winter and summer seasons of 2023-24 and 2024-25 at research farm of the Krishi Vigyan Kendra, Jamtara, (B.A.U. Ranchi), Jarkhand, which is situated at a latitude of $24^0 25^{"}$ N and longitude of $87^0 24^{"}$ E and an altitude of 235 meters above the mean sea level (Arabian Sea). The mean annual rainfall of Jamtara is around 1450 mm of which 80-85 per cent is receiving generally during the south-west monsoon season (July-September). The soil during 2024, the starting year of the experiment, was well drained, loam in texture with pH 5.9, (1:2.5 soil and water ratio) by (Jackson, 1973) bulk density 1.39 g/cm^3, CEC 5.4 mmhos, textural class sandy clay loam, organic carbon 3.9 g/kg (Walkley and Black, 1934)., available N 228.0 kg/ha (Subbiah and Asija, 1956), available P 18 kg/ha (Olsen *et al.*, 1954), and available K_2O 122.7 kg/ha. There were 9 treatments, out of which 6 are included in legume crops and rest 3 are cereals based cropping system. The treatments were compared in randomized block design with 3 replications. The treatment are comprised with 9 cropping systems *viz.*, Maize - fallow, Maize - wheat, Maize (Green cob) - toria - wheat, Maize (Green cob) - toria - chickpea, Maize - pea - Greengram, Maize - linseed - Greengram, Maize - lentil - Greengram, Maize - chickpea - Greengram and Maize - potato - Greengram. The variety used for maize, wheat, toria, chickpea, pea, linseed, lentil, potato and Greengram crop was 'DMH-121, DBW-187, Tapeshwari, Birsa Chann-3, Dantewada Field pea-1, Birsa Tisi-2, WBL-77, Kufri Ashoka and IPM 2-3 respectively. The sources used for applying N, P and K were urea, DAP (adjusted for its N content) and muriate of potash, respectively. The harvesting of maize was done manually followed by manual harvesting and mechanical threshing of maize crop. Data on yield attributes and yield of maize crop was recorded at different interval during crop growth stage and statistically analyzed with OPSTAT software. The F variance test was used to compare the mean of two treatments.

3. Results and Discussion

3.1 Effect of cropping system on growth parameter

The statistically analysed data on growth parameters of maize are presented in table 3.1. In pooled analysis, difference in plant height was non-significant, however, maximum plant height was recorded in maize-pea-greengram (201.77 cm) and minimum in maize (green cob)-toria-wheat (190.56 cm) at harvest. Data on dry matter accumulation (g m^{-2}) recorded at different stages have been presented in table 3.2. In pooled analysis, the maximum value (1696.43 g m^{-2}) was associated with maize-pea-greengram cropping sequence and minimum (1280.43 g m^{-2}) with maize (green cob)-toria-wheat cropping sequence. The recorded results are similar to Jasbir Singh and Thenua (2014) [14].

3.2 Effect of cropping system on Yield attributing parameter

Yield attributing characters of maize crop in maize based cropping system recorded better performance during the 2nd year of experiment. Data on yield attributing ***parameter*** of maize are presented in table 3.3. and 3.4

The yield parameters *viz.*, number of grain rows cob-1, number of total grains cob-1 and cob weight (g) were recorded and analysed statistically and presented in in table 3.3. and 3.4. The legume based cropping system significantly influenced the yield parameters of maize.

In pooled analysis, the highest number of cob ha^{-1} was observed in maize-fallow cropping system (65,128) and lowest (62,703) in maize-lentil-greengram cropping sequence., length of cob was maize-pea-greengram sequence recorded longer cob length (19.85 cm), while shorter cob length (16.99 cm) was recorded in maize (green cob)-toria-wheat cropping system, Higher cob girth (14.86 cm) was recorded in maize-pea-greengram sequence followed by maize-chickpea-greengram (14.81 cm) and lower cob girth (13.55 cm) was observed in maize-wheat sequence, the higher number of grains per row (33.64) was recorded in maize-pea-greengram while lower (29.92) in maize (green cob)-toria-wheat cropping system, the maximum value (13.29) numbers of grains row per cob was observed in maize-pea-greengram and minimum (12.03) in maize (green cob)-toria-wheat cropping system, maximum number of grains per cob (439.12) was found in maize-pea-greengram and minimum (353.30) was found in maize (green cob)-toria-wheat cropping system, highest value (263.38 g) of 1000 grain weight was observed in 300% cropping intensity i.e. maize-pea-greengram while lowest value (248.70 g) was observed in maize (green cob)-toria-wheat cropping system our results are similar to Patra *et al*. (1999) [7].

3.3 Effect of cropping system on yield of maize

3.3.1 Grain yield

Data on grain yield (kg ha^{-1}) of maize under different cropping sequences are presented in table 3.4. A critical examination of the data revealed that lower grain production was recorded during 2023-24 compared to 2024-25.

In general, it was found that inclusion of leguminous crop resulted in higher grain production compared to maize-fallow (100%) and maize-wheat (200%) systems.

During 2023-24, maize-chickpea-greengram cropping system recorded highest grain yield (6,216 kg ha^{-1}) followed by maize-pea-greengram (6,179 kg ha^{-1}) while maize-wheat system recorded lowest grain yield (5,883 kg ha^{-1}). In pooled analysis higher grain yield (6,555 kg ha^{-1}) was recorded in maize-pea-greengram cropping system and lower (5,943 kg ha^{-1}) in maize-wheat cropping system

3.3.2 Cob yield

Data presented in table 4.6 indicates that cob yield / green cob yield (kg ha^{-1}) differed significantly in different cropping system during both the year of experimentation, significant difference was also found in pooled data.

Maize (green cob)-toria-wheat cropping system recorded significantly highest cob yield (10,070 kg ha^{-1}) followed by maize-pea-greengram (10,023 kg ha^{-1}) during 2023-24, however significantly highest cob yield (10,854 kg ha^{-1}) during 2024-25 was recorded with maize (green cob)-toria-chickpea followed by maize (green cob)-toria-wheat cropping system (10,542 kg ha^{-1}). The lowest cob yield was recorded in maize-wheat system (7,194 and 7,332 kg ha^{-1}) during 2023-24 and 2024-25, respectively.

Significantly highest cob yield (10,439 kgha^{-1}) was recorded in maize (green cob)-toria-chickpea cropping system and lowest (7,263 kgha^{-1}) in maize-wheat cropping system in pooled data analysis.

3.3.3 Stover yield/ Green stover yield

Significant differences in stover yield (kg ha^{-1}) among different cropping systems were recorded during the period of experimentation (2023-24 and 2024-25) and also in pooled data. The observations on stover yield were almost similar to the trend observed in case of cob yield. In pooled analysis, maize (green cob)-toria-chickpea cropping system recorded significantly highest stover yield (15,040 kg ha^{-1}) and maize-wheat system recorded lowest stover yield (10,289 kg ha^{-1}). Das *et al.* (2010) [4] and Bastia *et al* (2010) [3].

3.4 Effect of cropping system on harvest index of maize

The data on harvest index (%) of maize under different crop sequences were slightly higher during first year as compared to second year (Table 4.7). The difference in harvest index of maize crop due to different cropping system was observed during both years but it was non-significant. The maximum harvest index during 2023-24 (37.99%) at 300% cropping intensity was computed with maize-pea-greengram followed maize-chickpea-greengram (37.96%) however, lowest was associated (37.37%) with maize-wheat cropping system during 2023-24.

In pooled data, harvest index was found higher at 300% cropping intensity in maize-pea-greengram (37.70%) followed by maize-chickpea-greengram sequence (37.69%) while lowest was found in maize-wheat cropping system (36.70%).

3.5 Effect of cropping system on Shelling percentage of maize

The data on shelling percentage of maize under different crop sequences varied according to cropping sequence but the differences found were statistically non-significant. In pooled data, shelling percentage was found highest at 300% cropping intensity in maize-pea-greengram (83.09%) followed by in maize-chickpea-greengram sequence (82.89%) while lowest shelling percentage was found in maize-wheat cropping system (81.85%).

Conclusion

The study evaluated the performance of maize crop under maize based cropping system. On the bases of our results the higher growth, yield attributes, yields, shelling and harvest index percentage of maize crop was observe higher under inclusion of legume crops in cropping system compared to cereals crops. The pooled data showed highest green cob yield, green stover yield (kg/ha) was recorded in Maize (Green Cob)-Toria- Chickpea, where cob yield and stover yield (kg/ha), shelling and harvest index was maximum found under Maize-Pea-Greengram cropping system. The inclusion of legume crops in maize based cropping systems not only increased yield also increase dry matter accumulation of maize crop.

Table 3.1 Effect of Diversification and intensification of maize-based cropping system plant height of maize

Treatments	Plant height (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T_1: Maize-Fallow	118.38	124.90	121.64	183.18	186.02	184.60	192.02	190.28	191.15	193.80	191.72	192.76
T_2: Maize-Wheat	117.89	122.65	120.27	181.52	185.35	183.44	190.13	189.41	189.77	191.69	190.29	190.99
T_3: Maize (Green Cob)-Toria-Wheat	120.85	118.99	119.92	185.92	180.92	183.42	193.69	185.78	189.74	194.16	186.95	190.56
T_4: Maize (Green Cob)-Toria- Chickpea	121.99	127.45	124.72	187.23	190.05	188.64	194.88	194.26	194.57	195.87	195.22	195.54
T_5: Maize-Pea-Greengram	124.31	133.83	129.07	191.08	197.02	194.05	198.16	203.36	200.76	199.21	204.33	201.77
T_6: Maize-Linseed-Greengram	122.27	129.67	125.97	189.37	192.02	190.70	196.00	197.39	196.69	197.28	198.40	197.84
T_7: Maize-Lentil-Greengram	123.52	130.98	127.25	190.19	192.30	191.24	197.41	197.62	197.51	198.18	198.27	198.22
T_8: Maize-Chickpea-Greengram	125.81	131.75	128.78	192.02	194.86	193.44	199.57	200.79	200.18	200.55	201.62	201.08
T_9: Maize-Potato-Greengram	119.24	128.48	123.86	184.26	190.41	187.34	191.40	194.56	192.98	192.40	195.24	193.82
SEm±	5.04	5.55	3.75	8.81	8.81	6.23	9.24	9.70	6.70	9.46	9.52	6.71
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	7.18	7.53	7.37	8.15	8.03	8.09	8.22	8.62	8.42	8.36	8.42	8.39

Table 3.2: Effect of Diversification and intensification of maize-based cropping system on dry matter accumulation of maize

Treatments	Dry matter accumulation (g/m^2)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T_1: Maize-Fallow	171.99	179.00	175.49	500.88	516.58	508.73	1303.98	1320.35	1312.17	1541.20	1624.12	1582.66
T_2: Maize-Wheat	170.49	178.36	174.42	497.58	513.97	505.77	1298.93	1309.68	1304.31	1535.04	1603.16	1569.10
T_3: Maize (Green Cob)-Toria-Wheat	175.59	163.67	169.63	507.34	480.87	494.11	-	-	-	1312.50	1248.36	1280.43
T_4: Maize (Green Cob)-Toria- Chickpea	178.56	180.27	179.42	511.76	519.13	515.45	-	-	-	1318.00	1310.11	1314.06
T_5: Maize-Pea-Greengram	184.07	204.45	194.26	522.81	606.47	564.64	1333.20	1473.80	1403.50	1581.72	1811.13	1696.43
T_6: Maize-Linseed-Greengram	180.56	199.54	190.05	516.08	541.38	528.73	1322.65	1372.55	1347.60	1567.70	1688.82	1628.26
T_7: Maize-Lentil-Greengram	182.89	200.38	191.64	519.75	548.84	534.30	1328.26	1388.73	1358.50	1575.20	1716.58	1645.89
T_8: Maize-Chickpea-Greengram	186.45	201.06	193.75	526.14	551.27	538.70	1337.36	1416.17	1376.77	1587.11	1746.53	1666.82
T_9: Maize-Potato-Greengram	173.99	191.63	182.81	504.14	524.53	514.33	1308.17	1343.41	1325.79	1546.56	1655.57	1601.06
SEm±	10.83	9.10	7.07	29.85	29.84	21.11	-	-	-	72.26	77.78	53.08
CD (p=0.05)	NS	27.52	20.49	NS	90.283	61.13	-	-	-	218.58	235.27	153.74
CV (%)	10.53	8.35	9.44	10.10	9.69	9.89	-	-	-	8.30	8.42	8.37

Table 3.2: Effect of Diversification and intensification of maize-based cropping system on yield attributes of maize

Treatments	Number of cob/ha			Length of cob(cm)			Cob girth (cm)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T_1: Maize-Fallow	65117	65139	65128	17.69	18.15	17.92	13.59	14.01	13.80
T_2: Maize-Wheat	64835	64733	64784	17.47	16.69	17.08	13.49	13.61	13.55
T_3: Maize (Green Cob)-Toria-Wheat	64122	64873	64498	17.91	16.06	16.99	13.76	13.21	13.49
T_4: Maize (Green Cob)-Toria- Chickpea	63765	63282	63524	18.08	17.93	18.01	13.85	14.11	13.98
T_5: Maize-Pea-Greengram	62624	64821	63723	18.34	19.89	19.12	14.10	15.61	14.86
T_6: Maize-Linseed-Greengram	63260	65077	64168	18.15	18.47	18.31	13.93	14.59	14.26
T_7: Maize-Lentil-Greengram	62544	62862	62703	18.25	18.65	18.45	13.99	14.71	14.35
T_8: Maize-Chickpea-Greengram	62203	64843	63523	18.44	19.75	19.10	14.20	15.41	14.81
T_9: Maize-Potato-Greengram	64856	63050	63953	17.78	18.17	17.98	13.69	14.41	14.05
SEm±	2258	2193	1574	0.91	0.86	0.62	0.58	0.61	0.42
CD (p=0.05)	NS	NS	NS	NS	2.60	1.81	NS	1.83	1.22
CV (%)	6.14	5.91	6.02	8.72	8.18	8.45	7.31	7.29	7.30

Table 3.3: Effect of Diversification and intensification of maize-based cropping system on yield attributes of maize

Treatments	Number of grains/rows			Number of grains row/cob			Number of grains/cobs			1000 grain weight (g)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T_1: Maize-Fallow	31.34	31.75	31.55	12.28	12.42	12.35	378.16	387.23	382.70	247.80	255.50	251.65
T_2: Maize-Wheat	30.62	29.25	29.94	12.15	11.95	12.05	364.95	342.17	353.56	246.03	253.10	249.57
T_3: Maize (Green Cob)-Toria-Wheat	31.66	28.18	29.92	12.44	11.62	12.03	385.92	320.67	353.30	249.90	247.50	248.70
T_4: Maize (Green Cob)-Toria- Chickpea	31.96	31.37	31.67	12.55	12.51	12.53	393.91	385.73	389.82	250.20	258.80	254.50
T_5: Maize-Pea-Greengram	32.46	34.82	33.64	12.76	13.83	13.29	406.11	472.12	439.12	255.10	271.67	263.38
T_6: Maize-Linseed-Greengram	32.13	32.37	32.25	12.57	12.90	12.73	396.62	410.21	403.41	251.60	264.33	257.97
T_7: Maize-Lentil-Greengram	32.36	32.59	32.48	12.62	12.98	12.80	401.67	415.73	408.70	253.63	266.50	260.07
T_8: Maize-Chickpea-Greengram	32.58	34.58	33.58	12.80	13.60	13.20	410.54	460.91	435.73	255.47	269.13	262.30
T_9: Maize-Potato-Greengram	31.50	31.88	31.69	12.39	12.68	12.54	383.09	396.39	389.74	248.20	261.33	254.77
SEm±	1.50	1.54	1.08	0.59	0.61	0.42	21.62	22.34	15.55	10.37	9.66	7.09
CD (p=0.05)	NS	4.67	3.12	NS	1.86	1.23	**NS**	67.59	45.02	NS	NS	NS
CV (%)	8.18	8.39	8.29	8.12	8.37	8.25	9.57	9.70	9.64	7.16	6.42	6.78

Table 3.4: Effect of Diversification and intensification of maize-based cropping system on yield attributes of maize

Treatments	Grain yield (kg/ha)			Cob Yield / Green Cob yield (kg/ha)			Stover yield/ Green stover yield (kg/ha)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T_1: Maize-Fallow	5984	6115	6049	7277	7452	7365	9932	10686	10309
T_2: Maize-Wheat	5883	6004	5943	7194	7332	7263	9922	10656	10289
T_3: Maize (Green Cob)-Toria-Wheat	-	-	-	10070	10542	10306	14501	14839	14670
T_4: Maize (Green Cob)-Toria- Chickpea	-	-	-	10023	10854	10439	14839	15241	15040
T_5: Maize-Pea-Greengram	6179	6930	6555	7466	8322	7894	10083	11597	10840
T_6: Maize-Linseed-Greengram	6060	6478	6269	7364	7871	7618	10001	10965	10483
T_7: Maize-Lentil-Greengram	6113	6669	6391	7408	8080	7744	10033	11235	10634
T_8: Maize-Chickpea-Greengram	6216	6821	6519	7504	8216	7860	10136	11448	10792
T_9: Maize-Potato-Greengram	6029	6362	6195	7340	7759	7549	9985	10915	10450
SEm±	-	-	-	418	439	303	532	586	396
CD (p=0.05)	-	-	-	1264	1329	878	1610	1771	1146
CV (%)	-	-	-	9.09	8.96	9.03	8.35	8.48	8.43

Table 3.5: Effect of Diversification and intensification of maize-based cropping system on yields and shelling (%) of maize

Treatments	Harvest Index (%)			Shelling (%)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T_1: Maize-Fallow	37.41	36.23	36.82	82.39	82.19	82.29
T_2: Maize-Wheat	37.37	36.03	36.70	81.72	81.99	81.85
T_3: Maize (Green Cob)-Toria-Wheat	-	-	-	-	-	-
T_4: Maize (Green Cob)-Toria- Chickpea	-	-	-	-	-	-
T_5: Maize-Pea-Greengram	37.99	37.41	37.70	82.81	83.38	83.09
T_6: Maize-Linseed-Greengram	37.85	37.15	37.50	82.20	82.46	82.33
T_7: Maize-Lentil-Greengram	37.90	37.33	37.62	82.48	82.54	82.51
T_8: Maize-Chickpea-Greengram	37.96	37.42	37.69	82.75	83.03	82.89
T_9: Maize-Potato-Greengram	37.85	37.08	37.47	82.79	81.97	82.38
SEm±	-	-	-	-	-	-
CD (p=0.05)	-	-	-	-	-	-
CV (%)	-	-	-	-	-	-

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