

Original Research Article

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Wheat Physiological Parameters under Long Term Fertilizer and Manure Application in a Vertisol

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ABSTRACT

Keywords

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A field experiment was conducted in an on going Long-Term Fertilizer Experiment during 2017-18 and 2018-19 at the Research Farm, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur to study the effect of long-term fertilizer application on performance of wheat crop and soil properties. The experiment was conducted in a randomized block design with ten treatments in four replications. The treatments comprised were 50% NPK, 100% NPK, 150% NPK, 100% NPK + Hand weeding, 100% NPK + Zn, 100% NP, 100% N, 100% NPK + FYM, 100% NPK-S and Control. The wheat crop (cv. GW-366) was grown with recommended nutrient dose of 120:80:40 (N: P₂O₅: K₂O) in rabi season. The leaf area index, leaf area duration and relative growth rate was determined at important growth stages viz., crown root initiation, tillering stage, flowering stage, milking stage and at dough stage. The grain and straw yield were recorded at crop harvest. The results revealed that, the wheat responded positively to the balanced nutrition as compared to no fertilization and imbalanced fertilization. The wheat physiology and crop yield showed significant and positive response to 100% NPK + FYM, recommended NPK and super optimal NPK application. The stage wise physiological response of wheat was also observed irrespective of the treatments.

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops globally and is a staple food for about one third of the world's population. It occupies second position both in terms of area and production in the world (Evans and Wardlaw, 1996). It is cultivated over an area of 29.86 million hectares with an annual production of 94.88 million tonnes and

productivity of 3.18 Mt/ha in India, whereas in Madhya Pradesh, it is cultivated in 4.89 thousand hectares of land with an annual production of 12.69 million tonnes and productivity of 2.36 Mt/ha (Krishnan *et al.*, 2019).

Long Term Fertilizer Experiment (LTFE) plays an important role in understanding the complex interactions between soil, plant and

environmental continuum (Dwivedi and Dwivedi, 2015). The LTFE provides valuable inputs for making the agriculture sustainable where the fertilizer application is very high and cropping is intensive (Singh and Wanjari, 2013). At the beginning of the LTFE's, they were aimed for optimum production with fertilizer application and study the ill effects on soil (Dwivedi *et al.*, 2018).

The aim of starting the LTFE was to study the impact of the continuous addition of fertilizer and organic manure for sustainability of high production farming (Tomar and Dwivedi, 2007; Dwivedi *et al.*, 2007). The continuous and imbalanced fertilizer application to the soils resulting in deterioration of soil health especially due to imbalanced fertilizer application and continuous application of inorganic fertilizer without organic inputs (Rajput *et al.*, 2016; Singh and Wanjari, 2018). However, the combined application of manures and chemical fertilizers has shown beneficial effects on soil physico-chemical and biological properties, and crop yields (Dwivedi *et al.*, 2016). The changes in soil properties are reflected in crop economic yield through physiological parameters in a growing crop.

The physiological parameters ultimately show positive influence on cell size, leaf area and ultimately photosynthetic activity (Rahman *et al.*, 2000). Nutrient management offers the opportunity for increasing wheat growth, yield and its nutrient components (Bange 2018; Dotaniya *et al.*, 2020). Appropriate fertilizer application rates and methods enhance the crop physiology and it reflects in to the crop yield. Increase in net accumulation rate is attributed to increased photosynthetic capacity of the leaves with improved nutrition of the plants.

The Relative Growth Rate (RGR) improve with the increasing soil N availability for

plant (Warraich *et al.*, 2002). The present field experiment was carried out to study the response of long-term fertilizer application on physiological parameters and wheat productivity in a Vertisol of central India. The integrated use of organic manuring and inorganic fertilizers has maintaining favourable ecological conditions and helps to restore and sustain fertility and crop productivity on long-term basis (Kumar & Dey, 2007).

Materials and Methods

Experimental site, climate and soil characteristics

Present study was conducted in an ongoing scheme All India Coordinated Research Project (AICRP) on Long Term Fertilizers Experiment (LTFE) of Indian Council of Agricultural Research (ICAR). The LTFE is laid out on a permanent site at the Experimental field Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalyaya, Jabalpur (M.P.). The experimental site is located in 'Kymore Plateau and Satpura Hills' agro climatic region of M.P. It falls on 23.9° N latitude and 79.6° E longitudes with an altitude of 411.8 m above the mean sea level.

Jabalpur is situated in the semi-arid region having sub-tropical climate with hot dry summer, and cold winter. The average rainfall is about 1350 mm, which is mainly distributed from mid-June to October. The maximum and minimum temperature ranges between 35.1°C and 5.3°C. The average annual relative humidity is 62-70%. The experiment was started in 1972; the cropping sequence being followed is soybean (Kharif) and wheat (Rabi). The soil of the experimental field is medium black belonging to Kheri series of fine montmorillonitic hyperthermic family of Typic Haplustert.

Treatments detail

The experiment was started from since 1972 with 10 different treatments. The details of the treatments are presented in Table 2. The 100% optimal NPK doses based on initial (1972) soil test values was 120:80:40 (N: P₂O₅: K₂O) for wheat. Nitrogen was applied through urea, phosphorus through single super phosphate and potassium was applied through murate of potash.

The farm yard manure (FYM) treatment was applied @ 5-ton ha⁻¹ year⁻¹ to soybean crop only. Due to build-up of Zn content in soil, the application of Zn as ZnSO₄ @ 20 Kg ha⁻¹ in alternate year to wheat crop was discontinued since, 1987. The treatments comprised were 50% NPK, 100% NPK, 150% NPK, 100% NPK + Hand weeding, 100% NPK + Zn, 100% NP, 100% N, 100% NPK + FYM, 100% NPK-S and Control.

Physiological observations

The wheat crop (cv. GW-366) was grown with nutrient dose of 120:80:40 (N: P₂O₅:K₂O) in *rabi* season of 2017-18 and 2018-19. The crop was sown in last week of November and first week of December in *rabi* season of 2017-18 and 2018-19, respectively. Similarly, the crop was harvested at physiological maturity in April.

The periodic wheat physiological parameters such as leaf area index (LAI), leaf area duration (LAD) and relative growth rate (RGR) were determined by standard methods (Watson, 1952). The physiological parameters were determined at crown root initiation (CRI), tillering stage (TS), flowering stage (FS), milking stage (MS) and at dough stage (DS). The field experiment was laid in a randomized block design (RBD) with ten treatments in four replications.

Statistical analysis

The data found was compiled and analysed for its significance ($p=0.05$) by statistical procedure for randomized block design as outlined by Gomez and Gomez (1984).

Results and Discussion

The physiological parameters of wheat viz. leaf area index, leaf area duration and relative growth rate, were studied during important growth stages and yield was recorded at harvesting of the crop.

Leaf Area Index

The pooled data of leaf area index (LAI) of wheat differed significantly under the influence of various treatments under long term fertilizer application during the various crop growth stages of wheat viz., crown root initiation (CRI), tillering (TS), flowering (FS), milking (MS) and dough stage (DS). The highest LAI of at CRI, TS, FS, MS and DS, respectively was observed under the treatment involving application of organic manure along with inorganic fertilizer i.e. treatment T₈ 100%NPK + FYM (0.67, 1.93, 3.71, 3.39 and 1.82). The data with respect to the LAI at various growth stages clearly showed that maximum values was found with higher doses of fertilizer followed by imbalanced, suboptimal fertilizer and balanced fertilizer application throughout the growth period. The leaf area was increased as growth of the plant proceeded from early to maturity. The lower LAI was found at FS and increased at MS but found declined further at DS. It has also been observed that the LAI was found significantly influenced under various treatments under study irrespective of the growth stages of wheat. The highest LAI was observed during flowering stage to milking stage irrespective of the treatment applied. The leaf area index expresses the

ratio of leaf surface (one sided green leaf area) to the ground area occupied by the crop. It also describes the functional size of assimilatory apparatus of other growth parameters (Watson, 1947). The assimilatory surface area of crop stands and its increase has a direct bearing on the amount of solar energy intercepted by canopy and represented the productive capacity of a crop. Yagoub *et al.*, (2012) showed an increase in LAI in

100% NPK + FYM as compared to control. The balanced use of fertilizer is also known for significantly increasing LAI (Singh and Sharma, 2014). Application of organic manure along with chemical fertilizer increased leaf area index as compared with inorganic fertilizer alone. The maximum leaf area was expressed (30, 45 and 60 DAS) in treatment 100% NPK + FYM by Verma *et al.*, (2017).

Table.1 Effect of long-term application of fertilizer and manure on leaf area index and leaf area duration in wheat

Treatment	Leaf area index					Leaf area duration (cm ² days)			
	CRI	TS	FS	MS	DS	CRI	TS	FS	DS
T ₁ -50% NPK	0.42	1.45	2.47	2.44	1.24	53.2	112.0	204.8	158.6
T ₂ - 100% NPK	0.55	1.68	3.01	2.92	1.54	64.8	127.5	241.0	187.7
T ₃ - 150% NPK	0.66	1.92	3.68	3.36	1.81	74.2	143.2	275.1	217.6
T ₄ - 100% NPK+HW	0.52	1.60	2.95	2.87	1.52	62.9	125.4	236.3	187.1
T ₅ - 100% NPK+Zn	0.53	1.62	2.97	2.88	1.53	63.6	126.0	238.0	187.2
T ₆ - 100% NP	0.45	1.50	2.46	2.53	1.34	57.1	110.3	194.0	158.5
T ₇ - 100% N	0.32	1.20	1.92	1.87	0.94	45.0	96.1	160.5	127.9
T ₈ - 100% NPK+FYM	0.67	1.93	3.71	3.39	1.82	75.0	147.8	280.6	219.3
T ₉ - 100% NPK-S	0.49	1.55	2.91	2.83	1.49	62.6	118.1	231.9	180.3
T ₁₀ - Control	0.27	0.79	1.88	1.76	0.91	43.6	94.1	153.3	117.7
SEm ±	0.03	0.06	0.16	0.12	0.06	2.39	5.09	9.38	9.38
CD (p=0.05)	0.08	0.17	0.47	0.35	0.18	6.93	14.75	27.21	27.21

Table.2 Effect of long-term application of fertilizer and manure on relative growth rate in wheat

Treatments	Relative growth rate (g ⁻¹ g ⁻¹ day)			
	CRI	TS	FS	DS
T ₁ -50% NPK	0.017	0.020	0.028	0.004
T ₂ - 100% NPK	0.025	0.030	0.039	0.008
T ₃ - 150% NPK	0.032	0.036	0.047	0.010
T ₄ - 100% NPK+HW	0.022	0.025	0.035	0.006
T ₅ - 100% NPK+Zn	0.023	0.026	0.037	0.007
T ₆ - 100% NP	0.021	0.023	0.033	0.005
T ₇ - 100% N	0.011	0.015	0.019	0.003
T ₈ - 100% NPK+FYM	0.034	0.038	0.048	0.011
T ₉ - 100% NPK-S	0.021	0.024	0.034	0.006
T ₁₀ - Control	0.011	0.013	0.017	0.002
SEm ±	0.027	0.001	0.001	0.002
CD (p=0.05)	0.106	0.003	0.004	0.005

Table.3 Grain and straw yield of wheat under different treatments given below

Treatments	Grain yield (t ha ⁻¹)			Straw yield (t ha ⁻¹)		
	2017	2018	Mean	2017	2018	Mean
T₁-50% NPK	4.30	4.19	4.24	5.38	5.56	5.47
T₂- 100% NPK	5.38	5.23	5.30	5.82	6.02	5.92
T₃- 150% NPK	5.99	6.03	6.01	6.12	6.31	6.22
T₄- 100% NPK+HW	5.33	5.25	5.29	5.90	6.11	6.01
T₅- 100% NPK+Zn	5.37	5.26	5.32	6.11	6.26	6.19
T₆- 100% NP	4.38	4.15	4.26	5.62	5.79	5.71
T₇- 100% N	1.78	1.78	1.78	5.26	5.44	5.35
T₈- 100% NPK+FYM	6.18	6.14	6.16	6.46	6.68	6.57
T₉- 100% NPK-S	4.58	4.54	4.56	5.73	5.98	5.86
T₁₀- Control	1.45	1.36	1.41	3.87	4.02	3.95
SEm ±	0.26	0.24	0.24	0.32	0.36	0.57
CD (p=0.05)	0.76	0.71	0.91	0.93	1.05	1.22

Fig.1 Meteorological observations during experimental period

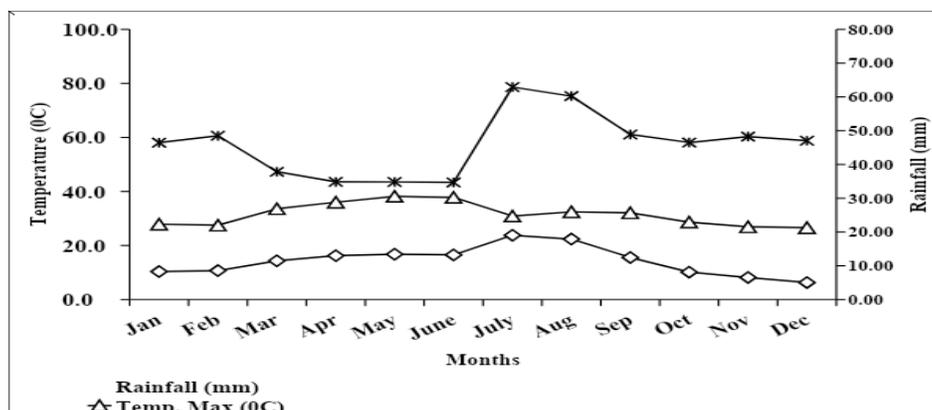


Fig.2 Effect of long-term application of fertilizer and manure on Leaf area index

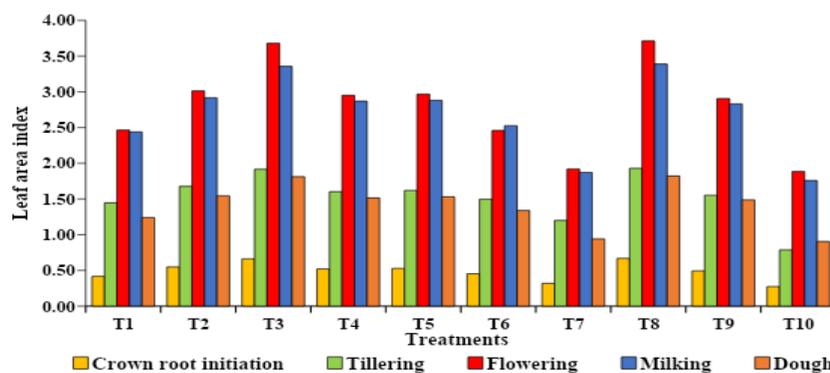


Fig.3 Effect of long-term application of fertilizer and manure on leaf area duration (cm² days) of wheat

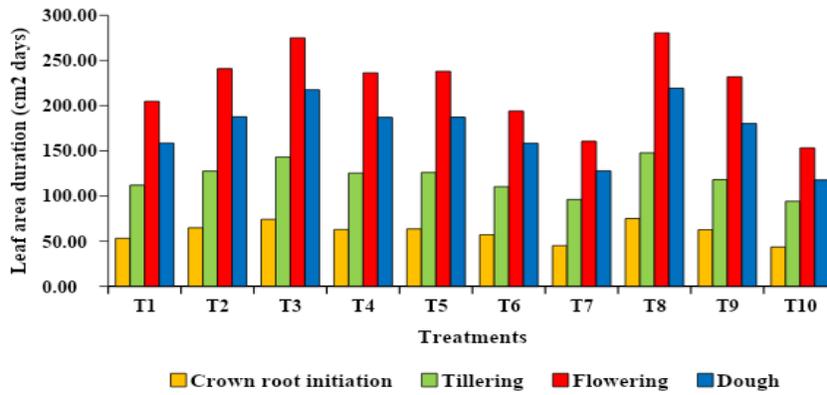


Fig.4 Effect of long-term application of fertilizer and manure on relative growth rate (g⁻¹ g⁻¹ day) of wheat

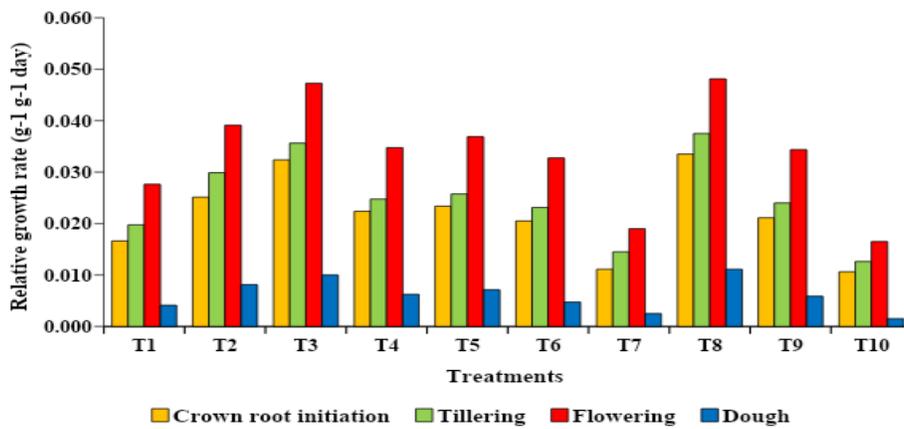
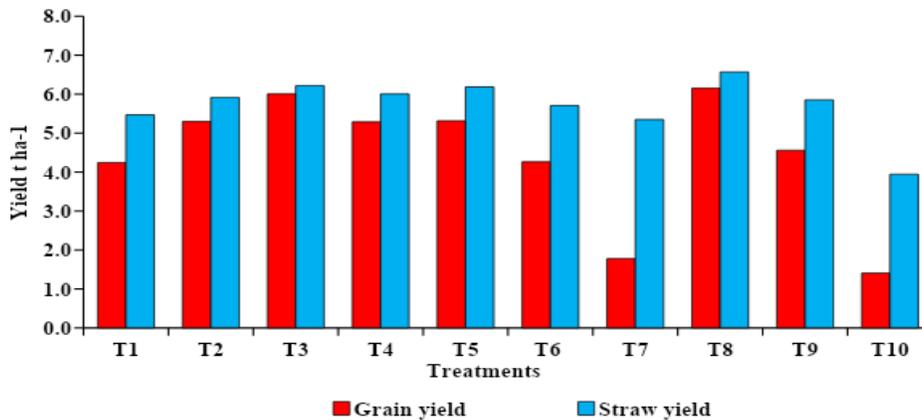


Fig.5 Grain yield and straw yield of wheat under various treatments



Leaf area duration

The LAD of wheat was found highest under the treatment receiving 100% NPK + FYM (75, 147.8, 280.6, 219.3 cm² days) followed by super optimal dose of fertilizer 150% NPK (74.2, 143.2, 275.1 and 217.6 cm² days) and recommended dose of chemical fertilizers (100% NPK). The lower LAD values were found under sole N application 100% N (45, 96.1, 160.5, 127.9 cm²days) and under unfertilized control (43.6, 94.1, 153.3, 117.7 cm²days). The leaf area duration was increased with the growth of the plant and again declined i.e. early to flowering and flowering to maturity. Hence, the lower LAD values were found at tillering stage and increased till flowering stage but was found declined at dough stage (Peltonen-Sainio *et al.*, 1997). Bandopadhyay *et al.*, (2010), Kumar *et al.*, (2012) and Shaukat *et al.*, (2020) reported similar findings with respect to the LAD. The LAD expresses the magnitude and persistence of leaf area and leafiness during period of crop growth. Similarly, LAD may express the ability of plant to produce and maintain leaf area and efficiency to assimilation during growing season which is described as the leaf area duration (Watson, 1947) and it is also called the photosynthesis potential (Kvet, 1978). The LAD is significantly dependent on the maintenance of photo synthetically active assimilatory surface area. These processes are influenced by both genetic as well as environmental factor especially nutrient management (Singh and Agarwal, 2001).

Relative Growth Rate

The relative growth rate (RGR) was found higher with optimal dose of fertilizer along with organic manure at various growth stages (CRI, TS, FS and DS) followed by super optimal dose of fertilizer (0.032, 0.036, 0.047 and 0.010 g⁻¹g⁻¹ day). The lowest RGR

content in control (0.011, 0.013, 0.017 and 0.002 g⁻¹g⁻¹ day) and highest in value was observed in 100% NPK + FYM (0.034, 0.038, 0.048 and 0.011 g⁻¹g⁻¹ day). The maximum RGR was expressed at CRI, TS, FS and DS in treatment 100% NPK + FYM. Karimi and Siddique (1991) studied the RGR of wheat in Australia and found significant differences under different nutrition. Similarly, Tandale and Ubale (2007), Alam (2013), Mohanty *et al.*, (2015) and Verma *et al.*, (2017) observed the significantly higher growth rates in wheat under the application of higher nitrogen and combined application with organic manures in various soil types.

Crop productivity

The two-year pooled data of grain yield and straw yield of wheat showed during 2017-18 and 2018-19 is presented in table 3 and Fig 5. The grain and straw yield of wheat was significantly influenced under various nutrient management practices. The highest grain yield and straw yield was observed under the treatment T8 receiving combined application of 100% NPK and FYM @5t/ha (6.16 and 6.57 t ha⁻¹) followed by T3 (6.01 and 6.22 t ha⁻¹) and T5 (5.32, 6.19 t ha⁻¹). The grain yield and straw yield of wheat crop followed similar trend during the period of investigation. The lowest grain and straw yield were observed in unfertilized control (1.41 and 3.95 t ha⁻¹). Organic manures and inorganic fertilizers with combinations, as increased the nutrient 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 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. The data clearly indicated that under intensive cultivation addition of integrated application of fertilizer with FYM was found to be beneficial for maintain the fertility of the soil as well as subsequently improving the potential of soybean-wheat cropping system (Dubey & Dwivedi, 2016). These findings confirm those of (Sharma and Singh 2011; Chuan *et al.*, 2013).

In conclusion the wheat responded positively to the balanced nutrition as compared to no fertilization and imbalanced fertilization. The wheat physiology showed significant and positive response to NPK+FYM, recommended NPK and super optimal NPK application. The stage wise physiological response of wheat was also observed irrespective of the treatments. The impact of integrated approaches on wheat physiology were showed the maximum growth of the plant and higher productivity.

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