GRAIN YIELD OF NEWLY DEVELOPED WHEAT CULTIVAR (NARC 2011) AS ENHANCED BY FOLIAR APPLICATION OF HUMIC ACID UNDER RAINFED CONDITIONS

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ABSTRACT

A newly developed wheat cultivar NARC 2011 was evaluated for physio- agronomic traits by varying Humic acid concentrations and Effective microbes at different phenological stages during rabi season of 2010-11 in the field area allocated to national coordinated wheat program of national agricultural research centre, Islamabad. The experiment was laid out using randomized complete block design (RCBD) for an assortment of growth and yield characters at various Humic acid concentrations and Effective microbe under rainfed conditions. There were six treatments and were replicated three times. Results revealed that E.M enhanced sub stomatal CO_2 concentration in the flag leaf of mother shoot significantly, whereas for transpiration rate, spike length, number of spikelets spike^{-1}, flag leaf area and thousand seed weight, its effect but statistically at par. The highest grain yield of 3566 kg ha^{-1} was achieved at N P (115:85 kg ha^{-1}) in combination with 3000 mL ha^{-1} concentration of humic acid at tillering +flag leaf initiation +grain filling stages hence resulting in 30 percent greater yield than control (2747 kg ha^{-1}). Similarly the highest biological yield of 12667 kg ha^{-1} was achieved at same level of NP in combination with 3000 mL ha^{-1} concentration of humic acid at tillering +flag leaf initiation +grain filling stages hence resulting in 31 percent greater biological yield than control (9667 kg ha^{-1}). Hence in order to achieve higher biological and grain yield in rainfed regime, humic acid along with optimum recommended area specific NP levels depending up on soil nutritional status may be applied at appropriate phenological stages of wheat crop.

Key words: **Wheat, Advance line; Humic acid; Effective microbes; Grain yield; Phenological stages**

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INTRODUCTION

The magnitude of wheat is escalating being a most essential staple food of the people of Pakistan with the increasing population and its giant need for food security. It contributes 10.1 percent (%) to value added in agriculture and 2.2 % to GDP. The average wheat yield of Pakistan is 2787 kg ha^{-1} (Anon, 2012-13). Although the average yield in Pakistan has improved 3.2 percent (%) compared to the previous year due to high yielding cultivars, implementation of improved production management, increase in wheat support price and positive weather conditions but still less than the yield potential of existing wheat cultivars. Wheat yield can be enhanced through genetics means with the development of new varieties having better yield potential and appropriate crop managing techniques. High yielding varieties demand adequate nutrient supply to produce maximum grain yield (Ali and Yasin, 1991).Cultivars take an active part in increasing per hectare yield under optimum growing season. A lot of wheat varieties have been evolved but many of these have lost their adaptability to site specific environmental conditions. Every crop variety has its own explicit requirements for particular agro-ecological conditions to have optimum growth and grain yield (Qasim *et al*., 2008). Different wheat cultivars respond in their own way for their genotypic characters, input requirements, growth and development processes to the prevailing environment during growing season which may result in significantly diverse grain yield and growth traits (Alam *et al*., 2007). Sustainability in agriculture is an important goal, which can be gained through the effective and economic utilization of natural resources as well as careful management of agricultural inputs.

Fertilizers are the important input, which is proved to be essential for better and quality production. Deficient and excessive fertilization induces ill-effects on crop health and produce quality. The fertilizer requirements of plants differ with nature and age of plant, edaphic and climatic factors. Balanced nutrients availability at the proper growth stage improves yield, quality and other growth characters. Organic matter (O.M) acts as store house of nutrients and can reduce the use of mineral fertilizers. Organic fertilization enhances vegetative growth, yield and reduces the residual effects of nitrates and nitrites. It significantly affects the soil microbial activity, soil aggregation and utilization of chemical fertilizers. Soil organic matter status in the cropped fields can be raised by adopting conventional methods like utilization of farm yard manure (FYM), crop residues, composts etc. The supplementation of chemical fertilizers with cheaper lignitic coal derived humic acid could reduce cost of production without compromising on yield. Humic acid (HA) is a natural product, which is present in Pakistan's lignitic coal in reasonable concentrations and is used in agriculture. The substantial increase in seed cotton yield with combined application of 1.0 kg HA ha^{-1} with NPK over alone NPK revealed additive effect of HA. This suggested that supplementation of chemical fertilizer with humic acid could reduce the cost of production without compromise on yield and thus could increase the farmer's income. (Haroon *et al*., 2010). Non conventional sources utilized for improvement of soil organic matter status include use of humate products as bio-fertilizers and bio-stimulants, which should be encouraged among farmers. They prove to be an immediate source of improving soil fertility. It is helpful over conventional organic matter sources because of easy availability, feasibility in using over large area, immediate response to plants, less handling problems and keeping the environment, pollution free. EM (Effective Microbes) contains microbes that can enhance the natural fertilising processes within the soil, increasing the resident nitrogen fixation capacity directly through the stimulation of N fixing bacteria, and indirectly by increasing clover growth, increasing mycorrhizal activity and reducing the need for fertiliser inputs, whilst maintaining levels of production.

Synthetic fertilizers are very costly and do not fulfill the farmer's demand, so there is need to use biochemicals like humic acid and micro nutrients to increase yield. Subsequent decomposition of dead material and modified organic matter results in the formation of more complex organic matter, called humus (Juma, 1998). This process is called humification. Humus consists of a group of humic substances that includes humic acids, fulvic acids, hymatomelanic acids and humins (Tan, 1994) and is probably the most widely distributed organic carbon-containing material in terrestrial and aquatic environments. Thus humic acid is capable of improving seed germination, root initiation and uptake of plant nutrients, and serves as a source of nitrogen, phosphorus and sulphur (Tan, 1994; Schnitzer, 1986). Indirectly, they may affect plant growth through modifications of physical, chemical and biological properties of the soil, such as an increase in water holding capacity and cation exchange capacity, and improvement of tilth and aeration through good soil structure (Stevenson, 1994). Humic substances (humic and fulvic acid) constitute 65-70 % of the organic matter in soils (Abbas *et al*., 2009). It is used as a supplement to chemical fertilizers to enhance their utilization in many crops. It also reduces fertilizer requirement of the crop by encouraging the activity of microorganisms which enhances the plant growth. Humic acid is found to affect the morphological, physiological and biochemical attributes of different crops (Clapp *et al*., 2001).The newly released wheat cultivar (NARC 2011) is a wheat genotype and little information is available regarding its growth and yield attributes, therefore its physiological and agronomic performances were checked at different concentrations of humic acid and E.M under rainfed conditions of pothowar, Pakistan.

MATERIALS AND METHODS

The experiment was conducted at National Coordinated Wheat program of National Agricultural Research Centre (NARC), Islamabad (33° 42' N, 73º 10' E) during rabi season of 2010-11 to evaluate new wheat cultivar NARC 2011 which was developed by National Coordinated Wheat Programme, NARC, Islamabad. The new cultivar was assessed at different humic acid concentrations and one concentration of Effective microbes at different phenological stages for various growth and development parameters in relationship with grain yield under rainfed conditions. Weather data were collected from the Meterogical observatory of Water Resources Research Institute, Field Station NARC Islamabad. The soil was sandy loam having a pH of 8.13, Olsen-P of 1.13mg kg^{-1} and 22.2 mg kg^{-1} nitrogen, potassium 107.6 mg kg^{-1} and Ec 0.33 ds m^{-1}.

The crop was sown on November 10, 2010 with a seed drill adjusted for six rows at 25 cm row spacing using the seed rate of 120 kg ha^{-1}. The plot size was 2.5 m x 5 m. The trial was laid out in randomized complete block design (RCBD). Humic acid was present as 8 % (wt/vol). In 3000 $mLha^{-}$ level, 240 g humic acid was dissolved in three litter water. EM and HA were procured from Water Resources Research Institute and Organic Directorate, NARC Islamabad. The treatments were T1 Control (N: P 115 : 85 kg ha^{-} sole application), T2 HA1 (Humic Acid @ 3000 mL ha^{-} at tillering + Flag leaf initiation + grain filling), T3 HA2 (Humic Acid @ 6000 mL ha^{-}), T4(E.M @ 1 : 500 L ha^{-}), T5 HA1+EM (Humic Acid @ 3000 mL ha^{-} + E.M @ 1 : 500 L ha^{-}) and T6 HA2+EM (Humic Acid @ 6000 mL ha^{-} + E.M @ 1 : 500 L /ha). N and P were uniformly applied in all treatment plots. At the mentioned stages, foliar sprays of humic acid and E.M were made on the wheat plants in designed plots by use of knap sack hand sprayer machine after calibrating it. All the other agronomic measures were kept standardized.

The observations on different growth and development parameters were recorded along with the grain yield. Photosynthetic rate, sub stomatal CO_2 concentration, transpiration rate and stomatal conductance of three leaves from mothershoot from each treatment per plot were measured at flag leaf stage under field conditions after calibrating and adjusting LC Pro, portable photosynthesis system which is principally based on the concept of non destructive method of measuring plant's inside mechanisms. The device consisted of an enclosed reservoir; the reservoir contained a volume of CO_2 enriched air, which was monitored by an infrared gas analyzer (IRGA). When the internal CO_2 concentration within the reservoir was elevated, diffusion rates through the porous medium were measured by recording changes in CO_2 concentration within the reservoir. All gas exchange measurements were made between the hours of 1000 and 1400. The LC Pro was ''environmentally controlled'' with an adjustable light source and a Peltier-cooling unit built into the Parkinson Leaf Chamber (PLC). The measurement light level was maintained at about 800 µ mol m^{-2} s^{-1}. The chamber temperature ranged between 25^o and 29^oC among days. *Impatiens capensis* exhibits maximum carbon assimilation rates at a photon flux density of approximately 800 µ mol m^{-2} s^{-1}, irrespective of sun-shade acclimation (Heschel *et al*., 2004). Thus, gas exchange measurements were made under light-saturating conditions. The light levels used were higher than average ambient levels. Flag leaf area was taken manually on (length * width * 0.75 correction factor) basis. Number spikelets $spike^{-1}$ was recoded by counting at maturity. Spike length and plant height were measured for each plot with the use of a meter rod. Thousand-seed weight was measured with the help of an electronic balance. Biological and grain yields were determined for each plot and then the average was computed and converted into kg ha^{-1}.

Statistical analysis was performed with the use of a computer software package, "Statistix" to analyze the data and the means were compared on least significance difference basis as described by Steel and Torrie (1997).

RESULTS AND DISCUSSION

Climatic Conditions during the Crop Period (2010-11)

The weather conditions for the period under research are summarized in Fig. 1. Seasonal rainfall was 225.3 mm (Fig. 1). The maximum rainfall was recorded in the month of February (78.73 mm). The air temperature during the season was normal. Mean air temperature of November, December, January, February, March and April were 26.0, 20.1, 17.3, 17.7, 25.8 & 28.8^o C (Fig. 1). The maximum average temperature was recorded in the month of April (28.8^oC). The minimum average temperature was observed in the month of January (1.8^oC).

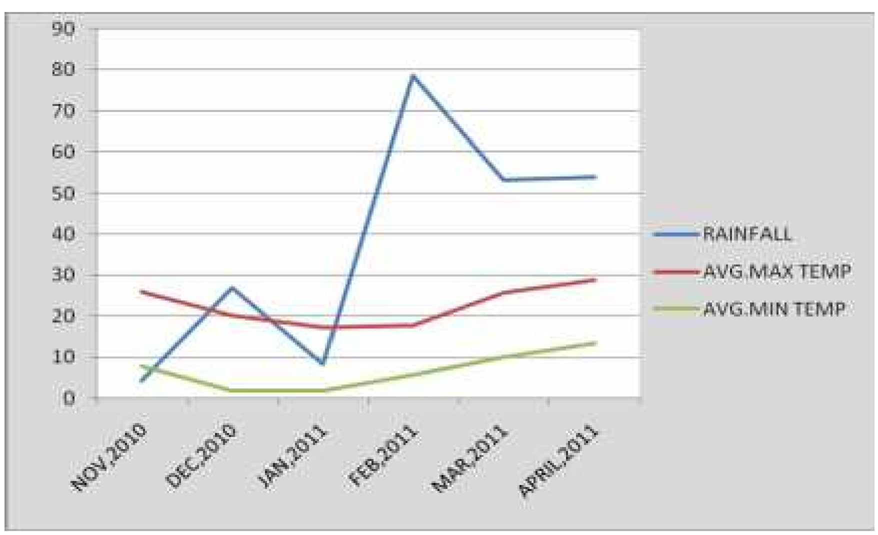

Fig. 1. Average Maximum/Minimum Temperature and Rainfall Pattern during the 2010-11

Physiological Traits

From the data given in the table (I) revealed that there was non significant effect among the treatments for photosynthetic rate (µ mol m^{-2} s^{-1}). The highest photosynthetic rate (12.563) was observed in T5 (HA1 + E.M) followed by T6 (HA2 + E.M)which was 12.100, whereas the lowest was recorded in T1 (N: P 115 : 85 kg/ha) which was 11.023. These findings are in line with the work of Delfine *et al.,* (2005) who narrated that Humic acid did not affect photosynthesis, while Rubisco activity and leaf protein content showed intermediate responses between unfertilized control and split soil N application.

From the data given in the table (I) shown that there was significant effect among the treatments for Sub stomatal CO_2 concentration (µ mol mol^{-1}). The highest (198.00) was observed in T4 (E.M) followed by T3 (HA2) which was 184.00, whereas the lowest was recorded in T6 (HA2 @ 6000 ml /ha + E.M) which was 161.33. From the data, it is shown that sole foliar application of E.M significantly enhanced sub stomatal CO_2 concentration. Whereas sub stomatal CO_2 concentration was lower in HA and HA+E.M, it might be due to slowing down of mineralization of organic matter by the application of humic acid, hence lower concentration was recorded.

Table 1. ***Effect of Humic acid and EM on Physiological Traits of wheat cultivar NARC 2011 at Flag Leaf Stage***

Treatments	Photosynthetic rate (A) (µ mol m^{-2} s^{-1})	Sub Stomata CO_2 Concentration (Ci) (µ mol mol^{-1})	Transpiration rate (E) (mol m^{-2} s^{-1})	Stomatal conductance (gs) (mol m^{-2} s^{-1})
T1 (NP)	11.023 NS	180.67 b	3.0367 NS	0.2000 NS
T2 (HA1)	11.897	168.33 bc	3.2733	0.2533
T3 (HA2)	11.913	184.00 ab	3.1333	0.2500
T4 (EM)	11.823	198.00 a	3.7767	0.2767
T5 (HA1+EM)	12.563	168.33 bc	3.4133	0.2033
T6 (HA2+EM)	12.100	161.33 c	3.4800	0.2933
LSD(5 %)	**1.3813**	**17.139**	**0.6892**	**0.1190**

Means in a column not sharing a letter in common differ significantly at ($p \leq 0.05$)

HA1 (Humic Acid level 1 i.e 3000 ml ha^{-1}), HA 2 (Humic Acid level 2 i.e 6000 ml ha^{-1}), E.M (Effective Microbes)

From the data shown in the table (I) revealed that it was non significant difference among the treatments for transpiration rate (mol m^{-2} $s^{-1)}$. The highest transpiration rate (3.7767) was observed in T4 (E.M @ 1 : 500 L /ha at tillering + Flag leaf initiation + grain filling) followed by T6 (Humic Acid @ 6000 ml /ha + E.M @ 1 : 500 L /ha) which was 3.4800, whereas the lowest was recorded in T1 (N: P 115 : 85 kg/ha) which was 3.0367.

From the data incorporated in the table (I) shown that there was non significant effect among the treatments for stomatal conductance (mol m^{-2} s^{-1}). The highest stomatal conductance (0.2933) was observed in T6 (Humic Acid @ 6000 ml /ha + E.M @ 1 : 500 L /ha at tillering + Flag leaf initiation + grain filling) followed by T4 (E.M @ 1 : 500 L /ha) which was 0.2767, whereas the lowest was recorded in T1 (N: P 115 : 85 kg/ha) which was 0.2000. These findings are in partial agreement with the work of Delfine *et al.,* (2005) who narrated that Humic acid did not affect stomatal conductance.

Agronomic Traits

From the data presented in the table (II) revealed that there was significant differences among the treatments for plant height (cm). The highest plant height (105.53) was observed in T2 (Humic Acid @ 3000 ml /ha at tillering + Flag leaf initiation + grain filling) followed by T3 (Humic Acid @ 6000 ml /ha at tillering + Flag leaf initiation + grain filling) which was 101.93, whereas the lowest was recorded in T4 (E.M @ 1 : 500 L /ha at tillering + Flag leaf initiation + grain filling) which was 90.87. These findings are in contrary with the work of Shabaan *et al.,* (2009) who narrated that humic acid in combination with NPK fertilizer didn't show significant increment in plant height of wheat. These results are also in contrary with the findings of Reza and Vahid, (2011) who concluded that potassium humate had not significantly affected on plant height in wheat.

From the data given in the table (II) shown that there was non significant effect among the treatments for spike length (cm). The highest spike length (11.4 cm) was observed in T4 (E.M @ 1 : 500 L /ha at tillering + Flag leaf initiation + grain filling) followed by T3 (Humic Acid @ 6000 ml /ha at tillering + Flag leaf initiation + grain filling) which was 11.36 cm, whereas the lowest was recorded in T2 (Humic Acid @ 3000 ml /ha at tillering + Flag leaf initiation + grain filling) which was 10.7 cm). These findings are in line with the findings of Reza and Vahid (2011), who narrated that a non significant difference was observed by the application of humic acid.

Table 2. ***Effect of Humic acid and EM on Agronomic Traits of New Wheat Cultivar NARC 2011 at phenological stages***

Treatments	Plant Height (cm)	Spike Length (cm)	Flag Leaf Area (cm^2)	No of Spikelet Spike^{-}	Thousand Seed Weight (g)	Biological Yield (kg ha^{-})	Grain Yield (kg ha^{-})
T1 (NP)	100.67ab	11.22 NS	42.26 NS	19.7 NS	33.37 NS	9667 bc	2747.2 b
T2 (HA1)	105.53 a	10.70	37.09	19.3	32.21	12667 a	3566.3 a
T3(HA2)	101.93ab	11.36	40.33	20.0	32.1	10667 abc	3070.5 ab
T4 (EM)	90.87 b	11.4	45.53	20.3	34.0	10000 bc	3189.7 ab
T5 (HA1+EM)	92.70 ab	10.8	41.60	19.0	33.63	8333 c	2652.7 b
T6 (HA2+EM)	91.30 b	10.96	43.83	18.7	33.83	11000 ab	3027.0 ab
LSD(5 %)	**14.201**	**1.7776**	**8.4952**	**2.2771**	**2.6671**	**2516.8**	**554.54**

Means in a column not sharing a letter in common differ significantly at ($p \leq 0.05$)

From the data incorporated in the table (II) revealed that there was non significant effect among the treatments for flag leaf area (cm^2). The highest flag leaf area (45.53 cm^2) was observed in T4 (E.M @ 1 : 500 L /ha at tillering + Flag leaf initiation + grain filling) followed by T6 (Humic Acid @ 6000 ml /ha + E.M @ 1 : 500 L /ha at tillering + Flag leaf initiation + grain filling) which was 43.83 cm^2, whereas the lowest was recorded in T2 (Humic Acid @ 3000 ml /ha at tillering + Flag leaf initiation + grain filling) which was 37.09 cm^2.

From the data given in the table (II) revealed that there was non significant effect among the treatments for number of spikelets spike^{-1}. The highest number of spikelets spike^{-1} (20.3) was observed in T4 (E.M @ 1 : 500 L /ha at tillering + Flag leaf initiation + grain filling) followed by T3 (Humic Acid @ 6000 ml /ha at tillering + Flag leaf initiation + grain filling) which was 20, whereas the lowest was recorded in T6 (Humic Acid @ 6000 ml /ha + E.M @ 1 : 500 L /ha at tillering + Flag leaf initiation + grain filling) which was 18.7.

According to data presented in the table (II) shown that there was non significant effect among the treatments for thousand seeds weight (g). The highest thousand seeds weight (34 g) was observed in T4 (E.M @ 1 : 500 L /ha at tillering + Flag leaf initiation + grain filling) followed by T6 (Humic Acid @ 6000 ml /ha + E.M @ 1 : 500 L /ha at tillering + Flag leaf initiation + grain filling) which was 33.83g, whereas the lowest was recorded in T3 (Humic Acid @ 6000 ml /ha at tillering + Flag leaf initiation + grain filling) which was 32.1g. These findings are in line with the findings of Reza and Vahid, (2011) who narrated that potassium humate had no significant effect on 1000 seed weight.

From the data shown in the table (II) revealed that there was significant effect among the treatments for biological yield (kg ha^{-1}). The highest biological yield (12667) was observed in T2 (Humic Acid @ 3000 ml /ha at tillering + Flag leaf initiation + grain filling) followed by T6 (Humic Acid @ 6000 ml /ha + E.M @ 1 : 500 L /ha) which was 11000. These are in line with the work of Reza and Vahid, (2011) who reported that foliar application of potassium humate had significant effect on yield and biomass.

From the data given in the table (II) shown that there was significant effect among the treatments for grain yield (kg ha^{-1}). The highest grain yield (3566.3) was observed in T2 (Humic Acid @ 3000 ml /ha) followed by T4 (E.M @ 1 : 500 L /ha) which was 3189.7. These observations match with the work of Delfine *et al.*, 2005 who reported that the foliar application of humic acid caused significant effects on wheat grain yield. Moreover, these findings are also in conferment with the findings of Reza and Vahid (2011), who reported that humic acid had significant effect on grain yield. However, these findings are in contrast with the work of Jones *et al*., (2007) who reported that no significant differences were found in grain yield of wheat between humic acid and control treatments.

CONCLUSION AND RECOMMENDATIONS

To have a knowledge about the behavior and performance of Newly developed wheat cultivar, NARC 2011 at different concentrations of Humic acid and constant dose (1: 500 L/ha) of E.M, a field experiment carried out at NARC, Islamabad showed that a sole foliar application of Effective microbes at various phenological stages enhanced sub stomatal CO_2 in the leaf significantly, but did not affect transpiration rate, spike length, number of spikelet spike^{-1}, flag leaf area and thousand seed weight significantly. Sole foliar application of humic acid @ 3000 ml/ha at tillering, flag leaf initiation and grain filling stages significantly enhanced grain yield and biological yields and were 30 and 31% greater than sole pre sowing application of NP @ 115 : 85 kg/ha. Furthermore, the performance of this newly developed cultivar may be compared with other exciting latest varieties for growth, yield and other attributes.

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