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Integrated use of organic (FYM), inorganic and biofertilizer (PSB) on productivity, nutrient uptake of wheat and soil properties

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Abstract
A field experiment was carried out in the pot culture of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur during 2017-18. The experiment consisted 8 treatments *viz.* T_1: Control, T_2: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}), T_3: N (120 Kg ha^{-1}), K (40 Kg ha^{-1}), T_4: N (120 Kg ha^{-1}), K (40 Kg ha^{-1}), T_5: N (120 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) +PSB (10 Kg ha^{-1}), T_6: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1}), T_7: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1}) and T_8: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}), K (40 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1}) assigned in randomized block design with three replication during *rabi* season of 2017-18. The soil of the experimental plot was sandy loam in texture, medium in fertility and slightly alkaline in reaction. The weather during the experimental period was by and large normal and devoid of any extreme conditions. The results indicated that application of T_8: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}), K (40 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1}) resulted in significantly maximum days to 50% flowering and maturity and ultimately higher seed yield and straw yield as compared to other corresponding tested treatments. The treatment also excelled in Biological yield and harvest index under control.

Keywords: Seed yield, straw yield, biological yield and harvet index

Introduction
Wheat (*Triticum aestivum* L.) is the most important cereal crop for the majority of world's populations. It is the most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Anonymous, 2019). Wheat is cultivated over a wide range of climatic conditions and therefore understanding of genetics is of great value for genetics and plant breeding purposes. Wheat is grown in all the states in India except Southern and North Eastern states. Uttar Pradesh, Haryana, Punjab, Rajasthan are the major wheat producing states and accounts for almost 80% of total production in India. Only 13% area is rainfed. Major Rainfed wheat areas are in Madhya Pradesh, Gujarat, Maharashtra, West Bengal and Karnataka. Central and Peninsular Zone accounts for total 1/3rd of wheat area in India. All India basis only 1/3 irrigated wheat receives desired irrigations and remaining is limited irrigation only. Breeding programmes are generally aimed for rainfed and irrigated environments and there is need to develop varieties which are responsive to limited irrigation conditions. Thus to increase the productivity of this region different physiological techniques need to be adopted, for improving water use efficiency and breeding wheat genotypes tolerant to water stress and heat. Phosphatic fertilizers improve growth of crops and reduces the adverse effect of excess nitrogen fertilizers. The potash activates a wide range of enzyme system. It also controls other physiological functions like water economy through regulation of stomata opening and closing.

Biofertilizers not only add nitrogen and increase native phosphorus availability to some extent. The chemical fertilizers are main suppliers of major plant nutrient (N P K). Therefore, the rational and practical means to maintain soil fertility and to supply plant nutrients in balanced proportion is to practice integrated plant nutrients supply through the combined use of chemical and biological sources of plant nutrients. Biofertilizers are microbial inoculants of selective micro-organism like bacteria, algae and fungi already existing in nature (Gupta *et al.*, 2018) [3].

Materials and Methods

The experiment was conducted during *rabi* season of 2017-18 in pot culture of Soil Science and Agricultural Chemistry of C S Azad University of Agriculture & Technology, Kanpur in alluvial soil. Soil of the experimental plot was sandy loam in texture and slightly calcareous having organic carbon 0.33%, total nitrogen 0.03%, available P_2O_5 16.2 ha^{-1}, pH 7.6, electrical conductivity 0.36 dSm^{-1}, permanent wilting point 6.2%, field capacity 18.4%, maximum water holding capacity 29.5%, Bulk density 1.46 Mgm^{-3}, particle density 2.56 Mgm^{-3} and porosity 42.9%. The experiment was conducted in a randomized block design with three replications and eighth treatments *viz.* T_1: Control, T_2: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}), T_3: N (120 Kg ha^{-1}), K (40 Kg ha^{-1}), T_4: N (120 Kg ha^{-1}), K (40 Kg ha^{-1}), T_5: N (120 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) +PSB (10 Kg ha^{-1}), T_6: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1}), T_7: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1}) and T_8: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}), K (40 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1}). Full dose of P and K while half dose of N was applied as basal dose at the time of sowing where rest of N was given in two split doses during experimentation. Available moisture at sowing time upto 100 cm soil profile was 275.2 mm. Whereas amount of rainfall received during the crop period was nil against the average annual rainfall of about 800 mm. Recommended package of practices were applied in different treatments. Soil moisture was monitored gravimetrically using the sample collected from 0-25, 25-50, 50-75 and 75-100 cm soil depths at regular monthly intervals to quantify the soil moisture content and growth parameters by randomly selecting three plants for each plots till the harvest.

The data collected on growth, yield attributes and yields were statistically analyzed (Fisher and Yates, 1958) [2]. Recommended package of practices and fertilizers doses were applied in different treatments. The harvest index was worked out with the help of following formula:

$$\text{Harvest Index}(\%) = \frac{\text{Seed yield}(\text{q ha}^{-1})}{\text{Biological yield}(\text{q ha}^{-1})} \times 100$$

Results and Discussion

Days to 50% flowering as well as 50% maturity of the plants. The beneficial effect of FYM on these parameters might be due to its contribution in supplying additional plant nutrients and its capacity to improving solubility in the presence of PSB of native soil nutrients. Adequate availability of these nutrients in wheat improved growth and vigour of the crop with efficient and greater partitioning of metabolites and greater translocation of synthesized food material to the reproductive organs would have delayed the flowering and maturity. The application of increasing levels of fertility significantly increased root depth as well as dry weight of roots over the period of study. Supply of nitrogen and phosphorus to soil have accelerated various physiological processes in plants favoring increased root development possibly the result of effective uptake and utilization of other nutrients absorbed through its extensive root system developed due to PSB application Verma *et al.*, (2017) [7].

Number of ear $plant^{-1}$ and Number of seeds ear^{-1} will significantly increased to maximum in the treatment of T_8: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}), K (40 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1}) and lowest under control. This could be attributed to amending of soil with organic manure in conjunction with mineral fertilizer and PSB which helped in growth and development of plants. The use of FYM solubilised, transformed P forms in to comparatively more soluble forms. Further, the addition of FYM over other treatments showed superiority over others in improving the attribute characters. Moreover, balanced nutrition under favorable environment of FYM and PSB to crop plants would have helped in producing new tissues and development of leading ultimately to increased branching and girth of plant. Thus, the treatment of T_8 excelled over control in the present investigation. The yield attributing characters of wheat crop such as 1000-seed weight were affected significantly due to different levels of biofertilizer application. Yield attributing characters were found in increasing trend with increasing doses of PSB application Rahul Ranjan *et al.* (2018) [5] and Jakhar *et al.*, 2019 [4].

The seed yield differences due to fertilizer were found to be statistically significant over control. Seed yield $plant^{-1}$ and 1000-seed weight. These characters were highest in T_8: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}), K (40 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1}) in soil and lowest under control. All these characters might have resulted in appreciably higher seed yield per plant which might be held responsible for seed yield per hectare. It has been established that the efficiency of inorganic fertilizer can be greatly increased through its integration with organic manures, there by reflecting in harvest index too Verma *et al.* (2017) [7] & Verma and Yadav (2018) [8].

Table 1: Effect on yield attributes of wheat crop under different treatments.

Treatments	Days to 50% flowering	Days to 50% Maturity	No. of ear $plant^{-1}$	No. of Seeds ear^{-1}	Weight of ear^{-1} (g)	Grain Weight ear^{-1}(g)	1000-seed weight
T_1: Control	43.87	52.34	17.34	17.65	2.25	1.97	38.00
T_2: N (120 Kg ha^{-1}), P (60 Kg ha^{-1})	45.03	52.89	18.49	17.98	2.40	2.10	39.39
T_3: N (120 Kg ha^{-1}), K (40 Kg ha^{-1})	46.00	53.45	18.93	18.00	2.46	2.15	39.73
T_4: N (120 Kg ha^{-1}), K (40 Kg ha^{-1})	48.87	54.89	19.35	18.12	2.51	2.20	39.95
T_5: N (120 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) +PSB (10 Kg ha^{-1})	48.90	55.00	19.72	18.34	2.56	2.24	40.22
T_6: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1})	48.98	55.45	20.50	18.56	2.66	2.33	40.38
T_7: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1})	49.34	55.65	21.50	19.00	2.79	2.45	40.55
T_8: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}), K (40 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1})	50.87	56.34	22.70	20.98	2.95	2.58	40.73
SE (d)	0.34	0.65	0.36	0.43	0.71	0.28	0.34
CD (P=0.05)	0.86	1.28	0.78	1.23	1.23	0.59	0.71

Table 2: Effect on Seed yield, Straw yield, Biological yield and Harvest index of wheat crop under different treatment

Treatments	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
T_1: Control	37.55	61.31	98.87	37.99
T_2: N (120 Kg ha^{-1}), P (60 Kg ha^{-1})	43.92	72.07	116.98	37.58
T_3: N (120 Kg ha^{-1}), K (40 Kg ha^{-1})	46.10	75.96	122.06	37.76
T_4: N (120 Kg ha^{-1}), K (40 Kg ha^{-1})	47.98	78.34	126.62	37.98
T_5: N (120 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) +PSB (10 Kg ha^{-1})	49.07	80.11	129.35	37.93
T_6: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1})	50.03	81.69	131.73	37.98
T_7: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1})	51.50	83.08	134.58	38.26
T_8: N (120 Kg ha^{-1}), P (60 Kg ha^{-1}), K (40 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1})	52.68	84.18	136.86	38.49
SE (d)	0.43	0.63	0.76	0.34
CD (P=0.05)	0.91	1.18	1.23	0.89

Conclusion

Based on results obtained during the one years of experimentation, it can be concluded that application of N (120 Kg ha^{-1}), P (60 Kg ha^{-1}), K (40 Kg ha^{-1}) + Organic (10-15 ton ha^{-1}) + PSB (10 Kg ha^{-1}) incorporated in the soil have fetched higher productivity along with seed yield in light textured alluvial soils of Uttar Pradesh.

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