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Relative performance of sesame (S*esamum indicum*) under organic, inorganic and integrated nutrient management

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ABSTRACT

The experiments were carried out during *kharif* season in 2009–10 and 2010–11. The study comprised 8 treatment combinations consisting with different nutrient management, viz. T_1, Control; T_2, 100% RDF (Recommended dose of fertilizers-60 kg N + 40 kg P_2O_5 + 20 kg K_2O/ha); T_3, 50% RDF + 50% N through FYM (Farmyard manure); T_4, 100% Recommended N through FYM; T_5, 50% RDF + 50% N through VC (Vermicompost); T_6, 100% recommended N through VC; T_7, 50% RDF + 50% N through NOC (Neem oil cake); T_8, 100% recommended N through NOC were tested in a randomized block design with three replications and two varieties Gujrat Til 2 and TKG 22. The LAI values were higher at later stage of growth (60 DAS) than early stage (30 DAS) under all treatments in both the years. At 90 DAS, the crop growth rate was maximum (5.40 g/m²/day) with T_4 and T_7 treatment during both the years. At 90 DAS, RGR was maximum (8.13 mg/g/day in 2009–10 and 8.20 mg/g/day in 2010–11) with T_4 treatment. The seed yield was maximum (810 kg/ha in 2009-10 and 757 kg/ha in 2010–11) with the application of 100% recommended dose of fertilizers (T_2). While the straw yield was maximum (4 650 kg/ha in 2009–10 and 4 497 kg/ha in 2010–11) in 100% recommended dose of fertilizers (T_2). Application of 100% RDF through inorganics, recorded highest seed and straw yields which were at par to those recorded with application of 50% RDF + 50% N through NOC, 50% RDF + 50% N through VC and 50% RDF + 50% N through FYM. Application of full quantity of nutrients through organics, viz. NOC/VC/FYM produced lesser yields than 100% inorganic and other integrated nutrient management. The maximum NUE value was observed with application of 100% RDF through inorganic sources (88.37% in 2009–10 and 84.66% in 2010–11).The cost of cultivation was maximum (₹ 14 283/ha in 2009–10 and ₹ 17 675/ha in 2010–11) under T_6 (100% recommended N through VC). The benefit-cost (B:C) ratio was significantly maximum (2.27 in 2009–10 and 2.14 in 2010–11) in T_2 (100% RDF) among all treatments.

Key words: B:C ratio, HI, Inorganic, Integrated Nutrient Management, Organic, RGR, Sesame

Sesame (S*esamum indicum* L.) is the oldest indigenous oilseed crop, with longest history of cultivation in India. Sesame seed contains 50% oil, 25%, protein and 15% carbohydrates. Its seed are used in baking, candy making and other food industries. It is an integral part of rituals, religion and culture. It is used in cooking, in the manufacture of soaps, paints, perfumes, pharmaceuticals and insecticides. India ranks first in area and second in sesame production by contributing 23.2% and 18.5% of the world area and production respectively. In India, it is cultivated in an area of about 1.80 million hectares with a production of 0.64 million tonnes and productivity of 354 kg seeds/ha. The major sesame growing states in the country are Gujrat, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. Madhya Pradesh ranks third in area and production by contributing 11.58 and 13.68 share of country's area and production respectively. Madhya Pradesh covers an area of 2.09 lakh hectare under this crop with an annual production of 0.87 lakh tonnes and productivity of 418 kg seeds/ha (Anonymous 2010). Sesame cultivation is done under varying agro-ecosystems. It is mostly grown during *kharif* season under rainfed conditions on marginal and sub-marginal lands having low organic matter and poor soil-fertility. The main reasons for low productivity in the state are its cultivation confined on marginal and submarginal lands with the use of negligible agro-inputs. Nutrients stress is one of the most important factors for low productivity of this crop. Sesame responds well to application of NPK fertilizers and organic manures (Mondal *et al*. 1992). Integration of organics with inorganics has been found to be quite promising not only in

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maintaining higher productivity but also in providing greater stability in crop production. Popularizing the use of organics to reduce the dependence on chemical fertilizers and to contribute the pollution free environment is the greatest need of the hour. Farmyard manure and vermicompost have been advocated as good organic manure for use in integrated nutrient management programme in field crops (Shroff and Devasthali 1992).

MATERIALS AND METHODS

The present experiments were carried out at research farm of Project Coordinating Unit (Sesame and Niger), Jawarharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur (MP) during *kharif* season in 2009–10 and 2010–11. Jabalpur is situated at 23^0 90" N latitude and 79' 58" E longitude at an altitude of 411.78 m above the mean sea level. It falls under subtropical climatic conditions, which is characterized by the features of hot dry summers and cool dry winters. Mean annual rainfall of the area for 10 years is 1284 mm and nearly 90% of the total annual rainfall mainly receives during the period between end of June to end of September. The rainfall of the locality is often erratic and ill-distributed along with an occasional long dry spells or frequent heavy rainy days during rainy season. The maximum and minimum temperatures range between 24 °C to 45 °C, and 4°C to 32 °C, respectively. In some of the years, maximum temperature reaches as high as 45 °C in May or June, while minimum temperature falls down to a limit of 4 °C during end of December or January months. The relative humidity ranges between 80 to 90% during rainy season, which reduces as 60 to 70 and 30 to 40% during winter and summer seasons, respectively. It falls under "Kymore Plateau and Satpura Hills" agroclimatic zone of Madhya Pradesh. The soil of the experimental field is classified as "Vertisols" as per US classification of soil. The soil of the experimental field had a uniform topography with gentle slope (0.2%). It has medium to deep depth and black in colour. The physico-chemical properties of soil are presented in Table 1.

The present investigation was comprised 8 treatment combinations consisting with different nutrient management, viz T_1, Control, T_2, 100% RDF, T_3, 50% RDF + 50% N through FYM; T_4, 100% recommended N through FYM; T_5, 50% RDF + 50% N through VC; T_6, 100% recommended N through VC; T_7, 50% RDF + 50% N through NOC; T_8, 100% recommended N through NOC were tested in a randomized block design with three replications. Two varieties Gujrat Til 2 and TKG 22 were sown in the month of July of 2009–10 and 2010–11 respectively. Gujrat Til–2 matures in about 115–120 days during *kharif* season. The plants of this variety has branched type of growth habit with multicapsules bearing ability. The capsules are hairy and their attachment is opposite. Its yield potential is around 790 kg/ha. The oil content in its seeds is about 50.2%. Variety TKG 22 matures in about 110-115 days during *kharif* season. Its yield potential is around 600–700 kg/ha. The oil content in its seeds is about 53%. Before sowing, seeds were treated with Thiram at the rate of 3 g/kg to avoid the possible occurrence of the seed and soil borne diseases.

All the physiological parameters were recorded. The leaf area (LA) was recorded by automatic leaf area meter (LI 3000) from the randomly selected 10 leaves of each plot at 30 and 60 DAS growth stages.

The leaf area index (LAI) was determined plotwise at 30 and 60 DAS growth stages in all plots by using the following formula:

$$\text{LAI} = \frac{A}{P}$$

where, A, leaf area/m^2; P, ground area/m^2 from where leaf area was recorded.

The daily increment in stand biomass termed as CGR or productivity rate or rate of dry matter production. It was

Table 1 Physico-chemical properties of the soil of the experimental field

Constituent	Analytical value	Interpretation	Method of determination
Physical properties			
Sand (%)	29.10	Clay loam	Bouycos Hydrometer
Silt (%)	20.15		
Clay (%)	50.75		
Bulk density (Mg/m^3)	1.40		
Particle density (Mg/m^3)	2.75		
Chemical properties			
Soil pH(1:2 soil suspension)	7.20	Neutral	Glass Electrode pH Meter
Electrical conductivity (dS/m)	0.41	Normal	Solubridge method
Organic carbon (%)	0.46	Low	Walkley and Black rapid titration method
Available nitrogen (N kg/ha)	204	Low	Alkaline permanganate method
Available phosphorus (P kg/ha)	18.6	Medium	Olsen method
Available potassium (K kg/ha)	321.6	High	Flame Photometer method

calculated as per following formula:

$$CGR = \frac{W_2 - W_1}{P\ (t_2 - t_1)}\ (g/m^2/day)$$

where, W_1, Dry weight of plants/m^2 recorded at time t_1; W_2, dry weight of plants/m^2 recorded at time t_2; P, Ground area (m^2) t_1 and t_2 are the intervals of time, respectively.

It is an index of the amount of growing material per unit dry weight of plant per unit time. It is also called efficiency index. It was computed by using the following formula:

$$RGR = \frac{In\ W_2 - In\ W_1}{t_2 - t_1}\ (mg/g/day)$$

where, W_1 and W_2 are the total dry weight at t_1 and t_2 times, respectively

It gives an indicative of the true monetary gain over every rupee of investment under a particular treatment. It was worked out by using the following formula:

$$\text{Benefit-cost ratio} = \frac{\text{Gross monetary return (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

RESULTS AND DISCUSSION

The leaf area index (LAI) values recorded at all growth stages were comparable for all treatments except control treatment which significantly recorded the lowest LAI in both years. Data on the LAI values at grand growth stage (30 and 60 DAS) as affected by various treatments are given in Table 2.

The LAI values were higher at later stage of growth (60 DAS) than early stage (30 DAS) under all treatments. The LAI values did not vary with each other due to different treatments at 30 DAS, while it significantly differed between the treatments at 60 DAS. Control treatment had significantly lesser LAI than other treatments receiving varying doses of manures and fertilizers and these were at par for this character with each other. The maximum LAI (4.69 in 2009–10 and 4.61 in 2010–11) was observed in T_2 experiment.

These results are in close conformity with findings of Kachapur and Radder (1983a&b) and Deshmukh (2003) and Badole (2009) in niger.

Table 2 Leaf area index of sesame under various nutrient managements

Nutrient management	Successive growth stages			
	2009–10		2010–11	
	30 DAS	60 DAS	30 DAS	60 DAS
T_1 – Control	3.42	4.24	3.30	4.16
T_2 - 100% RDF	3.41	4.69	3.29	4.61
T_3 - 50% RDF + 50% N through FYM	3.40	4.68	3.27	4.60
T_4 - 100% recommended N through FYM	3.43	4.66	3.30	4.57
T_5 - 50% RDF + 50% N through VC	3.39	4.68	3.26	4.60
T_6 - 100% recommended N through VC	3.36	4.64	3.24	4.55
T_7 - 50% RDF + 50% N through NOC	3.48	4.67	3.35	4.58
T_8 - 100% recommended N through NOC	3.37	4.67	3.24	4.60
SEm±	0.04	0.05	0.24	0.04
CD (P=0.05)	NS	0.15	NS	0.13

Crop growth rate (CGR)

The CGR values gradually increased with the advancement in the growth stages up to 90 DAS under all treatments (Table 3), but the rate of increment was most rapid during 60 to 90 DAS. The CGR values declined at maturity as compared to its preceeding stage (90 DAS) under all treatments.CGR value significantly differed due to treatments at all growth stages including maturity. At 60 DAS, the CGR was maximum (4.56 g/m^2/day in 2009–10 and 4.57 g/m^2/day in 2010–11) with T_3, which was at par to T_2 (4.53 g/m^2/day in both years), T_5 and T_7 (4.50 g/m^2/day in both years). The next best treatment for CGR was T_6 (4.16 g/m^2/day in 2009–10 and 4.17 g/m^2/day in 2010–11), which was at par to rest of the treatments having CGR values from 3.80 to 4.10 g/m^2/day. At 90 DAS, the CGR was maximum (5.40 g/m^2/day in both years) with T_4 and T_7, which was at par to remaining all treatments except to T_3 (5.03 g/m^2/day in both years) and T_1 (3.86 g/m^2/day in 2009–10 and 3.87 g/m^2/day in 2010–11). But the T_1 had significantly minimum CGR among all treatments. At maturity, the CGR was maximum (4.40 g/m^2/day in 2009–10 and 5.50 g/m^2/day in 2010–11) with T_2, which was at par to all treatments except to T_3 (3.72 g/m^2/day in 2009–10 and 4.65 g/m^2/day in 2010–11), T_4 (3.84 g/m^2/day in 2009–10 and 4.80 g/m^2/day in 2010-11) and T_1 (3.64 g/m^2/day in 2009–10 and 4.55 g/m^2/day in 2010–11). The later treatments were also at par with each other. Similar results are also reported by Kachapur and Radder (1983a&b) and by Deshmukh (2003) in niger crop.

Relative growth rate (RGR)

The RGR values declined with the advancement in the growth stages up to maturity under all treatments (table 4). At 60 DAS, the RGR was maximum (12.68 mg/g/day in 2009–10 and 13.14 mg/g/day in 2010–11) with T_2, which was comparable to the rest of the treatments except to T_4 (11.37 mg/g/day in 2009–10 and 11.79 mg/g/day in 2010–11) and T_1 (11.17 mg/g/day in 2009–10 and 11.59 mg/g/day in 2010–11). At 90 DAS, RGR was maximum (8.13 mg/g/day in 2009–10 and 8.20 mg/g/day in 2010–11) with T_4. Control treatment had the lowest RGR (6.31 mg/g/day in 2009–10 and 6.44 mg/g/day in 2010–11) among all treatments.At maturity, T_2 had the maximum (4.29 mg/g/day in 2009–10 and 5.43 mg/g/day in 2010–11) RGR. T_7 treatment had the lowest RGR (3.72 mg/g/day in 2009–10 and 4.71 mg/g/day in 2010–11) among all treatments. These results

Table 3 Crop growth rate ($g/m^2/day$) of sesame under various nutrient managements

Nutrient management	Successive growth stages					
	2009–10			2010–11		
	60 DAS	90 DAS	Maturity	60 DAS	90 DAS	Maturity
T_1 - Control	3.80	3.86	3.64	3.80	3.87	4.55
T_2 - 100% RDF	4.53	5.30	4.40	4.53	5.30	5.50
T_3 - 50% RDF + 50% N through FYM	4.56	5.03	3.72	4.57	5.03	4.65
T_4 - 100% recommended N through FYM	3.90	5.40	3.84	3.90	5.40	4.80
T_5 - 50% RDF + 50% N through VC	4.50	5.26	4.20	4.50	5.27	5.25
T_6 - 100% recommended N through VC	4.16	5.20	4.20	4.17	5.20	5.25
T_7 - 50% RDF + 50% N through NOC	4.50	5.40	3.80	4.50	5.40	4.75
T_8 - 100% recommended N through NOC	4.10	5.26	4.20	4.10	5.27	5.25
SEm±	0.10	0.09	0.13	0.10	0.08	0.12
CD (*P*=0.05)	0.31	0.28	0.40	0.32	0.27	0.36

Table 4 Relative growth rate (mg/g/day) of sesame under various nutrient managements

Nutrient management	Successive growth stages					
	2009–10			2010–11		
	60 DAS	90 DAS	Maturity	60 DAS	90 DAS	Maturity
T_1 - Control	11.17	6.31	4.25	11.59	6.44	5.39
T_2 - 100% RDF	12.68	7.53	4.29	13.14	7.66	5.43
T_3 - 50% RDF + 50% N through FYM	12.49	7.13	3.73	12.92	7.25	4.72
T_4 - 100% recommended N through FYM	11.37	8.13	3.94	11.79	8.20	4.98
T_5 - 50% RDF + 50% N through VC	12.62	7.51	4.14	13.08	7.65	5.23
T_6 - 100% recommended N through VC	11.82	7.65	4.23	12.24	7.78	5.36
T_7 - 50% RDF + 50% N through NOC	12.36	7.59	3.72	12.80	7.71	4.71
T_8 - 100% recommended N through NOC	11.93	7.86	4.26	12.38	8.00	5.39
SEm±	0.36	0.26	0.16	0.34	0.25	0.18
CD (P=0.05)	1.09	0.77	0.58	1.02	0.74	0.53

are in close conformity with the findings reported by Kachapur and Radder (1983a&b), Badole (2009) and Mondal *et al.* (1992) in sesame crop.

Seed yield, straw yield and harvest index

It is evident from data that seed yields significantly varied due to different treatments (Table 5). Control (no application of fertilizer and manure) treatment produced significantly the lowest seed yield (430 kg/ha in 2009–10 and 410 kg/ha in 2010–11) among all treatments. The seed yield was maximum (810 kg/ha in 2009–10 and 757 kg/ha in 2010–11) with the application of 100% recommended dose of fertilizers (T_2), but it was statistically at par to rest of the treatments producing seed yields from 780 to 810 kg/ha in 2009–10 and 727 to 752 kg/ha in 2010–11.

The straw yields also significantly differed due to different treatments. The control treatment led to record significantly minimum straw yields (2 610 kg/ha in 2009–10 and 2 590 kg/ha in 2010–11) among all treatments (Table 5). The straw yield was maximum (4 650 kg/ha in 2009–10 and 4 497 kg/ha in 2010–11) with T_2-(application of 100% RDF) closely followed by T_7-50% RDF + 50% N through NOC (4 630 kg/ha in 2009–10 and 4477 kg/ha in 2010–11).

The harvest index was maximum (14.83 in 2009–10 and 14.40 in 2010–11) with the application of 100% recommended dose of fertilizers (T_2). Control treatment produced significantly the lowest harvest index (14.14 in 2009–10 and 13.66 in 2010–11) among all treatments.

The seed yield and straw yield of sesame significantly varied due to different nutrient management treatment. Thus it can be said that seed yield of sesame was maximum with recommended dose of fertilizers. The control plot (T_1) produced significantly minimum seed yield among all treatments because of poor yield attributing characters. The nutrient availability to crop might be limiting factor under integrated nutrient management treatments which resulted in inferior growth parameters ultimately, lesser seed yields. The organically treated plot might not be able to fulfill the need of major nutrients in adequate quantity at proper time. Thus, it attributed to poor yield attributing characters and ultimately in lower yields. The similar results were observed by Mondal *et al.* (1993), Tiwari *et al.* (1995), Singh *et al.* (1997), Duhoon *et al.* (2001), Narkhede *et al.* (2001), Shashidhara *et al.* (2009), Deshmukh *et al.* (2002 a) and

Table 5 Seed yield and straw yield of sesame under different nutrient managements

Nutrient management	2009–10			2010–11		
	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest index	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest index
T_1 -Control	430	2 610	14.14	410	2 590	13.66
T_2 -100% RDF	810	4 650	14.83	757	4 497	14.40
T_3 -50% RDF + 50% N through FYM	790	4 590	14.68	737	4 437	14.24
T_4 -100% recommended N through FYM	780	4 560	14.60	727	4 407	14.18
T_5 -50% RDF + 50% N through VC	800	4 600	14.81	747	4 447	14.38
T_6 -100% recommended N through VC	780	4 530	14.68	727	4 377	14.23
T_7 -50% RDF + 50% N through NOC	805	4 630	14.81	752	4 477	14.12
T_8 -100% recommended N through NOC	785	4 560	14.68	732	4 407	14.25
SEm±	25	41	0.41	23	85	0.39
CD (P=0.05)	76	123	NS	68	260	NS

Badole (2009).

Nutrient use efficiency (NUE)

Nutrient use efficiency is the efficiency of percentage increased in yield due to various levels and sources of nutrients over control under a particular treatment. Application of 100% recommended dose of fertilizer (T_2) had maximum N-use efficiency (88.37 % in 2009–10 and 84.66 % in 2010–11) given in Table 6, followed by T_7, i e 50% RDF + 50% N through NOC (87.20 % in 2009–10 and 83.41 % in 2010–11). T_4 and T_6 treatment had minimum N-use efficiency (81.39% in 2009–10 and 77.31 % in 2010–11).

The nutrients supplementation through integration of 50% RDF + 50% N through FYM, VC and NOC had higher NUE than supplementation of nutrients 100% through organic sources alone, but it was numerically lesser than application of 100% RDF. The maximum NUE value was observed with application of 100% RDF (88.37 % in 2009–10 and 84.66% in 2010–11) through inorganic sources. Thus it can be said that integration of 50% RDF to 50% N through FYM/VC/NOC was more effective to increase the NUE over the nutrient application through organic sources alone. Thus, it is obvious that uptake of nutrients by the plants was more efficient with the integrated use of inorganic and organic fertilization than that of using all organic sources alone. Beneficial effects of FYM, VC and NOC have been also advocated by Rao *et al*. (1991), Balamurugan and Gunasekaran (1996) and Deshmukh (2003), and Deshmukh *et al*. (2008).

Economic analysis and cost of cultivation

The economic analysis of the treatments was made with different sub-heads as cost of cultivation and gross as well as net monetary returns as per hectare basis and finally as profitability (benefit: cost ratio). The data on these parameters are presented in Table 7.

The common cost of cultivation was ₹ 10 033/ha in 2009–10 and Rs 13 425/ha in 2010-11 for control treatment receiving use of no manure and fertilizer (Table 7). It increased due to application of different doses of fertilizers and manures under remaining treated plots. The cost of cultivation was maximum (₹ 14 283/ha in 2009–10 and ₹ 17 675/ha) under T_6 - 100% recommended N through VC.

Table 6 Nutrient use efficiency (NUE) as affected by various treatments

Nutrient management	NUE (%)	
	2009–10	2010–11
T_1 - Control		
T_2 - 100% RDF	88.37	84.66
T_3 - 50% RDF + 50% N through FYM	83.72	79.75
T_4 - 100% recommended N through FYM	81.39	77.31
T_5 - 50% RDF + 50% N through VC	86.04	82.19
T_6 - 100% recommended N through VC	81.39	77.31
T_7 - 50% RDF + 50% N through NOC	87.20	83.41
T_8 - 100% recommended N through NOC	82.55	78.53

Gross monetary returns (GMR)

The monetary value of the marketable produce is termed as GMR. The GMR values varied due to effect of different nutrient management treatments (Table 7). GMR is directly related to the value of the marketable produce, which could be realized from the existing market price of the produce. The GMR value was maximum (₹ 26 625/ha in 2009–10 and ₹ 32 528/ha in 2010–11) with T_2 - 100% RDF. The higher GMR's of these treatments were due to higher seed and straw yields. Treatment, T_1 (Control) led to record significantly minimum GMR of ₹ 14 205/ha in 2009–10 and ₹ 17 695/ha in 2010–11 as it recorded less seed and straw yields.

Net monetary returns (NMR)

The NMR was determined by subtracting the cost of cultivation from the GMR of same treatment. In this way

Table 7 Economics of the treatments under various nutrient managements

Treatment	2009–10				2010–11			
	Cost of cultivation (₹/ha)	Gross monetary returns (₹/ha)	Net monetary returns (₹/ha)	Benefit : cost ratio	Cost of cultivation (₹/ha)	Gross monetary returns (₹/ha)	Net monetary returns (₹/ha)	Benefit : cost ratio
T_1	10 033	14 205	4 172	1.41	13 425	17 695	4 270	1.31
T_2	11 723	26 625	14 902	2.27	15 125	32 528	17 403	2.14
T_3	12 933	25 995	13 062	2.00	16 325	31 698	15 373	1.93
T_4	14 133	25 680	11 547	1.81	17 525	31 283	13 758	1.78
T_5	13 008	26 300	13 292	2.02	16 400	32 103	15 703	1.95
T_6	14 283	25 665	11 382	1.79	17 675	31 268	13 593	1.76
T_7	12 970	26 465	13 495	2.04	16 362	32 318	15 956	1.97
T_8	14 208	25 830	11622	1.81	17 600	31 483	13 883	1.78
SEm±		545	198	0.05		543	195	0.04
CD (*P*=0.05)		1655	633	0.16		1631	625	0.13

Sale price of sesame seed and straw is ₹ 40/kg and 0.50/kg respectively.

it represents the true monetary gain for a particular treatment. NMR values were maximum (₹ 14 902/ha in 2009–10 and ₹ 17 403/ha in 2010–11) with T_2 (Application of 100% RDF) (Table 7). The NMR of treatments receiving 100% organic manures was less than treatments receiving chemical fertilizers. The cost of organic manures was more than fertilizers and higher market price of organic produce with organic manure may be reason for fetching higher GMR. Secondly higher cost of cultivation and lesser seed and straw yields with organic manures resulted into lesser NMR than other treatments. The control plot (T_1) significantly recorded the lowest NMR (4 172/ha in 2009–10 and ₹ 4 270/ha in 2010–11).The treatments associated with varying proportion of NPK through fertilizers and organic manures fetched the lesser NMR than to those recorded with the application of 100% N through organic manures.

Benefit-cost ratio

The B:C ratio is also termed as profitability. It is the profit or gain realized over each rupee of investment, as it is determined by dividing the GMR values with cost of cultivation of particular treatment. The B:C ratio was maximum (Table 7) under treatment T_2- 100% RDF (2.27 in 2009–10 and 2.14 in 2010–11) due to the maximum GMR value with the lowest cost of cultivation associated with it. Thus it could be concluded that investment on the use of every unit of fertilizers was more remunerative than the investment on organic manures. The control treatment had the minimum B:C ratio (1.41 in 2009–10 and 1.31 in 2010–11) among all treatments as it recorded less seed and straw yields.

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