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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 321-325

www.thepharmajournal.com
Received: 08-07-2022
Accepted: 13-08-2022

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Effect of organic, inorganic and integrated nutrient amendments on growth parameters of basmati rice (*Oryza sativa* L.)

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Abstract
A two year field experiment on basmati rice was conducted to investigate the impact of various organic, inorganic and integrated nutrient amendments on growth parameters i.e. plant height, leaf area index (LAI), leaf dry weight, shoot dry weight and total dry matter (TDM). Basmati rice was grown in completely randomized block design with four replications for each treatment. Six treatments i.e. T1 [100 kg N through green manure (GM) + 25kg N ha^{-1} through vermicompost (VC)]; T2 [50% N GM + Beejamrit + Ghanjeevamrit @ 250 kg ha^{-1} + Jeevamrit @ 500 L ha^{-1}/time]; T3 [50% NPK GM + 50% chemical fertilizer]; T4 [25% nutrients through organic + 25% nutrients through inorganic sources + Beejamrit + Ghanjeevamrit @250 kg ha^{-1} + Jeevamrit @500 L ha^{-1}/time]; T5 [Recommended doses of NPK (120:60:40) kg ha^{-1}]; T6 [Recommended doses of NPK (120:60:40) kg ha^{-1} + Farm yard manure (FYM) @ 5 t ha^{-1}] were applied. The results revealed that maximum plant height, LAI, leaf dry weight, shoot dry weight and total dry matter (TDM) was in T3 which was at par with T5. The values of all the growth parameters were lowest in organic treatments T2.

Keywords: Basmati rice, leaf area index, Beejamrit, Ghanjeevamrit, Jeevamrit, farm yard manure

Introduction
Basmati rice, also referred to as "scented pearls," is only grown on the Indian subcontinent for about 250 years. Pakistan, Haryana, Punjab, and western UP have optimal soil and weather conditions for expressing aroma and other qualitative properties. The export of basmati rice generates substantial amount of income. India is the largest producer and exporter of basmati rice and produces 75% of it consumed worldwide (Lorieux *et al*., 1996; Singh and Singh, 2009; Mahajan *et al*., 2018) [7, 14, 9].

Nutrient management in rice is of pivotal importance to achieve sustainability in production. Imbalanced use of fertilizers results in stagnant yields and leads to deteriorated soil health (Rao *et al*., 2013) [15]. For enhancing crop productivity, the current agricultural system is entirely dependent on chemical fertilizers (CFs). However, excessive use of CFs has a detrimental impact on crop productivity, environment, and soil health (Iqbal *et al*., 2019) [2]. In order to complement or replace CFs, it is necessary to embrace and broaden environmentally beneficial choices. Organic manure is a rich, well-balanced source of macro and micronutrients as compared to CFs. Organic manure increases soil microbial activity, which enhances the physical and chemical characteristics of the soil. The sole application of organic manure might not be enough to meet the agricultural production since the nutrient content and nutrient release capacity of organic manure is insufficient to meet crop requirements in a short period of time. It has been demonstrated that using organic manure in addition to synthetic fertilizers improves and sustains soil fertility and crop yield more effectively than using only mineral or organic manure (Bandopadhyay *et al*., 2010; Kumar *et al*., 2017) [1, 4]. Integrated nutrient management (INM) helps in efficient use of synthetic fertilizers combined with organic nutrient sources (Mahajan *et al*., 2008) [8]. The application of organic materials improves physical, chemical and biological soil properties, while inorganic materials improve the chemical soil properties, such as sufficing the supply of macro and micro essential nutrients to meet crop needs. It is developed with an understanding of the interactions among crops, soils and climate **(**Prasetyo *et al*., 2013) [11].

The objective of present investigation was to study the effect of different nutrient sources on the growth characteristics of basmati rice.

Materials and Methods

Experimental Site

The field experiment was conducted at Organic Block of Norman E. Borlaug Crop Research Center, GB Pant University of Agriculture and Technology Pantnagar during the kharif season of 2019 and 2020. The latitudinal and longitudinal location are 29° N and 70° 30' E respectively

Experimental Design and Treatment Application

A randomized complete block design with four replicates for each treatment was used. Six treatments were assigned: T1 [100 kg N through organic source i.e. green manure + 25kg N ha^{-1} through vermicompost (VC)]; T2 [50% N equivalent through organic sources (*Sesbania* was incorporated at 40 days after sowing) + seed/seedling treatment with *Beejamrit* + *Ghanjeevamrit* @ 250 kg ha^{-1} + *Jeevamrit* @ 500 L ha^{-1}/time]; T3 [50% NPK through organic sources (incorporation of GM) + 50% chemical fertilizer]; T4 [25% nutrients through organic + 25% nutrients through inorganic sources + seed/ seedling treatment with *Beejamrit* + *Ghanjeevamrit* @250 kg ha^{-1} + *Jeevamrit* @500 L ha^{-1}/time]; T5 [Recommended doses of NPK (120:60:40) kg ha^{-1}]; T6 [Recommended doses of NPK (120:60:40) kg ha^{-1} + FYM @ 5 t ha^{-1}]. Seedlings were grown and transplanted after 21 days at the spacing of 12.5 cm x 25 cm. FYM and VC were applied to the field in three splits. 50 percent at the time of transplanting, 25 percent at maximum tillering and remaining 25 percent at panicle initiation stage. Beejamrit treatment was given to the seeds of T2 and T4 nursery before sowing. Ghanjeevamrit was incorporated to the T2 and T4 field before transplanting and *Jeevamrit* application was done with irrigation. In inorganic treatments P and K were given as basal application whereas N was applied in three splits, 50 percent as basal application at the time of transplanting and 50 percent in two equal splits. First top dressing after 30 days of transplanting and second top dressing after 20 days of first top dressing.

Growth parameters

Plant height

Plant height of tagged plants from each replication was measured with meter scale at active tillering and panicle initiation. Height was measured in centimeters from base of the plant to the tip of the fully expanded leaf.

Leaf area index (LAI)

Leaf area index per plant was recorded at the time of active tillering by taking four replicates from each replication of every treatment. The numbers of large, medium and small leaves were separated and length and width of leaves was measured by meter scale from single hill. LAI was calculated with the help of following formula (Yoshida, 1981) [18].

$LAI = (\text{area} \times \text{number of leaves per hill}) / \text{ground area}$

$\text{Area} = (L_1 \times W_1 \times CF) + (L_2 \times W_2 \times CF) + (L_3 \times W_3 \times CF)/3$

$\text{Final LAI} = (LAI_1 + LAI_2 + LAI_3)/3$

Where,

L_1 = average length of 3 large leaves of a hill,
W_1 = average width of 3 large leaves of a hill
L_2 = average length of 3 medium leaves of a hill,
W_2= average width of 3 medium leaves of a hill
L_3 = average length of 3 small leaves of a hill,
W_3= average width of 3 small leaves of a hill
CF = correction factor

Leaf dry weight and shoot dry weight

Plant samples were collected at tillering stage and kept in paper bags and dried in a hot air oven for 72 hours at 65 ℃. Weight of dried samples was measured with the help of weighing balance and expressed in grams per plant and converted into g/m^2.

Results and Discussion

Plant height

The plant height of the Pant basmati I under various nutrient sources at active tillering and panicle initiation stages during kharif season 2019 and 2020 are depicted in the Fig 1a and Fig 1b. In 2019, at active tillering stage maximum and minimum height was observed in T3 (59.5) and T2 (51.25) respectively. At panicle initiation stage the maximum and minimum height was observed in T3 (92.25) and T2 (88) respectively. At active tillering stage, highest percent decrease (9.69) was observed in T2 and lowest percent decrease (5.73) was in T1 over T5 (recommended dose of NPK). At PI stage highest percent decrease (5.00) was observed in T1 and lowest percent decrease (2.22) was in T2 over T5 (recommended dose of NPK).

In 2020, at active tillering maximum and minimum plant height was observed in T3 (60) and T2 (50.75) respectively. At panicle initiation maximum and minimum height was observed in T3 (93.5) and T2 (86.25) respectively. The highest percent decrease (12.12) was observed in T2 and lowest percent decrease (6.93) was observed in (T1) at active tillering stage over T5 (recommended dose of NPK). At PI stage highest percent decrease (5.74) was observed in T3 and lowest percent decrease (2.19) was observed in T6 over T5 (recommended dose of NPK). During both stages plant height followed the same order T3>T5>T6>T4>T1>T2. Statistical analysis showed significant differences in plant height during both stages and years.

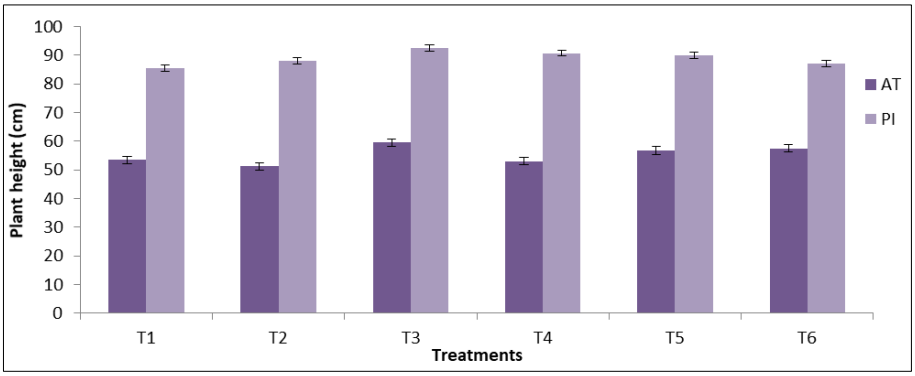

Fig 1a: Plant height of Pant Basmati I at active tillering (AT) and Panicle initiation stage (PI) during kharif season 2019.

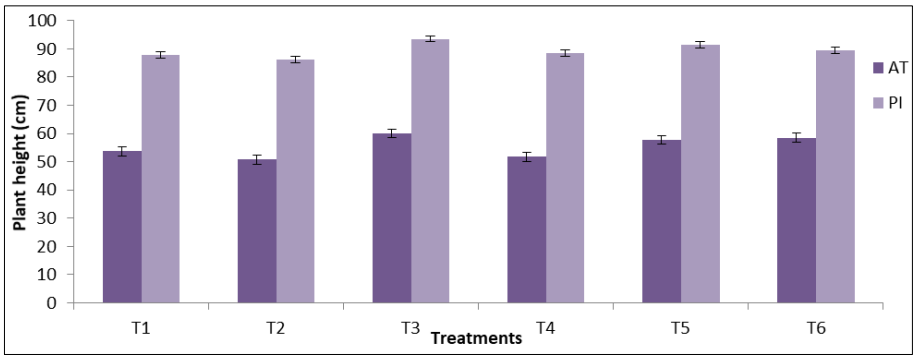

Fig 1b: Plant height of Pant Basmati I at active tillering (AT) and Panicle initiation (PI) stage during kharif season 2020.

Leaf Area Index (LAI)

The leaf area index of Pant basmati I under various nutrient sources at tillering stage during kharif season 2019 and 2020 are depicted in the Fig 2. During 2019, maximum and minimum LAI was observed in T3 (2.65) and T2 (2.37) respectively. Maximum percent decrease (8.14) was observed in T2 and lowest percent decrease (2.71) was observed in T6 as compared to T5 (recommended doses of NPK). During 2020, the maximum and minimum LAI was observed in T3 (2.64) and T2 (2.43) respectively. Maximum percent decrease was observed in T3 (6.18) and minimum percent decrease in T6 (1.93) as compared to T5 (recommended doses of NPK). The increasing order of leaf area index was T2<T1<T4<T6<T5<T3. Statistically significant difference was observed among treatments.

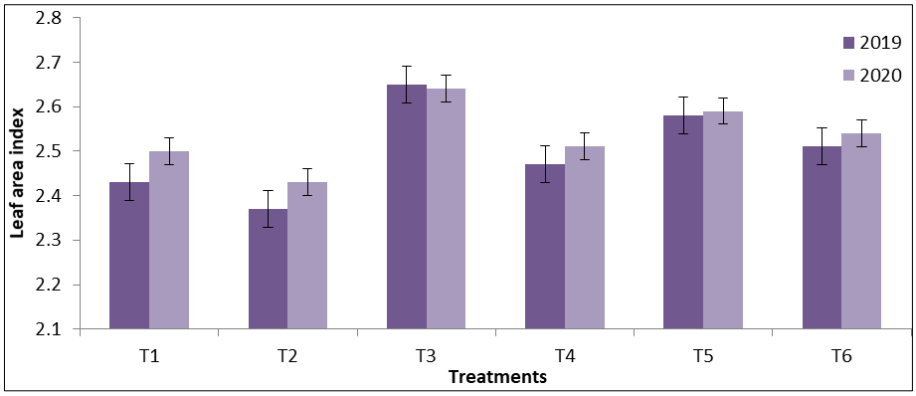

Fig 2: Impact of different nutrient sources (T1, T2, T3, T4, T5, T6) on leaf area index of Pant Basmati I at tillering stage during 2019 and 2020.

Leaf Dry Weight

The leaf dry weight of Pant basmati I under various nutrient sources at tillering stage during kharif season 2019 and 2020 are depicted in the Fig 3. During 2019, the maximum leaf dry weight was reported in T3 (126.9) and minimum in T2 (101.3). The highest percent reduction (15.16) was reported in T2 and lowest percent reduction (7.54) in T4 as compared to the recommended doses of NPK (T5). During 2020, the maximum leaf dry weight was reported in T3 (132.8) and minimum was in T2 (100.9). Highest percent reduction (20.05) was observed in T2 and lowest percent reduction (6.34) in T6 as compared to the recommended doses of NPK (T5). The increasing order of leaf dry weight was T2<T1<T4<T6<T5<T3. Statistically significant difference was observed among treatments.

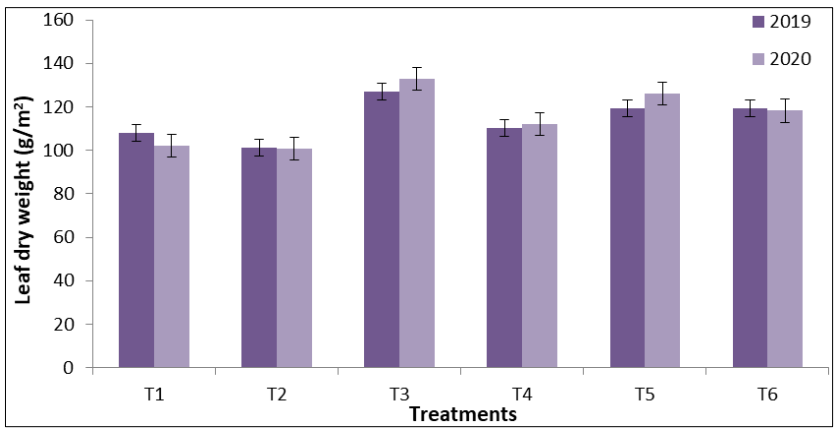

Fig 3: Leaf dry weight of Pant Basmati I at active tillering stage under different nutrient sources (T1, T2, T3, T4, T5, T6) of organic, inorganic and integrated during 2019 and 2020.

Shoot Dry Weight

Shoot dry weight of Pant Basmati I under different organic, inorganic and integrated nutrient sources at tillering stages during 2019 and 2020 are depicted in Fig.4. During 2019, maximum shoot dry weight was observed in T3 (247) and minimum in T2 (189). Highest percent decrease (20.25) was observed in T2 and lowest percent decrease (6.75) in T6 as compared to the T5 (recommended doses of NPK). During 2020, maximum shoot dry weight was observed in T3 (243) and minimum was observed in T2 (195). Highest percent decrease (17.02) was observed in T2 and lowest percent decrease (6.81) was observed in T6 as compared to T5 (recommended doses of NPK). The increasing order of shoot dry weight was T2<T1 <T4<T6<T3<T5. Statistically significant difference was observed among treatments.

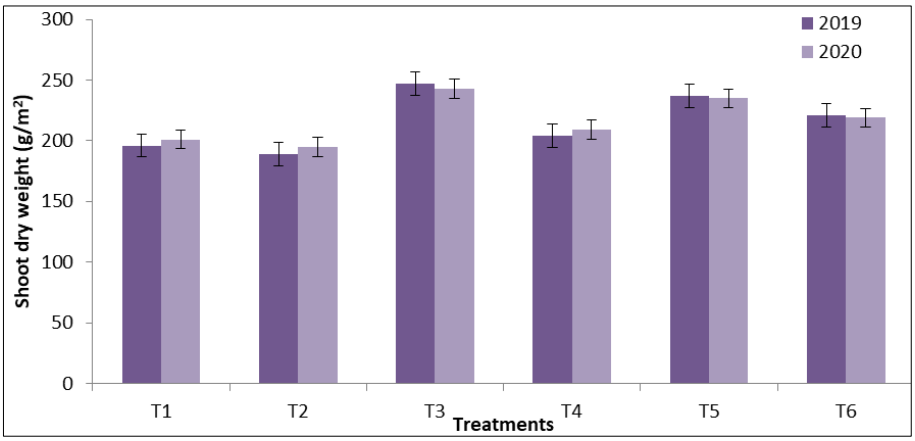

Fig 4: Shoot dry weight of Pant Basmati I at active tillering stage under different nutrient sources (T1, T2, T3, T4, T5, T6) of organic, inorganic and integrated during 2019 and 2020

Total Dry Matter (TDM)

Total dry matter (TDM) of Pant Basmati I under different organic, inorganic and integrated nutrient sources at tillering stage during 2019 and 2020 are illustrated in Fig.5. During 2019, maximum TDM was observed in T3 (373.9) and minimum in T2 (290.3). Highest percent decrease (18.46) was reported in T2 and lowest percent decrease (4.35) in T6 as compared to T5 (recommended doses of NPK). During 2020, maximum TDM was observed in T3 (375.8) and minimum was observed in T2 (295.9). Highest percent decrease (18.08) was observed in T2 and lowest percent decrease (6.64) in T6 as compared to the T5 (recommended doses of NPK). The increasing order of TDM was T2<T1<T4<T6<T5<T3. Statistically significant difference was observed among treatments.

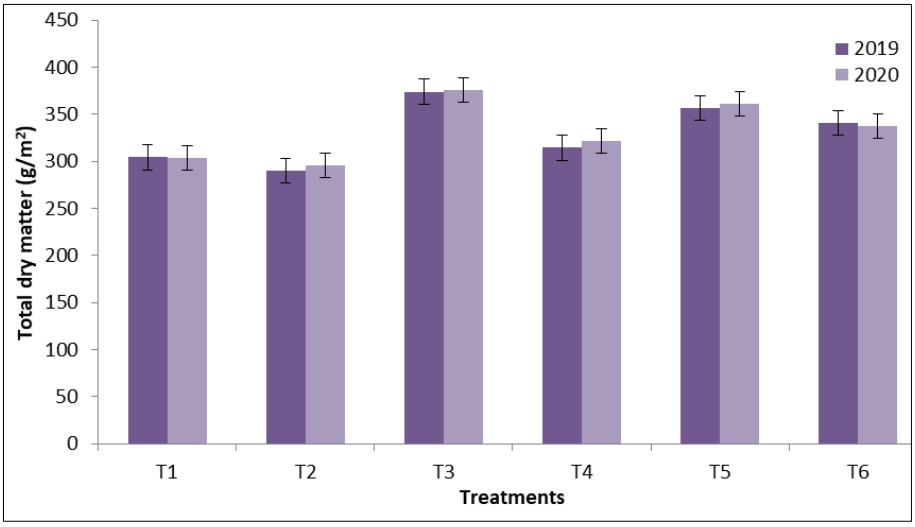

Fig 5: Total dry matter (TDM) of Pant basmati I at active tillering stage under different nutrient sources (T1, T2, T3, T4, T5, T6) of organic, inorganic and integrated during 2019 and 2020.

In the present investigation it was reported that all the growth parameters *viz*. plant height, LAI, leaf dry weight, shoot dry weight and total dry matter had maximum value in T3 (50% organic + 50% inorganic) and minimum in T2 (GM with ghanjeevamrit, jeevamrit and beejamrit treatments). The values of T3 (50% organic + 50% inorganic) were at par with T5 (100% RDF). The significant effect of combined use of organic and inorganic nutrient were also reported by Usman *et al*., 2003 [16] in Basmati rice, Marwanto *et al*., 2018 [10] in black rice, Sharma *et al*., 2019 [13] in cluster beans, etc. It was reported that, growth attributes were directly related to increase in yield of rice plant (Senthilvalavan and Ravichandran, 2019) [12]. LAI plays a significant role in the formation of photoassimilates, which are used to determine

crop yield and dry matter accumulation. When LAI rises, solar energy is utilised more efficiently, increasing the capacity of photosynthesis to generate dry matter (Kuttimani *et al*., 2013) [5]. Water soluble inorganic fertilizers provide nutrients to plants in easily available from within a short period of time and in a due course of time these nutrients get leached, which is why inorganic fertilizer is provided in three splits. In organic treatments the nutrients release was very slow because of gradual decomposition of organic compounds by microbes which results in less growth of plants. So the integration of organic and inorganic nutrient sources helps to overcome the shortcoming of sole use of inorganic and organic nutrient sources. Integrated nutrient sources brought about readily available nutrients contributed by inorganic fertilizer and an enhanced soil organic matter, improved soil structure and buffering capacity mainly provided by organic fertilizer resulting in higher growth parameters. In a study on wheat it was reported that the combined use of organic manure and inorganic fertilizers results in increased LAI and Dry matter accumulation as compared to only RDF and 125% RDF (Kakraliya *et al*., 2017) [3]. In *indica* and *japonica* rice varieties, integrated used of 50% chemical fertilizer and 50% poultry manure showed the highest plant height, tiller number and dry matter content in it (Moe *et al*., 2019) [19]. The increment in growth characters are directly related to the grain yield of the rice plant.

Conclusion

We can conclude from the two year field experiment that the best results of growth parameters *viz*. plant height, LAI, leaf weight, shoot weight and total dry matter were found in 50% NPK through organic sources (incorporation of GM) + 50% chemical fertilizer which are comparable with 100% RDF. Incorporation of Ghanjeevamrit and Jeevamrit also didn't show any beneficial impact on the growth parameters during these initial stages. Further research may be carried out to investigate if such effects can be maintained in a sustainable way on large-scale application as well as for a longer period of time. This research encourages farmers to adopt the combined application of manures and fertilizers to decrease the dependence on inorganic fertilizers.

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