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Effect of Vermicompost, Municipal Compost and Inorganic Fertilization on Growth Attributes on Plant Growth of Wet Season Rice

Labani Sarkar [a++*], Asanul Hoque [a++] and Sukanta Pal [b#]

[a] Department of Agronomy, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal-736165, India.
[b] Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal-741252, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted during the wet season (kharif) of 2020 at the Regional Research Sub-Station (RRSS), BCKV, Chakdaha, West Bengal, Indiato study the growth parameters with the application of Chemical fertilizers, Vermicompostand Municipal compost; to find out the comparative effect of organic and inorganic fertilizers on the growth of rice and to study the economics assessment of the experiments.Design of the experiment was Randomized Block Design (RBD) with six treatment combinations replicated four. The treatments were T_1= 100% Recommended Dose of Fertilizer (RDF) (N: P_2O_5: K_2O @ 60:30:30 kg ha^{-1}), T_2= 100% N from

[++] Ph.D Research Scholar;
[#] Professor;
**Corresponding author;*
E-mail: labaniagri19@gmail.com;

Vermicompost @ 3.75 t ha^{-1}, T_3= 100%N from Municipal Compost @ 3.75 t ha^{-1}, T_4= 50% N (from inorganic source) + 50% N (from Vermicompost), T_5= 50% N (from inorganic source) + 50% N (from Municipal Compost), T_6= Control (no fertilizer and no compost). Almost in all cases the growth parameters varied significantly. The plant height increases with the advancement of date and attains significantly high plant height in T_1 treatment (56.60 cm at 30 DAT and 89.25cm at 60 DAT respectively) but at 90 DAT highest plant height attained inT_4treatment (108.60 cm). Maximum significant number of tillers was found at T_1 treatment (15.20 and 16.20 at 60 and 90 DAT respectively). Regarding Dry Matter Production significantly highest dry matter was observed at 60 DAT (335.50g m^{-2}) in both T_1 and T_4treatment. At 30 DAT and 90 DAT it was observed highest in T_4treatment (151.20 and 440.60g m^{-2} respectively). Similar trend was also observed in case of Crop Growth Rate (CGR). LAI was highest in T_1 treatment followed by T_4 treatment in all the 3 dates. Therefore, it may be concluded that 50% organic manure with vermicompost or municipal compost were economical, which improves the soil characteristics.

Keywords: Organic fertilization; organo-mineral fertilization; dry matter production; leaf area index; crop growth rate.

1. INTRODUCTION

The high cost of fertilizers, unstable crop production and harmful effects towards environment call for substituting part of the inorganic fertilizers by locally available low cost organic sources in an integrated manner for sustainable crop production. Vermicompost hastens the decomposition process of on-farm waste to produce quality compost through physical breakdown of the raw biomass coupled with mixing of vast spectrum of microbes with the biomass while passing through earthworm gut. It contains most nutrients in plant available forms, improves the texture and structure of soil and increases plant and leaf growth and root length. Its application was found to improve crop growth & yield of rice [1-5]. Wastes come out from our homes, schools, hospitals and businesses but it excludes industrial, hazardous and constructional wastes, is called Municipal waste. It can restore saline and alkaline soils to fertility, improves soil physical property and can promote plant growth. The present study determines effect of Vermicompost, Municipal Compost and Inorganic Fertilization on growth attributes on plant growth of Wet Season Rice.

2. MATERIALS AND METHODS

The field experiment was conducted at Regional Research Sub-Station (RRSS), Chakdaha, Nadia under Bidhan Chandra KrishiViswavidyalaya, Mohanpur, West Bengal, which is situated at 23^0 5.3'N latitude and$83^0$5.3'E longitude and at an elevation of 9.75 meters above the mean sea level (MSL) in the new alluvial zone (NAZ) of West Bengal in *kharif* 2020.

Table 1. The initial physico-chemical properties of the experimental soil (0-15 cm soil depth)

Sl. No.	Particulars	Result	Analytical method employed
1.	Mechanical composition		Bouyounces hydrometer method (Piper, 1950)
	Sand (%)	46.50	
	Silt (%)	25.00	
	Clay (%)	28.50	
2.	Soil texture	Sandy clay loam	USDA system (Brady, 1950)
3.	Electrical conductivity or EC (dSm^{-1})	0.61	Conductivity bridge method
4.	Soil pH (in 1:2.5 soil water suspension)	7.05	Beckman's pH meter method (Jackson, 1973)
5.	Organic carbon (%)	0.68	Walkey and Black's rapid titration method (Jackson, 1973)
6.	Total N (%)	0.052	Macro-kjeldahl method (Jackson, 1973)
7.	Available P (kg ha^{-1})	16.00	Olsen's method (Black, 1965)
8.	Available K (kg ha^{-1})	129.00	Ammonium acetate method (Jackson, 1973)

Table 2. History of previous cropping

Year	Pre-kharif season	Kharif season	Rabi season
2015-2016	Sesamum	Rice	Rice
2016-2017	Mustard	Rice	Rice
2017-2018	Lathyrus	Rice	Rice
2018-2019	Mustard	Rice	Rice
2019-2020	Lentil	Rice	Rice

Table 3. Details of the experiment

Crop growing season	Kharif 2020
Design of the experiment	Randomized Block Design (RBD)
Number of replications	Four
Number of treatments	Six
Number of varieties	One, i.e., Satabdi (IET 4786)
Total number of plots	Twenty four
Plot size	5 m x 4 m
Spacing	20 cm x 15 cm
Recommended dose of fertilizers (RDF)	60:30:30 Kg N:P_2O_5:K_2O ha^{-1}
Dose of Vermicompost	3.75 t ha^{-1}
Dose of municipal compost	3.75 t ha^{-1}

Table 4. Treatment details of the experiment

Treatments	Details
T_1	100% NPK, i.e, 60: 30: 30 Kg N:P_2O_5:K_2O ha^{-1}
T_2	100% N from Vermicompost
T_3	100%N from Municipal Compost
T_4	50% N (inorganic source) + 50% N (from Vermicompost)
T_5	50% N (inorganic source) + 50% N (from Municipal Compost)
T_6	Control (no fertilizer and no compost)

2.1 Agronomic Management Followed in the Experiment

Table 5. Application of organic and inorganic fertilizer in the seed bed

Organic/ Inorganic fertilizer	Amount (kg 100 m^{-2})		
	Before seed sowing	15 days after sowing	7 days before seedling uprooting
FYM	200.0	-	-
Urea	1.5	1.5	0.5
SSP	4.0	-	-
MOP	1.0	-	-

Table 6. Pre-harvest observations for different parameters

Sl. No.	Parameters	Time of observation
1.	Plant height	30, 60 And 90 DAT
2.	Number of tillers m^{-2}	30, 60 And 90 DAT
3.	Dry matter productiom (g m^{-2})	30, 60 And 90 DAT
4.	Leaf Area Index (LAI)	30, 60 And 90 DAT
5.	Crop Growth Rate(g m^{-1} day^{-1})	30, 60 And 90 DAT

2.2 Methods of Calculating Growth Attribute

2.2.1 Plant height

Ten randomly selected plants were taken in each individual plot and their heights were taken manually. Then average height was calculated. A total of three observations were taken at 30, 60 and 90 DAT.

2.2.2 Number of tillers per hill

Four hills were selected randomly from each plot and tillers were counted at 30, 60 and 90 DAT. From the observations, average number of tillers $hill^{-1}$ was calculated.

2.2.3 Dry matter production

To determine the dry matter accumulation, plant samples were collected from each plot at 30, 60 and 90 DAT. Samples were cut at the ground level by using sickle. After that, leaves and stems were separated and put in paper packets with proper labeling to identify the individual plots. Then they were over dried at 70^{o}C for 12 hours and their dry weights were measured. After that, the dry matter accumulation m^{-2} was calculated [6-10].

2.2.4 Leaf Area Index

Ten samples of green leaf lamina from four hills of each plot were separated, a rectangular bit of 10 cm length were cut from ten leaves. Leaf weights were taken from middle portion of leaf having more or less similar, breadth, width of each cut leaf was measured. After that, the whole amount of the area-weight relationship was calculated. By using the relationship, leaf area of the leaf samples were measured.

Leaf Area Index (LAI) is the area of leaf surface per unit area on land surface. It can be calculated for each treatment and each plot at different growth stages. Leaf Area Index (LAI) was calculated from area-weight relationship using the formula given by Watson (1958).

$$LAI = \frac{\text{Leaf area of plants in unit area } (cm^2)}{\text{Ground surface in unit area } (cm^2)}$$

2.2.5 Crop growth rate

Each and every time, one hill was collected randomly from each plot. Then the crop growth rate was recorded on dry weight basis. It is calculated using the following formula:

$$CGR = \frac{W_2 - W_1}{P\,(t_2 - t_1)}$$

Where,

$W_1$and W_2- Whole plant dry weight at time t_1 and t_2 respectively
P- Ground area occupied by the plant (m^2)
t_1 and t_2- Time interval in days

3. RESULTS AND DISCUSSION

3.1 Plant Height

The plant heights of the different dates of transplanting were significantly differed among the different treatment combinations and also with the different dates of transplanting except at early growth stages of plant growth. The plant height ranges from 50.00 cm to 56.60 cm, 70.25 cm to 89.25 cm and 95.20 cm to 108.60 cm at 30 DAT, 60 DAT and 90 DAT respectively (Table 7) [11-15]. At 60 DAT plant height attains maximum (89.25) in the treatment T_1 i.e., 100% recommended doses of fertilizer which was at par with T_4 (50% RDN + 50 % N from vermicompost) and T_5 (50% RDN + 50 % N from Municipal compost) respectively. The plant height at 30 and 60 DAT in T_1, T_4 and T_5 treatment were 56.60, 56.03, 55.19 and 89.25, 86.50, 85.62 respectively. Mahmud et al. (2016) stated that the chemical fertilizer had a significant effect on plant height. The trend of increase of plant height is more in the peak crop growth stage i.e., 60-90 DATthan 30-60 DAT. The maximum plant height 108.60 cm was attained with the application of 50% chemical fertilizer along with the application of 50% organic nitrogen from vermicompost source i.e. the T_4 treatment at 90 DAT because organic along with chemical fertilizers increases the plant height due to the increase in absorption of available plant nutrient. Similar observation also reported by Sultana et al. (2021). In all the three dates, lowest plant height was observed in the control plot (treatment T_6) where no chemical fertilizer or organic compost was used.

3.2 Number of Tillers per Hill

The number of tillers $hill^{-1}$ differs significantly among the different dates of transplanting. Though the initial crop growth stage i.e. 30 DAT, did not differ significantly. The number of tillers $hill^{-1}$ ranges from 5.20 to 6.95 in control treatment and the treatment receiving 100% nitrogen from vermicompost i.e. treatment T_2 in 30 DAT. But the maximum numbers of tillers $hill^{-1}$ were 15.20 and 16.20 respectively in the treatment T_1 (Table 7) in 60 and 90 DAT respectively. The trend of increment in number of tillers $hill^{-1}$ is with the advancement of the crop growthstage [16-18]. Singh and Bharadwaj (2007) stated the similar observation as is found in their field study. During 60 DAT the range of number oftillers $hill^{-1}$ significantly varied among the different treatment combinations and it ranges from 10.30 in control treatment (T_6) to 15.20 in 100% RDF application i.e. treatment T_1. Similar observation was also recorded in 90 DAT though the rate of increment is bit slower than 30 DAT to 60 DAT (Table 8).

Table 7. Effect of vermicompost and municipal compost integrated with inorganic fertilizer on plant height (cm) of wet season rice

Treatment	Plant height (cm)		
	30 DAT	60 DAT	90 DAT
T_1	56.60	89.25	108.55
T_2	52.45	71.76	102.34
T_3	50.20	74.20	100.05
T_4	56.03	86.50	108.60
T_5	55.19	85.62	103.20
T_6	50.00	70.25	95.20
S.Em (±)	**3.213**	**4.197**	**2.250**
CD (P=0.05)	**NS**	**12.651**	**6.782**

(T_1= 100% RDF, T_2= 100% N from Vermicompost, T_3= 100%N from Municipal Compost, T_4= 50% N (inorganic source) + 50% N (from Vermicompost), T_5= 50% N (inorganic source) + 50% N (from Municipal Compost), T_6= Control (no fertilizer and no compost)

Application of vermicompost improves the micronutrient level of soil this has significant role in plant root development. So, the nutrient uptake is increased which helps to grow more tillers hill^{-1}.

3.3 Dry Matter Production

Dry matter production varied significantly among the different dates of transplanting. However, maximum dry matter production was with the application of the treatment receiving 50% N from inorganic source along with 50% N from vermicompost (T_4) in all the three dates of observation. Dry matter production ranges from control treatment to T_4 was 98.50 to 151.20, 220.30 to 335.50 and 305.20 to 440.60 g m^{-2} at 30, 60 and 90 DAT respectively (Table 9). Percentage increase in the treatment T_4 i.e.50% N (inorganic source) + 50% N (from Vermicompost) over control at 30 DAT, 60 DAT and 90 DAT were 53.30, 52.29 and 44.36 respectively. The increment of dry matter production was more during the early crop growth stages than the later stages. Dry matter production increased with the application of 50% inorganic along with the 50% organic either vermicompost or municipal compost. Similar observation was also reported by (Ghosh et al. 1994). In all the three dates of observations (30, 60 and 90 DAT) T_4 and T_5 i.e. 50% of RDN along with 50% either vermicompost or municipal compost were at par. But in all cases T_4 i.e. 50% nitrogen from vermicompost along with 50% RDN showed maximum response in dry matter production as we know thatvermicompost contains a combination of macro and micro-nutrients and the uptake of the nutrients has a positive effect on plant nutrition, growth, photosynthesis and chlorophyll content of the leaves which leads to a proper growth of a plant, as result we get high dry matter accumulation of plant.

3.4 Leaf Area Index

Leaf area index (LAI) varied significantly among the different treatments in all the dates of transplanting (Table 10). Though in early growth stages i.e. 30 DAT it was not significant, during peak growth period i.e. 60 DAT, leaf area index (3.85) was significantly recorded maximum in T_1 treatment where 100% recommended dose of

Table 8. Effect of vermicompost, municipal compost and inorganic fertilization on number of tillers hill^{-1}of wet season rice

Treatment	Number of tillers hill^{-1}		
	30 DAT	60 DAT	90 DAT
T_1	6.70	15.20	16.20
T_2	6.95	12.30	14.00
T_3	6.90	11.30	13.20
T_4	6.50	14.50	15.20
T_5	5.70	13.95	14.26
T_6	5.20	10.30	10.20
S.Em (±)	**0.451**	**1.059**	**1.026**
CD (P=0.05)	**NS**	**3.192**	**3.093**

(T_1= 100% RDF, T_2= 100% N from Vermicompost, T_3= 100%N from Municipal Compost, T_4= 50% N (inorganic source) + 50% N (from Vermicompost), T_5= 50% N (inorganic source) + 50% N (from Municipal Compost), T_6= Control (no fertilizer and no compost)

Table 9. Effect of vermicompost, municipal compost and inorganic fertilization on dry matter production of wet season rice

Treatment	Dry Matter Production (g m^{-2})		
	30 DAT	**60 DAT**	**90 DAT**
T_1	148.60	335.50	438.20
T_2	138.25	298.20	330.40
T_3	132.02	302.50	315.50
T_4	151.20	335.50	440.60
T_5	139.40	320.50	395.05
T_6	98.50	220.30	305.20
S.Em (±)	**9.718**	**20.400**	**30.854**
CD (P=0.05)	**29.293**	**61.492**	**93.004**

(T_1= 100% RDF, T_2= 100% N from Vermicompost, T_3= 100%N from Municipal Compost, T_4= 50% N (inorganic source) + 50% N (from Vermicompost), T_5= 50% N (inorganic source) + 50% N (from Municipal Compost), T_6= Control (no fertilizer and no compost)

chemical fertilizer was applied followed by T_4 (3.68) where 50% chemical fertilizer along with 50% nitrogen from vermicompost was applied. At both 30 and 60 DAT also maximum leaf area index were in T_1 treatment (2.15 and 3.85 respectively) followed by T_4 treatment (2.11 and 3.68 respectively). Minimum leaf area index was attained in control treatment where there was no application of any nutrients. Murthy et al. reported during his study on (1991) that leaf area index was attained its peak at early growth stages. As the growth increases the leaf area index gradually decreases as it enters into the sensitive stages. The increment of leaf area index on 60 DAT and 90 DAT was not wider. However highest leaf area index was attained 3.90 at 90 DAT in T_1 treatment followed by 3.70 in T_4 treatment where 50% chemical fertilizer along with 50% nitrogen from vermicompost was applied which contain some kinds of Phytohormones which play an important role in inducing and enhancing various physiological activities in the plant like they have a significant role in proper leave development of the crop, as a result increasing the process of transpiration which also induces stem and internode elongation, increasing leave size and shape as well. Roul et al. (2007) in his field study also reported that leaf area index was maximum during the application of recommended doses of chemical fertilizer.

3.5 Crop Growth Rate (g m^{-1} day^{-1})

Crop growth rate was also significantly differs among the three dates of transplanting like dry matter accumulation. However, the ranges among the treatments were 3.00 to 4.10 at 0-30 DAT, 9.05 to 15.53 at 31-60 DAT and 9.04 to 13.11 at 61-90 DAT respectively. The percentage increase over control to the maximum crop growth rate in three respective dates of transplanting was 36.67, 71.60 and 45.02 respectively. As dates advances from transplanting to harvesting the CGR increases upto 31-60 DAT and then showed declining trend as found in dry matter production. Maximum crop growth rate was recorded during the peak crop growth. From the Table 11, it has been found that T_4 i.e. 50% N from inorganic source + 50% RDN from vermicompost applied plot showed better result. In all the three dates T_4 treatment gave highest crop growth rate (4.10,15.53 and 13.11 at 0-30, 31-60 and 61-90 DAT respectively). Borah et al. (2016) also reported that combined effect of inorganic along with organic either in the form of vermicompost or FYM leads to more all the growth parameters as height of the plant, leaf area index, higher dry matter production, crop growth rate and also yield parameters which ultimately reflected the higher grain production. Organic matters like compost containing plant growth regulators are known to create effect on physiological and biochemical processes of plant. These include dormancy, organ size, crop development, flowering and fruit set, regulations of chemical composition of plants and control immobilisation which directly influences the plant growth that cause a huge impact on crop growth rate [19,20].

Table 10. Effect of vermicompost, municipal compost and inorganic fertilization on leaf area index (LAI) of wet season rice

Treatment	Leaf Area Index (LAI)		
	30 DAT	**60 DAT**	**90 DAT**
T_1	2.15	3.85	3.90
T_2	1.82	3.58	3.60
T_3	1.80	3.45	3.48
T_4	2.11	3.68	3.70
T_5	2.05	3.60	3.65
T_6	1.49	2.05	2.20
S.Em (±)	**0.258**	**0.357**	**0.331**
CD (P=0.05)	**NS**	**1.076**	**0.998**

(T_1= 100% RDF, T_2= 100% N from Vermicompost, T_3= 100%N from Municipal Compost, T_4= 50% N (inorganic source) + 50% N (from Vermicompost), T_5= 50% N (inorganic source) + 50% N (from Municipal Compost), T_6= Control (no fertilizer and no compost)

Table 11. Effect of vermicompost, municipal compost and inorganic fertilization on crop growth rate of wet season rice

Treatment	Crop Growth Rate (g m^{-1} day^{-1})		
	0-30 DAT	**31-60DAT**	**61-90DAT**
T_1	3.80	14.13	13.10
T_2	3.10	10.15	10.40
T_3	3.00	10.00	10.30
T_4	4.10	15.53	13.11
T_5	3.60	11.15	11.00
T_6	3.00	9.05	9.04
S.Em (±)	**0.009**	**0.01**	**0.141**
CD (P=0.05)	**0.026**	**0.300**	**0.402**

(T_1= 100% RDF, T_2= 100% N from Vermicompost, T_3= 100%N from Municipal Compost, T_4= 50% N (inorganic source) + 50% N (from Vermicompost), T_5= 50% N (inorganic source) + 50% N (from Municipal Compost), T_6= Control (no fertilizer and no compost)

4. CONCLUSION

The experiment was carried out using different level of chemical fertilizer and organic manures (vermicompost and municipal compost) to figure out if the using of organic manures (vermicompost and municipal compost) is economical or not as compared to the chemical fertilizers.

All the growth parameters such as plant height, number of tillers, leaf area index, dry matter production were observed maximum with the application of 100% recommended doses (60:30:30 Kg $N:P_2O_5:K_2O$ ha^{-1}) of chemical fertilizers followed by the 50% application of nitrogen from vermicompost along with 50% nitrogen from chemical fertilizers.

Among both the two organics – Vermicompost and Municipal compost applied in addition to chemical fertilizers were recorded much improved and positive effect over the control treatment.

Application of organic manures in addition to chemical fertilizers improves all the soil quality parameters resulting the uptake of others nutrients preferably micronutrients to the plants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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