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Production potential and fertility levels of soil influenced by integrated nutrient management in Indian mustard [*Brassica juncea* (L.) Czern. & Coss.]

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Abstract
The experiment was conducted at Agricultural Research Farm Dhablan of the GSSDGS Khalsa College Patiala, Punjab. The experiment was laid out in randomized block design with 3 replications and 13 treatment combination of integrated nutrient Management. The soil of experimental field was clay in texture with pH 7.2 and contained organic carbon 0.80%, available nitrogen 374kg/ha, available phosphorus 30.32kg/ha and available K 120kg/ha. All nutrients were applied in basal dose at one day before sowing. The crop was sown on 20th October, 2015. Application of Integrated nutrient Management significantly influenced the test weight (g) harvest index. The highest seed yield was recorded with the application of T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment) was found significantly higher over rest treatments.

Keywords: Indian mustard, integrated nutrient management, dry weight

Introduction
The oilseed crop *Brassica* are the third important edible oil sources after groundnut and soyabean, accounting for over 13.2 per cent of world's edible oil supply. Mustard is a major oilseed crop of India, it grown in tropical and temperate zones. They occupy a prominent place being next in importance to groundnut, both in area and production, meeting the fat requirement of about 50 percent population in India. It grown well from an altitude of 650-1500 meters, it require warm weather 20°C during seed germination, 15°C-20°C during plant growth and long sunny bright days 25°C-27°C, at flowering and pod formation are most suitable for these crops. Mustard grow best under relatively cool temperatures upto flowering. These crops grow profusely at 30-60% relative humidity. Oilseeds have prestigious place in Indian agriculture next only to cereals. India is blessed with favourable agro-ecological conditions for the growth of wide range of cultivated, perennial and annual oilseeds. Oilseeds are the most important crops in India both in respect of remunerative return per unit area and wider adaptability under constrained agro-climatic conditions. In India, mustard and rapeseed are the second most important oilseed crops after groundnut contributing about 30 per cent of total oilseeds production [2]. In India Oilseeds crop are cultivated on 26.82 million ha area with 31.1 million tonnes production (2010-11). The average yield of oil seeds crop in India is 1159kg /ha.

Materials and Methods
The present investigation entitles "Growth, Yield and quality of Indian Mustard [*Brassica juncea* (L.) Czern. & Coss.] Influence by Integrated Nutrient Management" was conducted during Rabi season of 2015-2016 at the Agricultural Research Farm Dhablan is situated at about 24-46 ^{0}N latitude and 76-24 ^{0}E longitude at an altitude of about 250 m above the mean sea level. The experiment was laid out in randomized block design with 3 replications. From the five randomly selected plants the heights were recorded in cm. The numbers of branches were counted from the sample plants and the values of these were averaged. After threshing and cleaning a hand full of seed were taken without any bias from the total seeds of the plot. One thousand grains from each plot sample were counted and weighed on electronic balance and their weight was expressed in grams.

These fresh samples were air dried and then dried in an oven at 60^0C till a constant weight was obtained and weighed to record the average dry weight of the plant. The weight of the sun dried harvested crop was recorded from net plot area and expressed in quintal per hectare after subtracting the seed yield. Seed yield of each plot excluding the border and sampling row was weighed in kilo gram and converted into quintal per hectare Nutrient uptake (N, P and K) by grain, straw and total (grain + straw) were calculated in kg/ ha from their corresponding yield and nutrient content by using formula.

Oil content in seed was determined by Soxlet method. The oil yield was calculated by multiplying the seed yield with oil content in seed.

Nutrient uptake (kg/ ha) = Nutrient content (%) × yield (q/ ha) / 100

The economics of different treatments was worked out by taking into consideration of all the expenses incurred. The cost of input and price of produce prevalent at the Agricultural Research Farm, Banaras Hindu University were taken into considerations for calculating economics of different treatments and expressed as net return and benefit cost ratio (B:C).

Result and Discussion

Integrated nutrient management also influenced the significant difference with respect to harvest index. Maximum harvest index (0.51) observed with application of T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment) recorded superior over all the treatments and minimum harvest index observed in control (0.40).

Integrated nutrient management also influenced the significant difference with respect to test weight. Maximum test weight (4.63) observed with application of T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment) recorded superior over all the treatments and minimum test weight observed in control (2.77) it is the main component of seed yield.

Stover yield increased with increasing fertilizer dose levels of INM treatment seven gives better response as comparison to other treatments. The higher stover yield with the application of INM can be attributed to better growth of the plant as expressed in terms of plant height, number of branch $plant^{-1}$, fresh and dry weight of plant all above character responsible for stover yield. This finding is also supported by Singh and Kanajuia [6], Anand *et al.* [7], Mandal *et al.* [4] in Indian mustard. The seed yield was affected by INM application. Such a positive yield response of INM application is obvious when it is limiting in the growing medium. Application of INM therefore provides better nutrition to Indian mustard which resulted in higher seed yield. Increased in seed yield with the application of INM may be due to better growth of the plant as expressed in term of plant height, fresh. Higher seed yield with the application of INM. This finding is also supported by Ramesh *et al.* [8] in Indian mustard.

Maximum oil content (39.65%) was obtained with in T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment) which were statistically at par recorded in T_6 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} (38.38%) which significantly superior to rest of all the treatments. Maximum protein content (20.98%) was obtained with in T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment) which were statistically at par recorded in T_6 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} (20.31%) which significantly superior to rest of all the treatments. This finding is also supported by Tripathi *et al.* (2011) [9].

Nitrogen uptake by seed and stover as affected by organic sources of nutrients. An analysis of the data revealed that organic sources of nutrients caused significant influence on nitrogen uptake by seed and stover. However, maximum removal of nitrogen was found in T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment) which proved significantly superior to other. Higher uptake of nitrogen (46.77kg ha^{-1}) by seed and (25.03kg ha^{-1}) by stover was noticed T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment) statistically at par to each other were significantly superior to all other treatments.

Higher uptake of phosphorus (11.33 kg ha^{-1}) by seed and (17.07 kg ha^{-1}) by stover was noticed T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment) statistically at par to each other were significantly superior to all other treatments.

Potassium uptake by seed and stover as affected by INM sources of nutrients. An analysis of the data revealed that organic sources of nutrients caused significant influence on potassium uptake by seed and stover. However, maximum removal of potassium was found in T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment) which proved significantly superior to other.

Higher uptake of potassium (29.27kg ha^{-1}) by seed and (40.21kg ha^{-1}) by stover was noticed T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment) statistically at par to each other Among the integrated nutrients management, the maximum net return (110854.13ha^{-1}) was recorded T_7 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + Azotobacter Seed treatment). The maximum B: C ratio of 4.92 was recorded at 4.92 T_5 (100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}. This finding is also supported by Meena *et al.* (2008) [10].

Table 1: Effect of INM on harvest index and test weight (g) of Indian mustard

Treatment	Harvest index (HI)	Test wt (g)
T_1	0.40	2.77
T_2	0.43	3.13
T_3	0.44	3.37
T_4	0.47	3.83
T_5	0.48	3.77
T_6	0.50	4.23
T_7	0.51	4.63
T_8	0.41	3.10
T_9	0.42	3.33
T_{10}	0.44	3.67
T_{11}	0.46	3.97
T_{12}	0.48	4.17
T_{13}	0.50	4.53
Mean	0.46	3.73
SE(d)±	0.02	0.39
CD (5%)	0.04	0.89

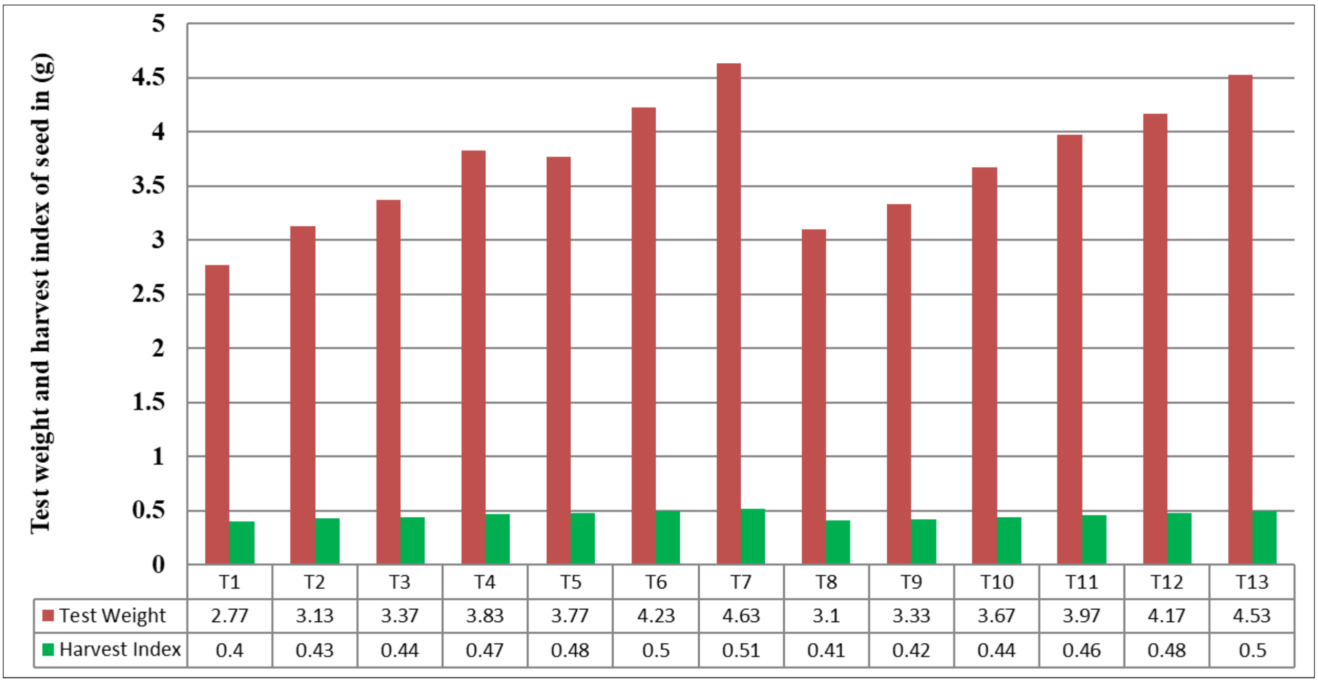


Fig 1: Effect of INM on test weight and harvest index of Indian mustard

Table 2: Effect of INM on stover and seed yield (q ha^{-1}) of Indian mustard

Treatment	Stover Yield	Seed Yield q ha^{-1}
T_1	11.37	9.07
T_2	14.37	17.37
T_3	15.27	19.27
T_4	16.73	22.73
T_5	19.40	24.07
T_6	19.77	25.10
T_7	24.27	26.93
T_8	13.53	15.10
T_9	17.73	17.40
T_{10}	18.07	20.50
T_{11}	21.27	22.60
T_{12}	22.87	23.50
T_{13}	24.40	25.05
Mean	18.39	20.66
SE(d)±	1.86	0.34
CD (5%)	4.19	0.76

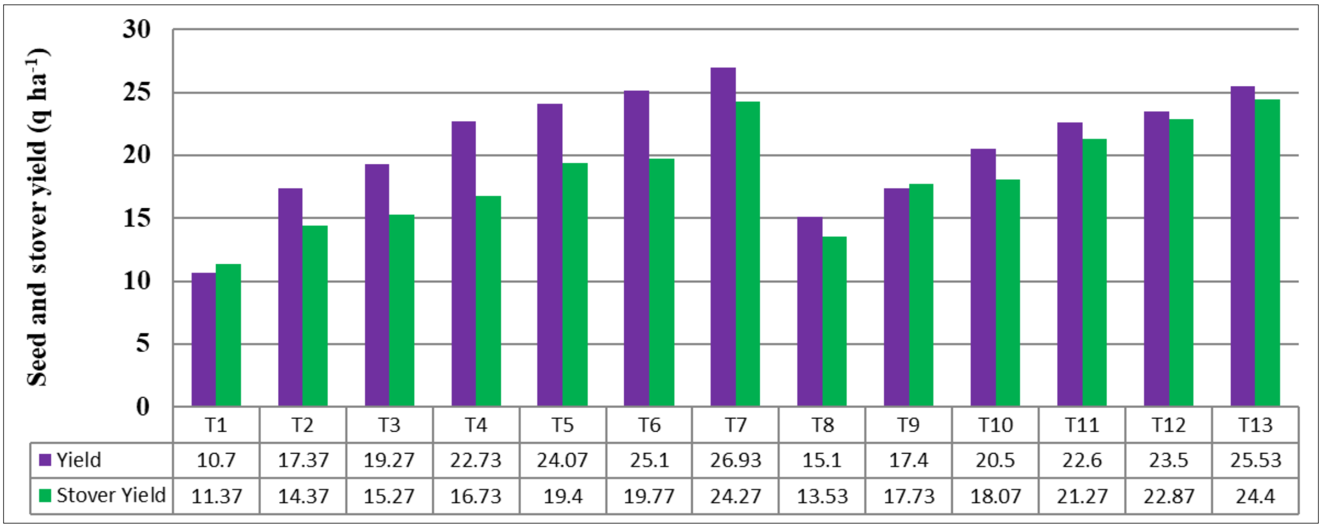


Fig 2: Effect of INM on stover and seed yield (q ha-1) of Indian mustard

Table 3: Effect of INM on protein and oil content of Indian mustard

Treatment	Protein Content	Oil Content
T_1	17.26	35.26
T_2	18.68	36.68
T_3	19.62	37.48
T_4	19.59	37.63
T_5	20.41	38.41
T_6	20.31	38.38
T_7	20.98	39.65
T_8	18.38	36.38
T_9	18.92	36.91
T_{10}	19.26	37.26
T_{11}	19.44	37.44
T_{12}	19.86	37.86
T_{13}	19.79	37.79
Mean	19.42	37.47
SE(d)±	0.24	0.26
CD (5%)	0.54	0.59

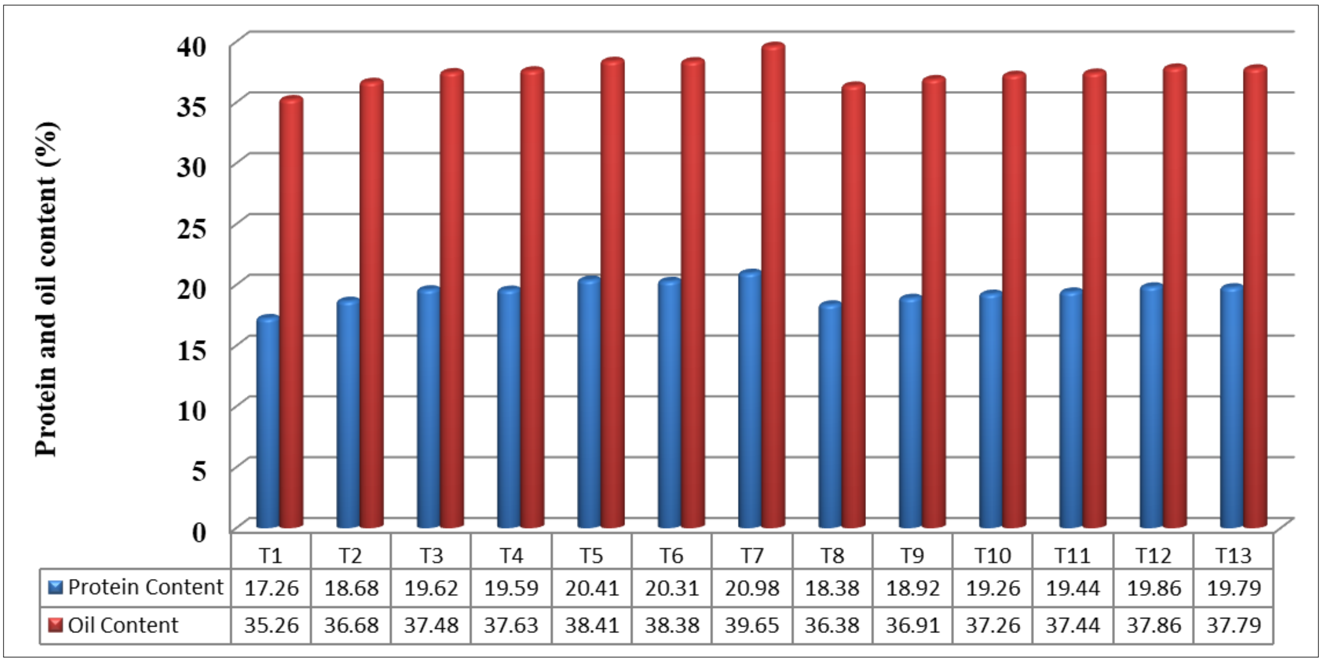
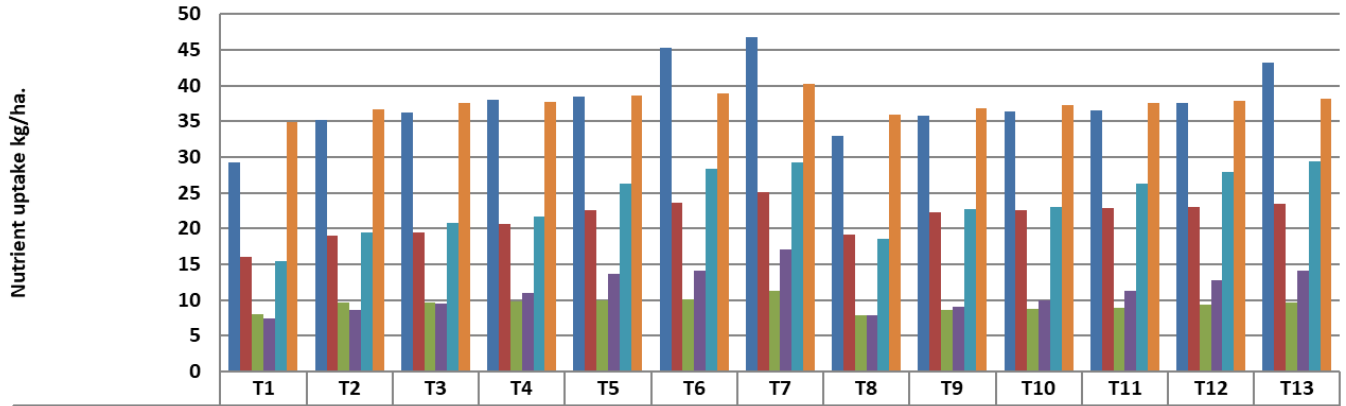


Fig 3: Effect of INM on quality of Indian mustard

Table 4: Effect of INM on nutrients uptake

Treatment	Nutrient uptake (kg ha^{-1})					
	Nitrogen		Phosphorus		Potassium	
	Seed	Stover	Seed	Stover	Seed	Stover
T_1	29.27	16.07	8.00	7.40	15.40	34.86
T_2	35.23	19.00	9.70	8.60	19.43	36.63
T_3	36.23	19.40	9.67	9.50	20.80	37.59
T_4	38.00	20.60	9.73	11.00	21.73	37.63
T_5	38.37	22.60	9.87	13.67	26.33	38.61
T_6	45.20	23.53	10.13	14.10	28.33	38.89
T_7	46.77	25.03	11.33	17.07	29.27	40.21
T_8	32.97	19.20	7.93	7.87	18.53	35.94
T_9	35.70	22.27	8.67	9.00	22.73	36.85
T_{10}	36.33	22.53	8.80	9.90	23.07	37.30
T_{11}	36.57	22.80	8.84	11.27	26.27	37.55
T_{12}	37.53	23.07	9.40	12.80	27.87	37.90
T_{13}	43.20	23.43	9.67	14.07	29.40	38.13
Mean	37.80	21.50	9.36	11.25	23.78	37.55
SE(d)±	1.17	0.80	1.17	1.10	1.25	0.600
CD (5%)	2.66	1.81	2.64	2.48	2.84	1.36



	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
N content in seed	29.27	35.23	36.23	38	38.37	45.2	46.77	32.97	35.7	36.33	36.57	37.53	43.2
N content in stover	16.07	19	19.4	20.6	22.6	23.53	25.03	19.2	22.27	22.53	22.8	23.07	23.43
P content in seed	8	9.7	9.67	9.73	9.87	10.13	11.33	7.93	8.67	8.8	8.84	9.4	9.67
P content in stover	7.4	8.6	9.5	11	13.67	14.1	17.07	7.87	9	9.9	11.27	12.8	14.07
K content in seed	15.4	19.43	20.8	21.73	26.33	28.33	29.27	18.53	22.73	23.07	26.27	27.87	29.4
K content in stover	34.86	36.63	37.59	37.63	38.61	38.89	40.21	35.94	36.85	37.3	37.55	37.9	38.13

Fig 4: Effect of INM on nutrients uptake

Table 5: Effect of INM on net return (ha^{-1}) and Benefit: cost ratio

Treatments	Gross return (ha^{-1})	Cost of Cultivation (ha^{-1})	Net return (ha^{-1})	B:C Ratio
T_1 – control	49054.15	13290.00	35764.15	2.69
T_2 – 100% RDF	92092.65	18721.72	73370.93	3.91
T_3 – 100% RDF + 2t FYM/ha	101998.15	20721.72	81276.43	3.92
T_4 – 100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1}	119991.85	21121.72	98870.13	4.68
T_5 – 100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}	127486.65	21521.72	105964.93	4.92
T_6 – 100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost/ha	132827.00	31521.72	101305.28	3.21
T_7 – 100% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg ZnSO4 ha^{-1} + 1t vermicompost ha^{-1} Azotobacter (Seed treatment)	143275.85	32421.72	110854.13	3.42
T_8 – 75% RDF	80317.00	17363.87	62953.13	3.62
T_9 – 75% RDF + 2t FYM $^{-1}$ ha	93085.50	19363.87	73721.63	3.80
T_{10} – 75% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1}	108965.00	19763.87	89201.13	4.51
T_{11} – 75% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}	120464.50	20163.87	100300.63	4.97
T_{12} – 75% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1}	125450.00	29063.87	96286.13	3.33
T_{13} – 75% RDF + 2t FYM ha^{-1} + 20kg S ha^{-1} + 20kg ZnSO4 ha^{-1} + 1t vermicompost ha^{-1} Azotobacter (Seed treatment)	133729.75	31063.87	102665.88	3.30

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