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RESEARCH ARTICLE

EFFECT OF BIOZYME AND FERTILITY LEVELS ON GROWTH, YIELDS, NUTRIENT UPTAKE, NUTRIENT HARVEST AND PHYSIOLOGICAL EFFICIENCY INDEX OF SOYBEAN (*GLYCINE MAX* L. MERRILL)

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ABSTRACT

Experiment was conducted, during rainy season of 2006, 2007 and 2008 with NPK (20 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha), half recommended NPK, Biozyme granule @ 20, 30, and 40 kg/ha alone and along with half recommended NPK and Biozyme crop$^+$ spray @ 200 and 400 ml/ha alone and along with half recommended NPK. At 60 DAS, Biozyme crop$^+$ spray @ 400ml/ha + half of recommended NPK resulted highest number of trifoliate leaves (28.13 leaves/plant), leaf area (1814.21 cm²/plant), LAI (5.945), and total chlorophyll content (1.99 mg/g leaf fresh weight) which stood 3.57, 2.97, 3.17 and 16.13 % higher over recommended NPK, respectively. Similarly, 400 ml Biozyme crop$^+$ with half of recommended NPK maintained, 9.01, 6.27, 5.41, 12.91 and 3.42 % higher branches/plant, pods/plant, seeds/pod and seed yield/plant and increased the seed yield by 8.54%, straw yield by 26.43% and biological yield by 17.13%, respectively over recommended NPK. Biozyme spray 400 ml/ha increased N uptake by 12.17, P uptake by 4.59 over recommended NPK. Higher Nutrient Harvest Index and Physiological Efficiency Indices observed under sole treatments of Biozyme.

INTRODUCTION

Earlier attempts to increase the yield of field crops have been mainly through agronomic manipulations *viz*., adoption of high yielding varieties, increased use of fertilizers, improved methods for controlling insect pest diseases and weeds. Considering the hazardous effects of inorganic inputs, in recent days under present scenario of sustainability and food security a great deal of interest have now being shown in selection of situation specific agrotypes and regulating the plant growth and development through the use of bio-physiological manipulators (Growth regulators), which enables the plant to modify their morphological and physiological behavior in such a way that they can have best use of existing as well as applied inputs (Carlson *et al*., 1987). Any imbalance in the normal hormonal composition of plant leads to poor growth, development and yield as well as quality. In high yielding varieties, their high yield potential and adaptability for an agro-ecological set up is largely attributed by their endogenous level of growth regulators, as they have triggering action on different biochemical and physiological processes of the plant. Their minute quantities are able to provide formative effects if present in balanced proportion.

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The Biozyme a product of M/S WOCKHARDT is a hormonal formulation developed from *Ascophyllum nodosum*, a sea weed alga known to be rich in cytokinin and auxin precursors in balanced proportion, chelating enzymes, and hydrolyzed proteins. Thus facilitates higher uptake of macro as well as micro nutrients, enhances the growth, yield and has beneficial impact on produce quality also (Zapade *et al*., 2008).

Therefore, there is need to investigate the appropriate dose of such bio- physiological manipulators (Biozyme or like formulations) along with fertility levels and to test their effects on growth dynamics and bio–physiological parameters of different field crops. On the proposed hypothesis an experiment was conducted to study the effect of Biozyme and fertility levels on photo-assimilatory surface, total chlorophyll content, yield components and yield and its economic feasibility in soybean (*Glycine max*).

MATERIALS AND METHODS

The experiment was conducted at Agronomy Research Block of R.K. (P.G.) College, Shamli, Uttar Praesh, India 247776, during rainy season of 2006, 2007 and 2008 at (20.6º N latitude, 77.15ºE longitude and 230.60 m altitude). The mean annual rainfall of the region is 858 mm, of which 80-90 % is normally received from June to September and rest is received

from few scattered rain showers during winter months from south-west monsoon. The soil was sandy loam having 7.4 pH. The soil was medium in organic carbon (0.5925) with available NPK status of 321.08, 10.98 and 142.30 kg/ha, respectively.

The twelve treatments consisted of recommended NPK (20 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha), half of recommended NPK, Biozyme granule @ 20, 30 and 40 kg/ha alone and along with half of recommended NPK, Biozyme crop$^+$ spray @200 and 400 ml/ha alone and along with half of recommended NPK were tested in Randomized Block Design with three replications. Biozyme granule was applied at the time of sowing where as, the Biozyme crop$^+$ spray was done at 30 days after sowing. The plant population of 0.4 millions/ha was maintained by thinning/gap filling the plants. The leaf area was measured using Automatic leaf Area Meter and the total chlorophyll content was determined by dimethyl sulfoxide (DMSO) method.

The nutrient harvest indices (NHI) for NPK were recorded as per the procedure developed by Chandel *et al.* (1989) using following formula;

$$\text{Nutrient Harvest Index (NHI)} = \frac{\text{Uptake of concerned nutrient in grain (kg/ha)}}{\text{Total uptake of nutrient (kg/ha)}} \times 100$$

However the physiological efficiency index (PEI) for NP and K were calculated as per the formula outlined by Isfan (1990) as follow;

$$\text{Physiological Efficiency Index (PEI)} = \frac{\text{Kilograms of grain produced}}{\text{Kilograms of targeted nutrient absorbed in above ground plant part}}$$

RESULTS AND DISCUSSION

Trifoliate leaves /plant

Number of trifoliate leaves/plant was significantly influenced due to Biozyme and NPK fertilization. Although the impact was not significant at 30 DAS but at 45 DAS it was observed maximum with 40 kg Biozyme granule + half of recommended NPK (17.26 leaves/plant) followed by recommended NPK (16.98 leaves/plant) Where as, at 60 DAS the same was noticed highest with Biozyme crop$^+$ spray 400ml/ha + half of recommended NPK (28.13 leaves /plant). At 60 DAS the plants enjoying 400ml /ha Biozyme crop$^+$ spray + half of recommended NPK maintained around 3.57 and 16.0 % higher number of trifoliate leaves over recommended and half of recommended NPK, respectively. The trifoliate leaves noticed against recommended NPK(27.16 leaves/plant), Biozyme granule 20 Kg + half recommended NPK (26.33 leaves/plant), Biozyme granule 30 Kg+ half recommended NPK(26.50 leaves/plant), Biozyme granule 40 Kg + half recommended NPK (26.96 leaves/plant) and Biozyme crop$^+$ spray 200 ml /ha +half recommended NPK (26.60 leaves/plant) were statistically on par to the Biozyme crop$^+$ spray 400 ml/ha + half of recommended NPK (Table 1).

Leaf area and Leaf Area Index

Leaf area and LAI recorded on pooled basis were greatly influenced by Biozyme and NPK fertilization (Table 1). The highest value of above cited parameters at 45 and 60 DAS, were noticed with Biozyme crop$^+$ spray @ 400 ml/ha done along with half of recommended NPK. However, the same recorded at 30 DAS were highest with Biozyme granule @ 40 kg/ha +half of recommended NPK. The plants receiving 400ml/ha Biozyme crop$^+$ spray + half of recommended NPK maintained 2.97 and 3.17 % higher leaf area per plant and leaf area index, respectively over the recommended NPK. The least value of above listed parameters was recorded with half of recommended NPK.

The combined application of Biozyme granule or Biozyme crop+ spray with half of recommended NPK had promotive effect on leaf area and LAI because the Biozyme application might enhanced the nodulation and root proliferation, which enabled the plants to mine more nutrients from deeper soil layers and from distant places in balanced proportion. The increased uptake of the nutrients, particularly those which are essential constituent of chlorophyll (Nitrogen, Sulfur, Iron, Magnesium) might increased the synthesis of chlorophyll and ultimately the plants were able to synthesize more photo-assimilates thus there was surplus availability of energy for creation of more number of leaves of bigger size. The results endorses the finding of Alizadeh *et al.,* (2004).

Total chlorophyll

The total content of chlorophyll was significantly influenced by Biozyme and NPK fertilization. The highest total chlorophyll at 30 DAS (1.685 mg/g leaf fresh weight) and at 45 DAS (2.095 mg/g leaf fresh weight) was noticed with Biozyme granule @40 kg/ha applied along with half of recommended NPK. Where as, at 60 DAS it was noticed highest (1.974 mg/g leaf fresh weight) in the plots receiving Biozyme crop$^+$ spray @ 400 ml/ha + half of recommended NPK. Higher performance of Biozyme granule in respect of total chlorophyll content at earlier sampling stages was perhaps because of its early time of application (Table-1). At 60 DAS, Biozyme crop$^+$ spray@ 400ml/ha done in conjunction with half of recommended NPK increased the total chlorophyll content by 4.4 and 16.13 % over recommended NPK and half of recommended NPK, respectively. The chlorophyll content recorded at 60 DAS against recommended NPK (1.891 mg/g leaf fresh weight), Biozyme granule 20 Kg/ha + half recommended NPK (1.904 mg/g leaf fresh weight), Biozyme granule 30 Kg+ half recommended NPK(1.958 mg/g leaf fresh weight), Biozyme granule 40 Kg + half recommended NPK (1.965 mg/g leaf fresh weight) and Biozyme crop$^+$ spray 200 ml /ha +half recommended NPK (1.897 mg/g leaf fresh weight) were statistically on par to the same re corded with Biozyme crop$^+$ spray 400 ml/ha + half of recommended NPK (Table 1).

The increased content of total chlorophyll was because of increased nodulation and root proliferation which resulted in to increased uptake of nutrients particularly nitrogen, sulphur, iron and magnesium which are required as a constituent for the synthesis of chlorophyll. Result endorses the finding of Arthur *et al.* (2003).

Yield attributes

Biozyme either granule or crop$^+$ spray done along with half of recommended NPK significantly improved the yield attributes of soybean *viz.*, number of branches, number of seeds /plant, 1000- seed weight and seed yield per plant (Table 2). Highest values for these parameters were recorded with Biozyme crop$^+$ spray @ 400 ml/ha done with half of recommended NPK, followed by Biozyme granule @ 40 kg/ha + half of recommended NPK, which registered its significant superiority over half of recommended NPK and pure treatments of the Biozyme. Highest number of branches/plant (66 branches/ plant), seeds/ pod (2.34) and seed yield /plant (14.59 g/plant) was observed with Biozyme crop$^+$ spray 400 ml/ha + half of recommended NPK. However highest number of seeds/plant (27.59 seeds) and 1000-seed weight (102.5 g) was noticed with application of 30 kg Biozyme granule + half of recommended NPK. Biozyme crop$^+$ spray @ 400 ml/ha done in conjunction of half of recommended NPK resulted 4.14 and 28.34 % higher per plant seed yield over recommended and half of recommended NPK, respectively (Table 2).

The enhancive effects of 'Biozyme' on yield attributes of soybean might was because, Biozyme being rich in cytokinin and auxin precursors and chelating enzymes, might had increased uptake of macro as well as micro nutrients in balanced proportion thus its application along with half of recommended NPK, increased the nodulation, root proliferation and their establishment and regulated the plant bio-physiological activities (increased chlorophyll content in leaf) leaf area and LAI. Thereby the plants were able to maintain higher photosynthetic activity/ efficiency even during later period of growth thus higher value of different yield attributes. The results are in corroboration of Zodape *et al.* (2009).

Yields and harvest index

Grain, straw and total biological yields and harvest index were significantly influenced by the application of Biozyme and NPK fertilization. Highest grain yield (2770 kg/ha) was recorded with Biozyme crop$^+$ spray @ 400ml/ha applied along with half of recommended NPK followed by Biozyme granule @ 30kg/ha +half of recommended NPK (2759 kg/ha). Biozyme crop$^+$ spray @ 400ml/ha + half of recommended NPK resulted in 8.54 % higher grain yield over recommended NPK. Highest straw (3267 kg/ha) and total biological yield (6038 kg/ha) also were recorded with Biozyme crop$^+$ spray @ 400ml/ha +half of recommended NPK. The plots receiving Biozyme crop$^+$ spray@ 400ml/ha + half of recommended NPK had 26.3 and 17.13 % higher straw and biological yields, respectively over recommended NPK. The yields under sole treatments of Biozyme were comparable to half of recommended NPK.

Increased straw and total biological yields might were largely attributed to the increased rate of photo-assimilate production. However increase in seed yield was largely attributed to the improved value of different yield attributes. Harvest index also was significantly influenced due to Biozyme and NPK fertilization, which was recorded highest with recommended NPK (0.496) followed by Biozyme granule @ 40kg /ha (0.487). Least value of harvest index (0.45) was registered under Biozyme granule @40 kg/ha applied with half of recommended NPK (Table 3). Relatively lower value of harvest index under Biozyme treated plots was because of higher proportion of biomass production. The result is in corroboration of the finding of Zodape *et al.* (2008).

Nutrient uptake

The uptake of nitrogen, phosphorus and potassium in grain, straw as well as total uptake were significantly influenced by Biozyme and NPK fertilization. The highest value of total nitrogen (192.23 kg N) and phosphorus (19.59 kg P) uptake were recorded under Biozyme spray 400ml/ha + half of recommended NPK. However, highest potassium uptake (53.33 kg K) was recorded under plots receiving 40 kg Biozyme granule +half of recommended NPK. The nitrogen and phosphorus uptake recorded with Biozyme spray 400ml/ha+ half of recommended NPK was 12.17 and 4.59 % higher than the same recorded under recommended control. Where as, total potassium uptake noticed with 40kg/ha Biozyme granule + half of recommended NPK were 2.79 % higher over recommended control. The NPK uptake noticed with sole treatments of Biozyme were comparable to half of recommended NPK. Similar results were for uptake of NPK in grain and straw as well. The combined application of Biozyme granule or spray with half of recommended NPK might promoted root proliferation and their establishments. Thus the plants were able to mine more nutrients even from deeper horizons and from far away places (Auderset *et al*., 2001).

Nutrient Harvest Index (NHI) and Physiological Efficiency Index (PEI)

Although the nutrient harvest index which is indication of percent of nutrient assimilated in grain out of total quantity of nutrient absorbed in above ground plant parts, were not influenced significantly due to Biozyme. But the highest value of nutrient harvest index for nitrogen (81.10%) was recorded with Biozyme crop spray 200ml/ha. Whereas, the highest value for phosphorus harvest index (68.89%) and potassium harvest index (57.73%) was recorded with half of recommended NPK. The physiological efficiency index, which is kilograms of grain produced per kg uptake of targeted nutrient, was influenced significantly by different treatments. Highest physiological efficiency index for nitrogen (15.22 kg/kg N) was observed under Biozyme granule 40kg/ha. However highest value of physiological efficiency index for phosphorus [PEIP (152.75kg/kg P)} and PEIK (57.65kg/kgK] were noticed with Biozyme spray 400ml/ha. Higher NPK harvest index under Biozyme sole plots might was attributed to highly mobile nature of NPK in side plant system. In the conditions when these nutrients were deficient *ie.* Half of recommended NPK or Biozyme sole, most of it might were mobilized towards grain to meet the plants bio-physiological demands resulting higher nutrient harvest index for NPK. Where as, higher physiological efficiency index for nitrogen, phosphorus and potassium with Biozyme treatment were accounted for maintaining better physiological activities and yield at least expanse of nutrients. The result corroborate the finding of Isfan, (1990) and Auderset *et al*. (2001).

Table 1. Effect of Biozyme and fertility levels on number of trifoliate leaves, leaf area, leaf area index and total chlorophyll content of soybean *cv.* PK 1042 (Pooled data of three years)

Treatment	Trifoliate leaves /plant			Leaf area (cm^2 /plant)			Leaf Area Index			Total chlorophyll (mg/g leaf fresh weight)		
	30DAS	45DAS	60DAS	30DAS	45DAS	60DAS	30DAS	45DAS	60DAS	30DAS	45DAS	60DAS
Recommended NPK(20 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha)	6.33	16.98	27.16	331.66	1023.6	1761.8	1.105	3.445	5.764	1.648	1.911	1.891
Half of recommendsed NPK	5.66	16.16	24.29	317.00	966.6	1631.9	1.056	3.221	5.296	1.531	1.742	1.704
Biozyme granule@20kg/ha	5.49	14.90	23.69	284.52	949.3	1629.0	1.024	3.164	5.214	1.565	1.759	1.768
Biozyme granule @30kg/ha	5.84	15.16	23.86	286.66	1013.3	164.3	1.040	3.377	5.330	1.578	1.792	1.784
Biozyme granule@40kg/ha	6.03	15.23	24.19	301.06	1040.0	1648.6	1.085	3.466	5.495	1.578	1.799	1.787
Biozyme granule @20kg/ha+half of recommended NPK	5.99	16.26	26.33	326.66	1022.6	1747.9	1.088	3.408	5.859	1.652	1.996	1.904
Biozyme granule@30kg/ha+half of recommended NPK	6.14	16.93	26.58	327.67	1038.3	1766.4	1.092	3.461	5.871	1.656	2.009	1.958
Biozyme granule@40kg/ha+half of recommended NPK	6.44	17.26	26.96	333.33	1048.3	1811.3	1.110	3.560	5.934	1.685	2.095	1.965
Biozyme crop$^+$spray@200ml/ha	5.23	14.93	23.83	289.48	953.3	1634.8	1.012	3.177	5.301	1.464	1.756	1.768
Biozyme crop$^+$Spray@400ml/ha	5.33	15.58	24.19	292.69	1046.3	1656.1	1.030	3.487	5.434	1.465	1.769	1.788
Biozyme crop$^+$spray@200ml/ha+half of recommended NPK	6.13	16.76	26.60	321.16	1037.0	1750.3	1.070	3.418	5.767	1.531	1.996	1.897
Biozyme crop$^+$spray@400ml/ha+half of recommended NPK	6.23	16.96	28.13	327.83	1054.6	1814.2	1.092	3.595	5.945	1.532	1.997	1.974
C D (P=0.05)	NS	2.14	3.64	45.70	83.4	135.9	0.157	0.310	0.405	0.097	0.142	0.134

*N.S. = Non significant

Table 2. Effect of Biozyme and fertility levels on yield components and yield of soybean *cv.* PK 1042 (Pooled data of three years)

Treatment	Branches/plant	Pods/ plant	Seeds/ pod	Seeds/ plant	1000-seed weight (g)	Seed yield/ plant (g)	Biological yield (Kg/ha)	Grain yield (Kg/ha)	Straw yield (Kg/ha)	Harvest index
Recommended NPK(20 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha)	6.11	85.00	2.22	190.41	102.0	14.20	5147	2552	2584	0.496
Half of recommended NPK	5.11	65.66	2.11	138.89	94.0	11.36	4693	2099	2494	0.447
Biozyme granule@20kg/ha	4.88	61.00	2.05	125.62	93.3	11.24	4596	2168	2428	0.472
Biozyme granule @30kg/ha	5.33	63.33	2.06	130.70	93.9	11.76	4886	2192	2644	0.449
Biozyme granule@40kg/ha	5.44	65.66	2.11	138.78	94.0	11.78	4844	2359	2649	0.487
Biozyme granule @20kg/ha + half recommended NPK	6.22	84.00	2.23	184.90	100.6	13.80	5448	2582	2841	0.474
Biozyme granule@30kg/ha + half of recommended NPK	6.33	85.33	2.24	217.39	102.5	14.48	5737	2759	2978	0.481
Biozyme granule@40kg/ha + half of recommended NPK	6.66	89.33	2.25	202.65	100.9	13.29	5785	2605	3180	0.450
Biozyme crop$^+$ spray @ 200ml/ha	4.99	60.66	2.06	125.44	94.0	11.07	4794	2216	2578	0.462
Biozyme crop$^+$ spray @ 400ml/ha	5.55	66.66	2.11	141.02	94.4	11.86	4957	2380	2627	0.480
Biozyme crop$^+$ spray @200ml/ha + half of recommended NPK	6.33	84.33	2.26	189.09	99.9	13.89	5.740	2676	3064	0.466
Biozyme crop$^+$ spray @400ml/ha + half of recommended NPK	6.66	90.33	2.34	214.99	100.8	14.59	6038	2770	3267	0.459
C D (P=0.05)	1.13	16.83	N.S.	53.16	6.10	2.11	711	281	388	0.038

Table 3. Effect of Biozyme and fertility levels on NPK uptake in soybean *cv.* PK 1042 (Pooled over three years)

Treatment	N uptake (Kg/ha)			P uptake (Kg P/ha)			K uptake (Kg K/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Recommended NPK (20kg N: 26.4kg P: 33.2kg K/ha)	138.98	32.38	171.36	12.49	6.24	18.73	29.10	22.78	51.88
Half recommended NPK	114.59	29.99	144.58	11.12	5.02	16.14	21.64	18.63	40.27
Biozyme granule@20kg/ha	113.97	28.93	142.90	10.03	5.20	15.23	22.21	18.50	40.01
Biozyme granule@30 kg/ha	115.35	31.81	147.16	10.50	5.66	16.16	22.24	18.77	41.01
Biozyme granule@40kg/ha	126.99	30.33	157.32	10.55	5.30	15.85	22.42	19.63	42.05
Biozyme granule@20kg/ha+half recommended NPK	140.66	33.60	174.26	12.37	6.19	18.56	28.96	22.07	51.03
Biozyme granule@30kg/ha+half recommended NPK	144.12	37.12	181.24	12.60	6.25	18.85	29.67	22.93	52.60
Biozyme granule@40kg/ha+half recommended NPK	143.09	40.57	183.66	12.97	6.60	19.57	29.40	23.38	53.33
Biozyme crop+ spray@200ml/ha	116.67	30.33	147.00	9.83	5.32	15.15	21.93	17.66	39.59
Biozyme crop+spray@400ml/ha	130.75	30.60	161.35	10.31	5.27	15.58	22.36	18.92	41.28
Biozyme crop+ spray @200ml/ha+half recommended NPK	146.26	38.59	184.85	12.27	6.51	18.78	24.04	21.50	46.44
Biozyme crop+spray@400ml/ha+half recommended NPK	152.91	39.32	192.23	12.98	6.61	19.59	29.90	23.23	53.13
C D (P= 0,05)	12.63	9.43	28.47	1.67	0.98	1.98	2.64	1.94	3.42

*N.S. = Non significant

Table 4. Effect of Biozyme and fertility levels on nutrient harvest and physiological efficiency index of soybean *cv.* PK 1042 (Pooled data of three years)

Treatment	Nutrient Harvest Index (NHI) (% nutrient in grain of total uptake)			Physiological efficiency index (PEI) (Kg grain / kg nutrient absorbed)		
	N	P	K	N	P	K
Recommended NPK (20kg N: 26.4kg P: 33.2kg K/ha)	81.00	66.68	56.09	14.89	136.25	49.19
Half recommended NPK	79.25	68.89	57.73	14.51	130.04	52.12
Biozyme granule@20kg/ha	79.75	65.85	54.55	15.17	142.35	53.25
Biozyme granule@30 kg/ha	78.38	64.97	54.23	14.89	135.64	53.45
Biozyme granule@40kg/ha	80.72	66.56	53.31	15.22	151.10	56.95
Biozyme granule@20kg/ha+half recommended NPK	80.71	66.61	56.75	14.81	139.11	50.59
Biozyme granule@30kg/ha+half recommended NPK	79.51	66.84	56.40	15.20	146.36	52.45
Biozyme granule@40kg/ha+half recommended NPK	77.91	66.27	55.12	14.18	133.11	48.84
Biozyme crop^{+} spray@200ml/ha	81.10	64.88	55.39	15.07	146.27	55.97
Biozyme crop^{+}spray@400ml/ha	81.03	66.17	54.16	14.75	152.75	57.65
Biozyme crop^{+} spray @200ml/ha+half recommended NPK	79.12	65.33	53.70	14.47	142.49	57.62
Biozyme crop^{+}spray@400ml/ha+half recommended NPK	79.54	66.25	56.27	14.40	141.39	52.13
C D (P= 0,05)	NS	NS	NS	0.96	11.46	4.69

*N.S. = Non significant

Table 5. Effect of Biozyme and fertility levels on economics of soybean *cv.* PK 1042 (Mean of three years)

Treatment	Gross return (₹ /ha)	Cost of cultivation (₹ /ha)	Net return (₹ /ha)	B: C ratio
Recommended NPK(20 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha)	52031	23080	28951	1.25
Half of recommendsed NPK	37173	21228	15945	0.75
Biozyme granule@20kg/ha	41818	20255	21563	1.06
Biozyme granule @30kg/ha	41625	20825	20797	0.99
Biozyme granule@40kg/ha	43683	21398	22285	1.04
Biozyme granule @20kg/ha + half recommended NPK	50641	22370	28271	1.26
Biozyme granule@30kg/ha + half of recommended NPK	53312	22940	30372	1.32
Biozyme granule@40kg/ha + half of recommended NPK	54425	23513	30912	1.31
Biozyme crop^{+} spray @ 200ml/ha	41902	19383	22519	1.16
Biozyme crop^{+} spray @ 400ml/ha	43964	19650	24314	1.23
Biozyme crop^{+} spray @200ml/ha + half of recommended NPK	51754	21497	30257	1.40
Biozyme crop^{+} spray @400ml/ha + half of recommended NPK	55650	21765	33885	1.55

Economics

The data on economic aspect presented in table 3 reveal that the cost of cultivation was higher with Biozyme granule 40 kg/ha + half of recommended NPK(₹ /ha 23515.00) followed by recommended NPK(₹ /ha 23080.00) owing to the higher cost of Biozyme granule and higher requirement of NPK, respectively. Different treatments showed differential gross, net returns and B:C ratio (Table 3). Highest gross(₹ 55650/ha), net return (₹ 33885.00/ha) and B:C ratio (1.55) was noticed with Biozyme crop+ spray 400 ml/ha + half of recommended NPK. The higher gross and net return was attributed to relatively higher yield obtained. Whereas, Highest B:C ratio was attributed to relatively low cost of cultivation (₹ 21765.00/ha) and higher net return (₹ 33885.00/ha) with Biozyme crop^{+} spray 400 ml/ha + half of recommended NPK. The plots receiving 400 ml Biozyme crop^{+} spray + half of recommended NPK resulted ₹ 4934.00 /ha additional net return over recommended NPK. The profit incurred under 400 ml Biozyme crop^{+} spray + half of recommended NPK was 17.04 % higher than the same with recommended NPK (Table 3).

Biozyme granule @40kg /ha or Biozyme crop^{+} spray 400ml /ha applied along with half of recommended NPK produced higher yields as well as gross and net return over recommended NPK. Therefore, in the present scenario of rising cost of fertilizers and food contaminations due to excessive use of fertilizers, the Biozyme application may be proved a problem coping strategy, can cut half of our fertilizer requirement. Thus would help in reducing our dependence on the chemical fertilizers.

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