**Impacts of Humic Acid on Growth and Yield of Wheat: A review**

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**Abstract**

Wheat (*Triticum aestivum* L.) is one of the most significant crops and provides 20% of the calories of a large number of populations worldwide. Soil organic matter is one of the most important parts of the soil that directly affects the soil fertility and textures. Humic substances are parts of humus in soil organic matter produced from the physical, chemical, and microbiological transformation of biomolecules.  The application of Humic acid is a common method for improving not only crop growth, and yield, however soil fertility. The effects of Humic Acid on wheat have been studied widely, however, the best type of humic acid and the proper method of application of humic acid to the soil for wheat is still not stated. The review aims to investigate a sustainable method of wheat production using Humic acid to reduce the negative effects of chemical fertilizers and climate change factors. It is reported that the Humic acid increased wheat plant growth parameters such as shoot length, root length, shoot dry weight, root dry weight, and chlorophyll content by (18%), (29%), (76%), (100%) and (96%) respectively. Furthermore, Humic acid increased significantly wheat yield and yield components such as spike length (14.66%), number of spike m-2 (28.73%), number of spikelet/spike (23.52%), and 1000 grain weight (23.90%). Humic acid is a sustainable organic substance, and the application of Humic acid can improve wheat production sustainably to produce sufficient food for the world and Afghanistan's increasing population.

**Key words:** Humic acid, Wheat, Wheat growth, Wheat yield.

**Introduction**

Wheat is one of the most significant crop worldwide, and it is provides 20% of the calories of large number of population around the world(Awad et al., 2022). Wheat also provides essential amino acids, minerals, vitamins, and beneficial phytochemicals and dietary fibres to the human diet around the globe (Shewry, 2009). Currently wheat is mostly consumes by human and it is cultivated in more than 100 countries around the world (Shewry, 2009).

Soil organic matter are one of the most important parts of the soil that directly affect the soil fertility and textures (Khaled & Fawy, 2011). Humic substances are part of humus in soil organic matter producing from the physical, chemical and microbiological transformation of biomolecules (Mindari et al., 2019). Humic acids are an important soil component which has the ability to improve nutrient availability and impact on other important chemical, biological, and physical properties of soils (Khaled & Fawy, 2011). As well as Humic acid fertilizer incorporation is a common method for improving crop growth, yield and soil fertility (Zheng et al., 2022).

It is reported that the application of Humic acid increased wheat plant growth parameters such as shoot length, root length, shoot dry weight, root dry weight, and chlorophyll content by (18%),(29%),(76%), (100%) and (96%) respectively (Arjumend et al., 2015). As well as Iqbal et al (2016) reported that Humic acid (15 Kg ha-1) with nitrogen (150 Kg ha-1) increased, productive tillers m-2, 1000 grain weight, grain spike-1, grain yield, biological yield and harvest index. Furthermore, Humic acid increased significantly wheat yield and yield components such as spike length (14.66%), number of spike m-2 (28.73%), number of spikelet/spike (23.52%) and 1000 grain weigh (23.90%) (Gomaa et al., 2015).

Humic Acid and wheat plant have been studied widely, however the best type of humic acid and the proper method of applying humic acid to soil for wheat is still not stated at the same time for wheat plant. This review aims to investigate the most beneficial type and method of application of humic acid that increasing wheat production significantly. The study also focuses on sustainable production of wheat using Humic acid in order to increase wheat production and reduce the negative effects of chemical fertilizer that have been used.

Wheat is the most important crop in the world and the first staple food for a large number of populations worldwide. On the other hand, recently the population of wheat consuming countries and wheat consumption per capita are increasing rapidly so, the production of wheat for the current growing population of the world is not enough. Furthermore, due to industrialization, global warming, and heat stress the worldwide wheat production affected negatively. Moreover, continuous use of chemical fertilizers accelerated the depletion of soil organic matter and impairs physical and chemical properties of soil in addition to causing micronutrient deficiencies. It is an urgent need to increase what production using sustainable methods to fulfil the wheat demands of the increasing population of the world. Humic acid is a sustainable organic fertilizer, and the application of Humic acid has the ability to improve wheat production sustainably in order to produce sufficient food for the world increasing population. The objectives of the review are to addresses the impact of Humic Acid on the growth and yield of wheat in order to provide some insight and suggestions regarding previous research on Humic Acid specifically in wheat, and this review also anticipated to facilitate the future research work, to improve wheat production by sustainable methods such as Humic Acid application in the future.

**Importance of Wheat in Human Nutrition**

Cereal crops are the major staple food around the world, which directly contribute more than 50% of the total human daily staple foods (El-Hashash et al., 2022). The first cultivation of wheat occurred about 10000 years ago, as part of the ‘Neolithic Revolution’, which saw a transition from hunting and gathering of food to settled agriculture (Shewry, 2009). Wheat is the most important crop around the world, and it is supplies about 20% of the foods all over the world (Awad et al., 2022). Wheat also contributes essential amino acids, minerals, and vitamins, and beneficial phytochemicals and dietary fibre components to the human diet, and these are particularly enriched in whole-grain products (Shewry, 2009).

The world’s total cultivated area of wheat is nearly 1.425 x 10 6 hectare and the total wheat production globally is 9.279 x 106 tons while the average production is 6.511 tons per hectare (Awad et al., 2022). Furthermore, the world would require around 840 million tonnes of wheat by 2050 from current production level of 642 million tonnes and it has to be achieved with less land and resources through genetic, physiological and agronomic interventions particularly resource conservation technologies (Sharma et al., 2015).

**Benefits of Humic Acid for Plants and Soil Condition**

Humic substances as part of humus-soil organic matter are compounds arising from the physical, chemical and microbiological transformation (humification) of biomolecules (Mindari et al., 2019). Soil organic contents are one of the important parts that directly affect the soil fertility and textures (Khaled & Fawy, 2011). Humic acid is decomposed organic matter that accumulates in ecological systems, and enhance plant growth by chelating unavailable nutrients and buffering pH (Tahir et al., 2011). However, Humic acids are an effective agent to use as a complement to synthetic or organic fertilizers (Khaled & Fawy, 2011). As well as Humic acids are an important soil component that can improve nutrient availability and impact on other important chemical, biological, and physical properties of soils (Khaled & Fawy, 2011). However, The effects of humic substances on plant growth depend on the source and concentration, as well as on the molecular fraction weight of humus (Saha et al., 2013).

Moreover, Humic acid also has the advantages of increasing yield and quality of grains (Awad et al., 2022). On the other hand, it is reported that Humic acids are technically not a fertilizer, although some people consider it as a fertilizer (Khaled & Fawy, 2011). In many instances, regular humic acids use will reduce the need for fertilization due to the soil and plant ability to make better use of it (Khaled & Fawy, 2011). Humic acid improves the physical, chemical and biological properties of the soil and influences plant growth by influencing the growth of roots (Saha et al., 2013). Humic acid not only affected positively the growth and yield of plants, but also affected grain quality such as Noroozisharaf & Kaviani, (2018) reported that Humic acid is natural biological organic, which has a high effect on plant growth and quality.

As well as, it is reported that organic fertilizers such as Humic acid have the ability to improve soil fertility (Ehsan et al., 2016). Furthermore, it is suggested that Humic acid has the potential as a low cost organic fertilizer to improve soil fertility on sustainable basis, resulting in high growth and yield of crops (Rahmat Ullah Khan et al., 2010). Such as Shafi et al, (2020) reported that, the most important results from the study obtained that by the combining of the chemical fertilizer with Humic acid will reduce up to 50% expenses of fertilizer use.

**Effects of Humic Acid on Growth of Wheat**

It is reported that all parameters of the wheat studied with the all three treatments of the HA were demonstrated higher (El-Hashash et al., 2022). The results also demonstrated that the application of Humic acid increased wheat plant growth parameters such as: shoot length (18%), root length (29%), shoot dry weight (76%), root dry weight(100%) and chlorophyll content (96%) (Arjumend et al., 2015). Furthermore, the application of additional single superphosphate and Humic acid improved wheat plant height, and spike length (Shafi et al., 2020). Moreover, Humic acid application increased wheat growth and nutrient uptake (Tahir et al., 2011).

Spraying wheat plant with the 15 g/L increased plant height, flag leaf area and, leaf chlorophyll content (Alfatlawi & Alrubaiee, 2020). While the three years collected data from the wheat plants also resulted significantly increase in plant height, number of tillers per plant, spike length with the application of (NPK+ HA liquid) treatment (Ehsan et al., 2016). Humic Acid also increased the roots fresh and dry weight significantly, such as by using 54 mg HA L-1 the wheat dry matter yield of shoot increased by 22% (El-Hashash et al., 2022).

Humic acid (15 Kg ha-1) with nitrogen (150 Kg ha-1) increased plant height, tillers m-2 (Iqbal et al., 2016). Moreover, the application of Humic acid with the (60 mg kg-1 soil) treatments increased wheat plant height, shoot fresh and dry weight increased significantly by 10%, 25%, and 18% respectively (Tahir et al., 2011). The treatment with (90 Kg P2O4 ha-1) and (5Kg HA ha-1) also increased wheat plant height (89cm) than the control (77cm) (Shafi et al., 2020). As well as the spike length was increased in wheat plant by HA significantly (Shafi et al., 2020).The results also demonstrated that all the Humic substances treatments have significantly affected the leaf Fe, Mn, Zn, and Cu contents (Awad et al., 2022).

**Effects of Humic acid on Yield and Yield Components of Wheat**

Humic acid application resulted in significant increase in the grain yield (2540 Kg ha-1) of wheat than the control (2338Kg ha-1) (Shafi et al., 2020). Furthermore, the Humic substances with the application rates of (4.03 ton ha-1) resulted in the highest yield of durum wheat (Pacuta et al., 2021). Moreover, the highest grain yield were recorded by using 60 Kg HA ha-1, under normal and dough-stress condition (El-Hashash et al., 2022). It is also reported that urea with Humic acid increased the wheat grain, straw, and total above ground biomass of mature wheat by 5.15-16.93%, 5.32-20.23%, and 5.23-18.38% respectively (Gao et al., 2022).

Furthermore, Khan et al (2010), reported that in the first growing season (2007-08), the combination of Humic acid increased rain feed wheat yield by 46.9% than the control. While in the second year (2008-09), application of 3 Kg ha-1 Humic acid significantly increased grain yield by 24% and saved 100% expenses of chemical fertilizer (Rahmat Ullah Khan et al., 2010). Moreover, the grain yield recorded 67.5 Kg P2O5 ha-1 with HA, while it was comparable statistically with 112.5 P2O5 ha-1 applied as commercial SSP (Shafi et al., 2020). As well as, the biological yield (grain+ straw yield) was increased significantly under the liquid fertigation fertilizer and liquid foliar fertilizer of Humic acid along wight 50 Kg urea application, while the highest yield was recorded with the usage of 12 litre of liquid fertilizer, 50 Kg of urea and foliar fertilizer as a foliar spray solution (Ahmad et al., 2018). Biological yield, grain yield, and harvest index of wheat also significantly affected by HA application (Dinçsoy & Sönmez, 2019).

However, the plant derived humic acid (PDHA) and coal derived humic acid (CDHA) application with 50 mg/Kg in two different types of alkaline soil increased grain yield by 21% and 11% respectively, as well as the grain yield of wheat plant increased significantly by 10% and 22% respectively, with the application of 100 mg/kg of PDHA and CDHA respectively in both types of soil(R. U. Khan et al., 2018). As well as the foliar application of the bioactive substances, increased durum wheat yield significantly, while maintaining or increasing the quality of the grain (Pacuta et al., 2021). On the other hand, the addition of Humic acid resulted in increase of P efficiency, that had the potential to improve crop yield and plants P uptake calcareous soils (Shafi et al., 2020). Moreover, the application of Humic acid also increased K concentration in the soil after crop harvest (Tahir et al., 2011). The seaweed and Humic based preparations were foliar sprayed at the vegetative stage of durum wheat three times, also caused increase in grain yield than the control (Pacuta et al., 2021).

Yield components of wheat for instance, 1000 grain weight (8-16%), biological yield ( 18-36%) dry matter yield (15-25%) and grain yield (19-48%) increased significantly and respectively by Humic acid application (Arjumend et al., 2015). Moreover, by using (4 kg/fed, 1feddan=0.4 ha) Humic acid increased significantly wheat yield and yield components such as spike length (14.66-15.56%), number of spike m-2 (28.73%), number of spikelet/spike (23.52%- 29.03%) and 1000 grain weigh (23.90%) (Gomaa et al., 2015). Furthermore, the results demonstrated that the spraying wheat with the 15 g/L increased the number of spikes per square meter, the number of grains per spike, the total grain yield and biological yield (Alfatlawi & Alrubaiee, 2020). While the spraying in the flowering stage also increased significantly the number of spikes per square meter, the number of grain per spike, total grain yield, and biological yield (Alfatlawi & and Alrubaiee, 2020).

Humic acid (15 Kg ha-1) with nitrogen (150 Kg ha-1) increased, productive tillers m-2, 1000 grain weight, grain spike-1, grain yield, biological yield and harvest index (Iqbal et al., 2016). The usage of Humic acid with 5 Kg ha-1 was also increased significantly grain per spike of wheat plant than the control (Shafi et al., 2020). As well as Humic acid application increased 1000 grain weight significantly than the control in wheat plant (Shafi et al., 2020). Moreover, the application of additional single superphosphate and Humic acid improved wheat number of grain spike-1, 1000 grain wight, grain, straw and biological yield (Shafi et al., 2020). Moreover, the three years collected data from the wheat plants also demonstrated significantly increase in grain per spike and 1000 grain weight under ( NPK+ HA liquid) treatment (Ehsan et al., 2016). As well as, urea with Humic Acid significantly increased spike number per pot and 1000-grain weight (Gao et al., 2022).

**Future Direction and Challenges in Applying Humic Acid to Wheat Plant**

Since industrial revolution, the chemical fertilizers have been used for wheat plant to improve wheat growth and yield in developing countries, however the organic fertilizers especially Humic Acid have not been considered. While it is reported that the Humic Acid as a soil conditioner not only increased wheat growth and yield of wheat, however increased soil fertility, nutrients uptake, micronutrients availability, as well as increased soil physical, chemical and biological properties sustainably. It is also reported that using Humic Acid will reduce the 50% of chemical fertilizers expenses for farmers. Currently most of the developed and developing countries suffering from unfavourable soils due to continuous using of chemical fertilizers, as well as climate change factors affected negatively soil properties around the world. Furthermore, the production of wheat is not enough for the increasing population of the world, and it is un urgent need to produce more wheat to fulfil wheat demands in the world and Afghanistan. In this regard the sustainable methods and substances are playing a most important role to reach the above-mentioned target. Humic Acid is the best option for all developing countries including Afghanistan in order to increase wheat production sustainably due to increase growth and yield of wheat, however maintain the soil fertility, and reduce the negative effects of chemical fertilizers and climate on the soil and plants. Furthermore, Humic Acid is available in different types and shapes locally in most of the countries with low prices than chemical fertilizers. However, there is lake of knowledge regarding the benefits of Humic Acid for local farmers. The governmental and nongovernmental active agencies are recommended to extend the benefits of Humic Acid to the wheat farmers and provide them subsides to grow what using Humic Acid, in order to improve wheat production suistanabley, around the world and Afghanistan.

**Conclusion**

Wheat is the most important and the first staple food in the world which is cultivated in more than 100 countries. It is projected that by 2050 the world wheat production should be 200 ton more than current wheat production. The increment of demand of wheat around the world could be due to increase population, and increase of wheat using per capita. Humic Acid is one of the world most important organic substances that increased wheat growth and yield. Humic acid not only affected wheat growth and yield positively, however increased soil fertility, condition and nutrients uptake. Furthermore, humic acid is a sustainable soil conditioner that reduces the negative effects of chemical fertilizer that has been used in the soil. Moreover, humic acid is deriving from natural resources, available in many types, has the ability to apply in various methods, and economical to the farmers. Besides, the application of humic acid reduces the chemical fertilizer amount, as well as the expenses, which is beneficial for soil conservation. The application of humic acid increased most of the wheat growth parameters such as shoot length, root length, shoot dry weight, root dry weight, chlorophyll content. As well as humic acid increased wheat yield parameters such as 1000 grain weight, biological yield, dry matter, and grain yield. The study stated that the most important and effective type of the humic acid for wheat plant that affected the wheat plant growth and yield, among the all types of humic acid is granule. It is also stated that the most significant method of application of Humic acid for wheat is the application of Humic acid with soil before cultivation of wheat. It is suggested that the further research should be conducted on the wheat in unfavourable soil and climate change condition.

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ا**ثرات هیومیک اسید بر نمو و حاصل گندم : مرور**

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**خلاصه**

گندم یکی از نباتات مزروعی بسیار مهم به شمار میرود و ۲۰ ٪ انرژی مورد نیاز یک تعداد زیادی از مردم جهان را تأمین مینماید. مواد عضوی خاک یکی از اجزای مهم خاک میباشد که حاصلخیزی و بافت خاک را تحت تأثیر مستقیم خود قرار میدهد. مواد هیومیک یکی از اجزای مهم هیومس در مواد عضوی خاک بوده، که در نتیجه تجزیه فزیکی،کیمیاوی و مایکروبیولوژیکی مالیکول های زنده تولید میشود. استفاده از هیومیک اسید یکی از روش های عام برای افزایش نه تنها نموی نباتات بلکه افزایش حاصل و بهبود حاصلخیزی خاک به شمار میرود. اثرات هیومیک اسید روی نموی گندم قبلآ به صورت وسیع مورد بررسی قرار گرفته است، اگر چه بهترین نوع هیومیک اسید و روش درست استعمال آن برای گندم به درستی بررسی نشده است. هدف این مرور این است که یک روش باثبات تولید گندم را با استفاده از هیومیک اسید دریابد تا بتواند اثرات منفی کود های کیمیاوی و تغیرات اقلیمی را کاهش دهد. گزارش شده است که استعمال هیومیک اسید شاخص های نموی گندم مانند قد نبات،طول ریشه، وزن خشک گیاه، وزن خشک ریشه و مقدار کلوروفیل را به ترتیب ۱۸٪، ۲۹٪،۷۶٪،۱۰۰٪ و ۹۶٪ افزایش داده است. علاوه بر این استعمال هیومیک اسید حاصل و اجزای حاصل گندام را مانند طول خوشه (۱۴.۶۶٪)، تعداد خوشه در متر مربع (۲۸.۷۳٪)، تعداد خوشچه(۲۳.۵۲٪) و وزن ۱۰۰۰ دانه (۲۳.۹۰٪) را به صورت معنی دار افزایش داده است. هیومیک اسید یک ماده باثبات عضوی بوده و استعمال آن میتواند تولید گندم را به صورت باثبات افزایش داده و باعث تولید غذای کافی برای نفوس روز افزون افغانستان وجهان گردد.

**کلمات کلیدی:** حاصل گندم؛ گندم؛ نموی گندم؛ هیومیک اسید.