The Bioscan 8(3): 811-815, 2013
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

INFLUENCE OF GROWTH AND YIELD ATTRIBUTES OF WHEAT (*TRITICUM AESTIVUM* L.) BY ORGANIC AND INORGANIC SOURCES OF NUTRIENTS WITH RESIDUAL EFFECT UNDER DIFFERENT FERTILITY LEVELS

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KEYWORDS
Organic manure
Growth,
Wellgrow

Received on :
18.01.2013

Accepted on :
03.05.2013

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ABSTRACT
This manuscript focuses on the effect of concentrate organic manure (wellgrow grain and wellgrow soil) and different levels of nutrients on growth and yield component of wheat under different levels of fertility. Significant improvement in terms of growth parameters like plant height, number of tillers, dry matter production and number of productive tillers with application of 100% NPK + 300 kg wellgrow grain/ha and at par with application of 100% NPK + 300 kg wellgrow soil/ha, 100% NPK + 200 kg wellgrow grain/ha. Treatment receiving 100% NPK + 300 kg wellgrow grain/ha resulted maximum effective tillers/hill (350 m^{-2}), grain yield (41.2 q/ha). Treatment 100% NPK + 300 kg wellgrow soil/ha maintained higher straw yield (53.53 q/ha) and test weight (42.20 g) due to application of 100 % NPK along with 300 kg wellgrow soil/ha whereas it was at par with application of 75% and 100% NPK with both levels of wellgrow formulation.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the world's leading cereal crop cultivated over an area of about 651 million tons making it the third most-produced cereal after maize and rice. India achieved remarkable progress in wheat production during the last four decades and is the second largest wheat producer in the world with the production touching a record level of 93.90 mt an area of around 28.40 m ha during 2011-12 (Anonymous, 2012), production has increased tremendously but is still far below the potential yield (11.2 tonnes/ha) (Singh *et al.,* 2010). Although, India is well placed in meeting its needs for food grains the major objective of food and nutritional secretary for its entire population has not been achieved. The demand for food grains is expected to rise not only as a function of population growth but also as more and more people cross the poverty line with economic and social development.

Wheat grains are comparatively better source of protein consumed in India. About 10-12% protein requirement is met by wheat. Maneuvering the application of different fertilizers could increase the productivity of the wheat crop and the protein content. On account of continuing world energy crisis and spiraling price of chemical fertilizer, the use of organic manure as a renewable source of plant nutrients is assuming importance. In this endeavor proper blend of organic manure and inorganic fertilizer is important not only for increasing yield but also for sustaining soil health (Kumar *et al.,* 2013).

Organic manure enhanced soil organic carbon (SOC) quality and quantity by an increased accumulation of various classes of organic compounds. Research on SOC following crop residue has been mainly focused on changes of bulk organic carbon (Sebastia *et al.*, 2007). The integrated use of concentrate organic materials and inorganic fertilizers has received considerable attention in the past with a hope of meeting the farmer's economic need as well as maintaining favorable ecological conditions on long-term basis (Kumar *et al.*, 2007).

Regular use of a reasonable dose of organic manure, along with crop residue recycling, is known to cater the nutrient requirements of a low to medium intensity rice-wheat cropping system (Coventry *et al.,* 2011). However, most of the long-term INM field research in South Asia pertains to rice-wheat system (Kumar and Dhar, 2010). The integrated nutrient management helps to restore and sustain fertility and crop productivity. It may also help to check the emerging deficiency of nutrients other than N, P and K. Further, it brings economy and efficiency in fertilizers. The integrated nutrient management favorably affects the physical, chemical and biological environment of soil. Keeping this in view, the present investigation was carried out to influence of growth and yield attributes of wheat by organic and inorganic sources of nutrients with residual effect under different fertility levels.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* seasons of 2009 to *rabi* season (2010) under the rice-wheat cropping system at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University. Varanasi. Rice was sown in the first week of August and harvested during last week of November during 2009. After harvesting of rice, 'HUW 234' wheat variety was sown in last week of December and harvested during third week of April in 2010.

WELLGROW is a plant product formulation in grain and in powder forms produced by an Indian Tobacco Company (ITC). Composition of wellgrow soil and grain presented in Table 1. In case of wellgrow soil (Certified organic input) is organic manure (powder) from plant products with better nutritional value made from non-timber forest product enhances efficiency of nitrogenous fertilizers and acts as a good nutritional media for the growth of bio-fertilizers and bio-pesticides to increase their performance.

Site description and field experiment

The study was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, BHU, Varanasi (25^0 $18^¢$ N latitude, 83^0 03¢ E longitude and 128.93 m above MSL) The weekly mean maximum and minimum temperature during the experimentation ranged from 15.1 to 42.3 ^oC and 7.1 to 29.7 ^oC, respectively.

Soil samples were collected from the experimental field and analyze for phyco-chemical and biological properties. Some of the initial soil properties were: the soil pH_w (1:2, soil: water) 7.40; electrical conductivity (EC_w 1:2, soil: water) 0.27 dSm^{-1} (Jackson, 1973); 2.4 g/kg organic carbon (Walkley and Black 1934), 175.54 kg/ha available N (Subbiah and Asija 1956), 11.30 kg/ha available P (Olsen *et al*. 1954), 113.41 kg/ha available K (Hanway and Heidel 1952),

Experimental design and treatments

The field experiment was laid out in a randomized block design with three replications. Treatments to rice consisted nine treatments of wellgrow and different levels of recommended dose of fertilizers (120:60:60 kg/ha) viz., (i) 100% NPK (control), (ii) 50% NPK + 300 kg wellgrow soil/ha, (iii) 50% NPK + 300 kg wellgrow grain/ha, (iv) 75% NPK + 200 kg wellgrow soil/ha, (v) 75% NPK + 200 kg wellgrow grain/ha, (vi) 100% NPK + 200 kg wellgrow soil/ha, (vii) 100% NPK + 200 kg wellgrow grain/ha, (viii) 100% NPK + 300 kg wellgrow soil/ha, (ix) 100% NPK + 300 kg wellgrow grain/ha. One-fourth of N and whole amount of P and K as per treatment were applied as basal in rice and remaining amount of N was divided into 2 equal splits and top-dressed at tillering and panicle initiation stage. In wheat, full amount of P and K as per treatments was applied as basal and nitrogen was applied into 3 equal splits 1/3rd each at sowing, jointing and pre flowering stage. Five irrigations were applied in wheat. Various growth and yield parameters were observed at harvest following the standard procedure.

Table 1: Characteristics of wellgrow soil and grain

Parameters	Wellgrow soil Range	Wellgrow grain Range
Organic carbon (%)	20-25	18-20
Total nitrogen (%)	1.6 -2.6	1.3 -1.4
Phosphorus (as P_2O_5) (%)	0.25-1.2	1.1-1.2
Potash (as K_2O) (%)	0.89-1.47	1.3-1.4
C/N ratio	10-16:1	13-15:1
Colour	Brown	Black
Moisture (%)	9 -10	8.2-8.4

Statistical analysis

Data were assessed by Duncan's multiple range tests (Duncan 1955) with a probability P = 0.05. Least significant difference (LSD) between the mean values was evaluated by a one-way analysis of variance by using SPSS version 10.0.

RESULTS AND DISCUSSION

The results in Table- 2 and 3 showed that plant height, Number of tillers (m^{-1}), dry matter accumulation, no. of effective tiller and spike length were significantly influenced in all treatments over control except 50% NPK + 300 kg wellgrow soil ha^{-1} (T_2) and 50% NPK + 300 kg wellgrow grain ha^{-1} (T_3).

Plant height: Plant height is not a yield component especially in grain crops but it indicates the influence of various nutrients on plant metabolism. It was found that application of concentrate organic manure with inorganic fertilizer increased the plant height as compare to inorganic sources when applied separately. But significantly maximum plant height was observed with 100% NPK + 200 kg wellgrow grain/ha which was at par with T_8 and T_9 at all the stages of plant growth. It was found that plant height increased by 3.94, 2.58, 4.70, 5.14% over control at 30, 60, 90 DAS and at harvest, respectively (Table-2).

At 30 DAS maximum plant height observed (23.15 cm with T_8). However, at 90 DAS and at harvest stage of wheat maximum plant height was recorded 100% NPK + 200 kg wellgrow grain/ha (90.95 and 91.86 cm, respectively). Significantly lowest plant height (22.19 with 50% NPK + 300 kg wellgrow soil/ha. The increase in plant height in response to combined application of organic and inorganic manures is might be due to enhanced availability of macro nutrients as well as micro nutrients. The enhancement in plant height with increase dose of organic manure is attributed to the rapid conversion of synthesized carbohydrates into protein and consequent to increase in the number and size of growing cells, resulting ultimately in increased plant height of wheat. These results are supported by the findings of Sarwer *et al*. (2008) who reported that the use of organic manures in combination with mineral fertilizers maximized the plant growth.

Number of tiller per hill: At 30 DAS no of tillers increased nonsignificant, but at 60, 90 DAS and harvest stage of wheat DAS, the no of tillers/m increased slowly from 30 to 90 DAS thereafter a gradual decline was observed up to at harvest. It is apparent from the data that tillers production/m was significantly affected by different wellgrow levels and NPK levels at all the growth stages. The increase in levels of wellgrow formulations with NPK significantly increased tillers/m up to 100% NPK and 200 kg wellgrow grain/ha at all the observation days.

Table 2: Effect of concentrate manure and nutrient levels on plant height, no. of tillers hill^{-1} and dry matter production at different growth stages of wheat

Treatment	Plant height (cm)				No. of tillers				Dry matter production (g plant^{-1})			
	30	60	90	At harvest	30	60	90	At harvest	30	60	90	At harvest
T_1	23.47^{a*}	72.69^{b}	86.67^{c}	87.67^{b}	95^{a}	131^{bcd}	127^{bc}	71^{e}	9.5^{a}	110^{ab}	211^{bc}	217^{d}
T_2	22.19^{a}	73.76^{a}	87.63^{bc}	88.30^{ab}	98^{a}	131^{bcd}	130^{ab}	78^{cd}	8.9^{a}	81.3^{abc}	199^{c}	211^{d}
T_3	23.49^{a}	75.33^{a}	88.38^{abc}	89.33^{ab}	91^{a}	144^{abc}	124^{bc}	76^{d}	9.3^{a}	99.2^{abc}	215^{bc}	231^{cd}
T_4	21.80^{a}	73.77^{a}	87.67^{bc}	88.67^{ab}	87^{a}	135^{bcd}	125^{bc}	81^{bc}	9.3^{a}	117.7^{a}	223^{bc}	231^{cd}
T_5	24.48^{a}	77.40^{a}	89.32^{abc}	90.98^{ab}	99^{a}	147^{ab}	121^{c}	78^{cd}	7.8^{ab}	117.3^{a}	212^{bc}	227^{cd}
T_6	23.05^{a}	75.64^{a}	87.85^{abc}	89.65^{ab}	90^{a}	125^{d}	123^{c}	81b^{c}	7.9^{ab}	77.2^{bc}	234^{b}	243^{bcd}
T_7	22.57^{a}	74.62^{a}	90.95^{a}	91.86^{a}	92^{a}	130^{cd}	128^{bc}	82^{b}	6.8^{b}	70.5^{c}	230^{b}	267^{abc}
T_8	23.15^{a}	76.68^{a}	90.12^{ab}	90.51^{ab}	98^{a}	153^{a}	136^{a}	90^{a}	9.7^{a}	86.6^{abc}	295^{a}	304^{a}
T_9	22.77^{a}	74.61^{a}	90.78^{ab}	91.67^{a}	98^{a}	132^{bcd}	131^{ab}	82^{b}	8.7^{a}	112.9^{ab}	273^{a}	285^{ab}
LSD (p=0.05)	NS	3.55	2.93	3.55	NS	14.92	6.61	3.50	NS	34.63	26.79	43.22

Attributes of wheat at 30, 60, 90 DAS and at harvest stage

* For each parameter, different lowercase letters within the same column indicate that treatment means are significantly different at P < 0.05 according to Duncan's Multiple Range Test for separation of means

Table 3: Effect of concentrate manure and nutrient levels on yield and yield attributes of wheat

Treatment	No. of effective tillers (m^{-2})	Spike length (cm)	No. of grain spike^{-1}	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1	316^{ab}	7.90^{abc}	33^{d}	36.80^{ab}	31.6^{e}	45.30^{d}	41.10^{ab}
T_2	335^{ab}	8.42^{abc}	38^{ab}	36.00^{ab}	32.6^{de}	48.04^{cd}	40.41^{b}
T_3	331^{ab}	8.59^{abc}	39^{ab}	36.40^{ab}	33.3^{de}	50.49^{abc}	39.76^{b}
T_4	312^{b}	7.76^{bc}	41^{ab}	35.60^{b}	34.6^{cde}	48.53^{bcd}	41.52^{ab}
T_5	350^{ab}	8.14^{abc}	40^{ab}	35.20^{ab}	34.9^{cde}	49.53^{bc}	41.36^{ab}
T_6	308^{b}	8.64^{ab}	39^{ab}	34.40^{ab}	35.6^{cd}	51.74^{abc}	40.75^{b}
T_7	341^{ab}	8.92^{a}	41^{ab}	38.00^{ab}	37.5^{bc}	51.07^{abc}	42.38^{ab}
T_8	346^{ab}	8.39^{abc}	47^{a}	42.40^{a}	39.9^{ab}	53.53^{a}	42.68^{ab}
T_9	362^{a}	7.54^{c}	43^{a}	41.00^{a}	41.2^{a}	52.06^{ab}	44.17^{a}
LSD (p=0.05)	41.96	0.98	10.65	NS	3.18	3.51	2.91

* For each parameter, different lowercase letters within the same column indicate that treatment means are significantly different at P < 0.05 according to Duncan's Multiple Range Test for separation of means

T_1: 100% NPK (120:60:60 kg ha-1), T_2: 50% NPK + 300 kg wellgrow soil ha^{-1}, T_3: 50% NPK + 300 kg wellgrow grain ha^{-1}, T_4: 75% NPK + 200 kg wellgrow soil ha-1, T_5: 75% NPK + 200 kg wellgrow grain ha^{-1}, T_6: 100% NPK + 200 kg wellgrow soil ha^{-1}, T_7: 100% NPK + 200 kg wellgrow grain ha^{-1}, T_8: 100% NPK + 300 kg wellgrow soil ha^{-1}, T_9: 100% NPK + 300 kg wellgrow grain ha^{-1}

At all stages of wheat highest no of tillers/m were recorded with treatment T_8 (98, 153, 136 and 90) and this treatment significantly superior to all rest of treatments. At 60 DAS number of tillers/m were increased as compared to 30 DAS. At 90 DAS tillers decreased as compared to 30 and 60 DAS. The maximum tillering in above mentioned treatments might be attributes to the more availability of macro and micro nutrients. Nutrients are an integral part of plant constituents but showed effective influence on all the growth parameter (number of tillers, dry matter accumulation etc.) on account of its balancing influence on the compatibility of different nutrient in soil solution resulting into greater uptake and utilization of all essential nutrients. Tillering is closely related to the physical conditions of soil that were improved by addition of organic matter This is in agreement with the earlier findings of Singh *et al*. (2011).

Dry matter production (g): The experimental results revealed that almost a consistent increase in the dry matter production occurred with the advancement of the crop growth stages and reaching the maximum at the maturity. The rate of increase in dry matter production was enhanced rapidly between 30 to 90 DAS. It is clearly evident that application of 100% NPK + 300 kg wellgrow soil/ha produced lucidly significantly higher dry matter production g/plant than lower doses at all the stages. Among all the treatments at 30 and 90 DAS with treatment T_8 caused maximum (86.6 and 295 g/plant, respectively) production of dry matter and this was significant superior over rest other treatments except 100% NPK+300 kg wellgrow grain/ha. At harvest the highest value was recorded with treatment T_8 (304 g/plant) which was significantly superior rest of treatment except T_7 (267) and T_9 (285), this may be due to the application of N through wellgrow is probably due to enhanced availability of nutrients might have helped in enhancing leaf area resulting in a higher photo-assimilates and there by resulted in more dry matter production. These finding is in close agreement with Kumar and Dhar, (2010).

Effective tillers m^{-2}: Effective tillers m^{-2} is the most important component of yield. Number of tillers is closely related to yield of wheat; more number of tillers especially fertile tillers, the more will be the yield. A close analysis of the revealed marked effect of various NPK levels with wellgrow formulations on the production of effective tillers m^{-2} of wheat. There was a significant improvement in the effective tillers m^{-2} with the application of graded doses of fertilizers up to 100% NPK+ 300 kg/ha wellgrow grain which produced significantly higher effective tillers m^{-2}. Among all the treatments T_9 (362 m^{-2}) gave maximum number of effective tillers m^{-2} (Table-3). Tillering is an important trait for grain production and is thereby an important aspect in wheat yield. Singh et *al*. (2011) reported increase in number of effective tillers in wheat crop due to influence of different fertilizer combinations. According to them more number of tillers per square meter might be due to the more availability of nitrogen, which plays a vital role in cell division. Organic sources offer more balanced nutrition to the plants, especially micro nutrients which positively affect number of tiller in plants (Sharma and Singh, 2011).

Spike length: The application of the graded doses of NPK with wellgrow formulations significantly increased the length of spike. Any curtailment of nutrient levels i.e. 50% and 75% NPK caused significant reduction in spike length. Among the two levels of organic source, the maximum length of spike (8.92 cm) was recorded with 100% NPK + 200 kg wellgrow grain/ha (Table-3). The spike length was directly showed the higher no of grains in panicle so that yield will be increased. The application of organic manure with inorganic fertilizers increased the nutrient mineralization and their availability for crop growth and higher yield. Similarly results were reported by Chuan et *al*. (2013).

Number of grain/spike: The different nutrient management practices of wheat significantly affected the yield components as effective grains/spike of wheat. It is evident from the data that maximum no of grain with 100% NPK with 300 kg wellgrow soil/ha. In term of per cent 29.79% higher value over the control (Table-3). These results are supported by Kallesh *et al*. (2012).

Test weight: The varying nutrient management practice *i*.e. NPK levels with wellgrow formulations brought about marked increase in the test weight of wheat. There was a consistent and non-significant increase in test weight with increasing levels of NPK application with wellgrow forms up to 100% NPK + 300 wellgrow soil/ha which gave 13.20% higher test weight over control. Nevertheless, the lowest test weight (35 g) of wheat was noticed with 50% NPK + 200 kg wellgrow grain/ha (Table-4). The results of present experiment confirmed the finding of Singh *et al.,* (2009).

Grain yield (q/ha): The wheat yield revealed that the crop responded significantly to combined application of organic manure and inorganic fertilizers as compared to control. Data generated from the present field study clearly indicated that significant (P = 0.05) increase in grain yield of wheat with increasing in NPK level significantly up to 100%, + 300 kg wellgrow grain/ha which was 26.54% over control. Maximum grain yield was recorded (41.2) with 100% NPK +200 kg wellgrow grain/ha and it was significantly superior all over the treatment except T_8 (39.9). The lowest value of grain yield was recorded with 100% NPK (Table-4). The grain yield of wheat was significantly increased by combined effect of organic and inorganic sources of nutrients. Organic manures, as discussed earlier, increased the fertilizer use efficiency and improved the physical and chemical properties of soil hence making better utilization of nutrients might also be a reason towards increased yield Singh *et al.,* (2009). Similar results were reported by Chuan *et al*. (2013).

Straw yield (q ha^{-1}): It was apparent from the data that increasing NPK levels from 50% NPK to 100% NPK exerted marked increase in straw yield. Among the treatments maximum straw yield was recorded in 100% NPK +300 kg wellgrow soil/ha (53.53) which was significant higher than T_1 (45.30), T_2 (48.04), T_4 (48.53), T_5 (49.53). Straw yield is a function of vegetative growth. The increase in growth and yield owing to the application of inorganic fertilizer may be attributed to the fact that this nutrient being important constituents of nucleotides, proteins, chlorophyll and enzymes, involves in various metabolic processes which have direct impact on vegetative and reproductive phase of plants. These findings confirm those of Sharma and Singh (2011); Chuan et *al*. (2013).

Harvest index (%): It is apparent from the data on harvest index of wheat as affected by recommended doses with wellgrow formulation soil and grain. Harvest index range from 39.76 to 44.17% (Table-3) was recorded in wheat. These findings confirm those of Rahimi, (2012).

In the present research, the use of concentrate organic manure with inorganic fertilizers significantly affected growth and yield of wheat variety HUW-234. Among treatments, the application of wellgrow grain @300 kg ha^{-1} with 100% NPK had significantly positive effect on most of growth and yield contributing parameters of wheat. However, application of 100% NPK + 300 kg wellgrow grain ha^{-1} in wheat was found statistically significant with most of the observed parameters.

ACKNOWLEDGEMENTS

The author acknowledges financial support available from Indian Tobacco Company (ITC) and facilitation obtained from Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, BHU Varanasi.

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