Effect of Foliar Application of Urea Fertilizer and Post Emergence Herbicide on Performances of Wheat (*Triticumaestivum* L.) at Ardaita, Arsi Zone, Oromia, Ethiopia

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Abstract

Wheat is largely grown in the highlands of Ethiopia. However, its productivity is very low due to plant nutrients limitations in the soil and weed infestation and low use of external inputs such as fertilizers and pesticides. Thus, the study was conducted in 2015/16 main cropping season under Ethiopian Seed Enterprise in Ardaita Seed Farm to evaluate the effect of foliar application of urea fertilizer and post emergence herbicide on performances of bread wheat. The experiment constituted seven treatments which were arranged in a randomized complete block design (RCBD) with three replications. Urea fertilizer were sprayed as a foliar combined with post emergence herbicide (Pallas 45OD) at different rates (10, 20, 30, 40 and 50 kg ha^{-1}), 50 kg ha^{-1} urea fertilizer was sprayed foliarly with pure water/without any post emergence herbicide (weedy check for comparison) and the control treatment was applied with only 50 kg ha^{-1} granular urea at sowing on soil and post emergence herbicide Pallas 45OD 0.5 lt ha^{-1}. The parameters recorded on the crop were grouped into agronomic and yield performances of wheat and weed components. The results of the experiment indicated that, there were significant differences for non-fertile tillers, number of spikes m^{-2}, biological yield, grain yield, harvest index, straw yield, fertile tiller and grain per spike, but plant height and thousand grain yield showed non-significant difference. This, study showed that combined application of urea fertilizer and Pallas had a significant effect on most agronomic and yield parameters. However, for most weed and weed component parameters the result did not show significant difference, except pre and post application weed density, pre and post emergence weed control efficiency, and grass and broad leave weeds dry weight. The result of the experiment were shown that more number of grain per spike (37) and higher yield (50 qt ht^{-1}) were recorded in plots treated with 40 kg ha^{-1} urea along 0.5 lt ha^{-1} Pallas. Higher biological yield was also recorded from plants treated with 40 kg ha^{-1} urea along 0.5 lt ha^{-1} Pallas. The plants treated with 40 and 30 kg ha^{-1} urea along 0.5 lt ha^{-1} Pallas was also shown the best economic returns. Thus, it could be concluded that the combined application of 40 kg ha^{-1} urea and 0.5 lt ha^{-1} Pallas significantly increases the wheat production in the study areas and the like. This experiment also needs to be repeatedly tested in order to clearly understand and confirm the right nitrogen fertilizer rate, concentration and application time of urea fertilizer and post emergence herbicide for the better performances of wheat under different varieties of the crop in different areas.

Keywords: Foliar urea application, Pallas 45OD, phytotoxicity effect, wheat yield

1. Introduction

Wheat *(Triticumaestivum* L.)is one of the important grain crops produced worldwide (Curtis and Halford, 2013) and highly prefer for food security. It occupies about 17% of the world's cropped land and contributes 35% of the staple foods (Tesfaye *et al.,* 2014). Wheat consumption is increasing from 651 metric ton in 1962 to 3745 metric ton in 2012 (Curtis and Halford, 2014). Demand is also rising partly as a result of population growth (world population more than doubled from 3.15 billion in 1962 to 7.05 billion in 2012).

Ethiopia is also the second largest wheat producing country in Africa next to South Africa (Bekele *et al.,* 2000). Wheat is one of the major staple and strategic food security crop and the second most consumed cereal in Ethiopia next to maize (Eyob *et al.*, 2015). It is one of the major cereal crops grown in the Ethiopian highlands with altitudes of 1500 to 3200 m.a.s.l. However, the most suitable regions fall between 1900 and 2700 masl with 6 and 16°N latitude, and 35 and 42°E longitude (Assefa *et al*., 2015). In area of production, wheat in Ethiopia ranks 4th after teff, maize, and sorghum, 3rd in total grain production after Maize and Teff and 2nd in yield to Maize (Assefa *et al*., 2015). It is cultivated by 4.746 million farmers and accounts for more than 16.3% of the total cereal production (CSA, 2014). Out of the total grain crops covered area, 11.82 million hectares in the country, 81.97% (9.69 million ha) was under cereals and wheat

(*Triticumaestivum* L.) occupied 1,706,323.86 ha (17.6%) with a total production of 4,039,113.674 tons. However, the mean national yield is 2.45 t ha^{-1}, which is 3- 4 t ha^{-1} far below the experimental yields of over 6 t ha^{-1} (CSA, 2014; Curtis and Halford, 2014; Dawit *et al.*, 2014). The share of smallholder farmers is 1,426,000 ha (4.5 million holders) that produce most of the wheat production in Ethiopia comparing to the 8% contribution of the large state-owned farms (124,000 ha of land). From the total coverage, about 60% of the wheat area is covered by bread wheat and 40% by durum wheat (Eyob *et al*., 2015).

The Arsi and Bale highlands are the major wheat belt areas of the country. These areas are highly fertile but the yield is generally lower because of monoculture practices and high weeds infestation (Ashenafi and Dawit, 2012). In the region there is a number of government and private state farms, many of them are cultivating cereal crops mainly wheat. Fertility problems and weed infestations are important considerations in profitable wheat production in modern agriculture (Walsh *et al*., 2014). Weeds are one of the major problems in the farm, reduce productivity due to competition and dominating the crop, topping up, providing habitats for pathogens as well as serving as alternate host for various insects and fungi, reducing seed quality and increase harvest cost (Adel and Ali, 2013). In Ardayita seed farm weeds are controlled by repeated ploughing and discing, crop rotation, applying chemicals and hand weeding. Urea fertilizer is applied at seeding mixing with DAP in a rate of 50kg to 100kg respectively. In order to overcome the competition effect of weeds currently Pallas 45OD chemical is widely used for both broad leave and grass weeds (Seed farm annual report, 2014).

However, low soil fertility, low levels of input (particularly fertilizers, pesticides and improved seeds), moisture stress, and salinity problems are some of the major crop production constraints in Ethiopia (Abreha *et al.,* 2013). Nitrogen fertilizer can be applied to a growing wheat crop by broadcast application of granular fertilizer or by foliar or surface dribble-banded application of liquid fertilizer. Under dry land conditions, late application of granular fertilizer may be ineffective if rainfall is insufficient to move applied N into the root zone (McKenzie *et al*., 2005). Applying high rates of N before or at seeding is risky, especially in dry land farming. If there is no enough rainfall, then the fertilizer may not produce additional yield. Nitrogen fertilizer like urea, Ammonium chloride, and Ammonium nitrate enhances the activities of some herbicide (Nader *et al*., 2012). Hence, plant nutrients, pesticides and herbicide all are applied in a single spray to save cost of application when all are compatible (Nader, 2012). In Ardaita seed farm herbicide application is mainly aerial and urea fertilizer is applied at planting. Since urea is a very mobile fertilizer it feeds the early established weeds instead of the late emerging crops, otherwise it eliminate through leaching or volatilization (Jarwar *et al.,* 2005).

Therefore, application of urea fertilizer at planting is not recommended because of the mobile nature of the nutrient (Rory *et al*., 2009). But in large scale farms top dressing is difficult due to different reasons. Physical methods are laborious, tiresome and expensive due to increasing cost of labor. Broadcasting the fertilizer using machinery is not easy due to heavy rain (Nader *et al*., 2012). The damage caused by traction on a crop is also severe. In large commercial state farms like Ardaita chemicals are sprayed aerial using Jet aircraft. However, the choice of most appropriate method of fertilizer use and herbicide application method (combined application of fertilizer and herbicide in one pass) is an important consideration for productive returns. Therefore, seeking and evaluating fertilizer- herbicides mixture application is an excellent option for efficient nutrient uptake and effective weed control. In view of these facts this study was designed with the aim of evaluating the compatibility of urea fertilizer and Pallas 45OD herbicides and their combined effect on weed management and wheat productivity having different rates of urea fertilizer mixing with the herbicide and applying as a foliar spray.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted in 2015/16 main crop growing season under Ethiopian Seed Enterprise of Ardayita seed farm, located in west Arsi Zone, Gedeb Hasasa Woreda, 301km South-East of Addis Ababa with an altitude of 2400 m.a.s.l. The area has bimodal rain type with an average annual rain fall was 800mm. The minimum temperature of the study area is 15^{o}c and the maximum is 27^{o}c with a silty-clay soil type (Table 3).

2.2. Experimental Materials and Fertilizer-Herbicide Solution Preparation

Wheat variety HAR 1685 (Kubsa) (MoARD, 2009), DAP and UREA fertilizer and Post emergence herbicide Pallas 45OD were used as experimental material in this study. 150 kg ha^{-1} wheat seed and 0.5 l ha^{-1} Pallas (except control) were used for the study. The different rates of urea (10, 20, 30, 40 and 50 kg ha^{-1}) fertilizer was mixed with post emergence herbicide Pallas 45OD and applied at 25 days after planting. For other treatments (10 kg ha^{-1} urea mixed with 0.5 l ha^{-1} Pallas, 20 kg ha^{-1} urea mixed with 0.5 l ha^{-1} Pallas, 30 kg ha^{-1} urea mixed with 0.5 l ha^{-1} Pallas, 40 kg ha^{-1} urea mixed with 0.5 l ha^{-1} Pallas, 50 kg ha^{-1} urea mixed with 0.5 l ha^{-1} Pallas,) DAP fertilizer was uniformly applied at the rate of 100 kg ha^{-1} at planting on the soil. A tank with mix of different rates of Urea fertilizer and 0.5 l ha^{-1} Pallas 45OD were sprayed with 200 l ha^{-1} spray volume of water. Each plot has a size of 5m by 3m having 15 rows for planting. A row maker was used for seed bed preparation and 150 kg ha^{-1} seed have been used for sowing. Sowing was made with hand by drilling along rows.

2.3. Experimental Treatment and Design

The experiment constituted seven treatments which were laid out in a randomized complete block design (RCBD) with three replications. The treatment consisted of five different rates of urea (10, 20, 30, 40 and 50 kg ha^{-1}) fertilizer mixed with post emergence herbicide Pallas 45OD. Additional two treatments were applied with 50 kg Urea fertilizer at planting which was sprayed with Pallas 45OD post emergence herbicide 25 days after planting (control) and unsprayed plot (weedy check) used as positive and negative control, respectively (Table 1).

Table 1: Detail description of the treatments outcome as per study area

Treatments	**Fertilizer Rate (Urea, kg)**	**Herbicide Rate (Pallas, lt)**
T1(Control)	50 kg ha^{-1} (at planting in the form of solid fertilizer on soil)	0.5
T2	10 kg ha^{-1} (Foliar)	0.5
T3	20 kg ha^{-1} (Foliar)	0.5
T4	30 kg ha^{-1} (Foliar)	0.5
T5	40 kg ha^{-1} (Foliar)	0.5
T6	50 kg ha^{-1} (Foliar)	0.5
T7	50 kg ha^{-1} (Foliar)	0.0 (weedy plot without herbicide application)

2.4. Data Collected

Just 25 days after sowing weed assessment was made and weed population density data were recorded before herbicide – fertilizer treatment application. Then, after treatments agronomic, yield and yield components as well as weed types and population data were collected using rows and quadrant.

2.4.1. Crop Growth and Yields Data

1. **Plant Height**: Measurement was taken at maturity; from each plot, 10 representative plants were randomly selected and have been measured from the ground surface to the tip of the spike using measuring tape. The average was used for the analysis purpose.
2. **Number of Tillers:** Number of tillers were recorded by using ten representative sample plants in each plot at maturity and converted to m^2.
3. **Number of Fertile Tillers/m^2:** Ten representative samples were taken and described for the numbers of fertile and non-fertile tillers per m^2.
4. **Grain per Spike:** From each plot ten representative spike samples have been handpicked and collected with bags, threshed and number of seeds in each spikes have been counted.
5. **Biological Yield**: Above ground biomass of two central rows have been harvested, collected with poly bags and weighed in order to express biological yield of each treatments.
6. **Grain Yield:** Harvested above ground center rows have been threshed. Seeds have been separated from the chaff and cleaned as manual winnow. Clean seeds was collected with sampling bags in separate of each plots sealed and tagged. Finally, each sample was weighed separately and its value was recorded. The yield was adjusted to 12.5% moisture content.
7. **Straw Yield:** Computed by subtracting grain yield from biological yield.
8. **Harvest Index:** It was calculated as ratio of grain yield to above ground total biomass multiplied by 100%;
9. **Thousand Seed Weight:** The weight per grain is commonly expressed as 1000-grain weight. Thousand grain seeds were randomly picked from the trashed sample plots and weighing with a sensitive balance separately and adjusted with 12.5% moisture content.

10. **Injury and Phytotoxicity Impact: -**observation of phytotoxicity and injury sign have been recorded two weeks after application of fertilizer herbicide foliar spray by visual observation and estimated as percentage. In commercial practice, foliar-applied nitrogen is applied as urea, which is available as a commercial nutrient spray solution containing up to 20 kg N per 100 liters of solution (Turley, 2001).

2.4.2. Weeds and Weed Components Data

Weed Flora/ Weed Population

Weed population have been recorded at different growth stages from each plot by placing a quadrant at random location in plots and counting weeds within quadrants. The size of the quadrant was 1m by 1m. Weeds have been categorized as grass and broadleaved. The weed community comprises of both broad leaves and grass types have been computed as percentage value.

1. **Weed Density:** Measured as the number of weed species per plot
2. **Weed Control Efficiency:** Weed control efficiency of the combined application of urea fertilizer and Pallas 45OD have been compared in each treatments by comparing weed population density difference before and after spray as:

   Weed Control Efficiency (WCE) = weed population density before spray – weed population density after spray divided by weed density of control multiplied by 100 or

   $$WCE=\frac{WDC-WDT}{WDC}x100$$

   (Where, WDC- Weed Density of Control, and WDT- Weed Density of Total)

3. **Weed Dry Weight:** This has been recorded by collecting above ground parts of the weed plant in a quadrant, dry with oven as its weight becomes constant. Finally the dry weights of the weeds have been converted to kg ha^{-1}.
4. **Relative Weed Density:** This have been also computed as a ratio of population per unit area of a particular weed (grass or broad leave) to total weed species and expressed as percentage.
5. **Relative Dry Weight of Weed:** Have been expressed as a ratio of the dry weight of the species (grass) to that of all the species combined present in the unit area/quadrant, and expressed as percentage.

2.4.3. Soil Data Collection and Analysis

Soil analysis was done by taking randomly six soil samples before planting from the experimental site at a depth of 20 cm using manual by digging in zigzag pattern and the samples were mixed thoroughly to produce one representative composite sample of 1kg. The soil result used for identification of soil physical and chemical characteristics. Soil pH: was determined in 1:2.5 soil to water ratio using a glass electrode attached to a digital pH meter (Page, 1982). Organic matter: was recorded based on the oxidation of organic carbon with acid potassium di-Chromate ($K_2C_2O_7^{-2}$) medium using the Walkley and Black method as described by Dewis and Freitas (1970). Total nitrogen: was determined using Kjeldal method (Dewis and Freitas, 1970) Mineral nitrogen: NH_4^+-N and NO_3^--N were determined according to the methods of Pawels *et al*. (1992) as described by Bernard et al. (1992). Exchangeable potassium, calcium and magnesium: were extracted using 1N neutral ammonium acetate at pH 7 (Pratt, 1965), and determined by atomic absorption spectrophotometer. Available phosphorus was determined according to the methods of Olsen and Dean (1965).

2.5. Economic Analysis

Economic evaluation of the effect of fertilizer along Pallas herbicide was performed on the grain yield. Partial budget was estimated for average yield of the different treatment combinations. At the time prices of wheat and Urea fertilizer was ETB 1500 and 1210 per 100kg respectively used for the analysis. The potential response of crop towards the added fertilizer and price of fertilizer during planting ultimately determine the economic feasibility of fertilizer application (CIMMYT, 1988). To estimate economic parameters, wheat yield was valued at an average open market price; a price of urea fertilizer at the time was collected at the time of planting. The wage rate per worker, cost of land preparation, field management, harvest, protection, storage, planting material, post-harvest, and others were included in the calculation. The economic analysis was based on the formula developed by CIMMYT (1988) and is shown as follows:

Gross Average Yield (GAY) (t ha^{-1}): was calculated as an average yield of each treatment.

Adjusted Yield (AJY): was the average yield adjusted downward by a 10% to reflect the difference between the experimental yield and yield of farmers. AJY = GAY - (GAY * 0.1)

Gross Field Benefit (GFB): computed by multiplying field/farm gate price that farmers receive for the crop when they sale it as adjusted yield.

GFB = **AJY** * field/farm gate price of a crop

Total cost (TC): mean current prices of applied inputs.

Net Benefit (NB): calculated by subtracting the total costs from the gross field benefit for each treatment. NB = GFB – TC

2.6. Data Analysis

Analysis of Variance (ANOVA) has been performed using SAS 2001 version 9.0.F test have been used to detect the significance of treatment effects and the list of significance differences (LSD) at 5% probability level have been used for means comparisons of each treatment.

3. Results and Discussion

3.1. Soil Physical and Chemical Properties of the Study Area

Physical and chemical properties of a soil have a direct impact on fertility status and highly affect crops growth and development. Pre-sowing soil analysis showed that the experimental soil had a total N of 0.08% which was deficient, 2.12% organic carbon, 9.14 mg kg^{-1} available P and a pH of 6.165 value (Table 2). Thus, the pH of the experimental soil is optimum within the range for productive (neutral) soils (FAO, 2000).

The area was known for mono-cropping of wheat where farmers burn crop residue every year for ease of land preparation, where most organic materials were depleted. Textural class of the soil was silt-clay with composition of 55 % silt, 32% clay and 13% sand. The structure of the soil is granular, it has an EC of 0.322 micro s/cm. Cation exchange capacity (CEC) of the experimental soil was 34 cmol kg^{-1} (Table 2). Characteristics of soil, its chemical composition and texture were good for crop production as well as for tillage practices.

Table 2: Pre-Sowing Soil Analysis Data of the Study Area

Description	**Amount**
Soil pH	6.165
Nitrate	22 kg ha^{-1}
Texture	Silty-Clay
Nitrogen	0.08%
Phosphorus	9.14 mg kg^{-1}
CEC	34 cmol kg^{-1}
OC	2.12%

3.2. Effect of Fertilizer and Herbicide Application on Growth and Yield Attributes of Wheat

The result of the experiment indicated that, there was a significant ($P<0.05$) difference for growth and yield related parameters like plant height, number of spikes per meter squares, fertile tillers, biological yield, grain per spikes, thousand grain weight, grain yield and straw yield due combined application of urea fertilizer and Pallas except non fertile tillers and harvest index (Table 3). However, for most of the weed and weed components the result did not show significant differences.

Table 5: Mean Square Values for Growth and Yield Components of Wheat As Influenced By Foliar Application of Urea Fertilizer and Pallas 45OD

Parameters	**Mean Value**
Fertile Tiller	442.10**
Non Fertile Tiller	6.85*
Plant Height	7.85**
Number of Spikes per Plant	17108.83**
Grain per Spikes	3.61**
Grain Yield	85.81**
Thousand Grain Weight	13.19ns
Biological Yield	0.07**
Straw Yield	0.036**
Harvest Index	9.75ns

3.2.1. Effect of Foliar Application of Fertilizer and Herbicide on Wheat Growth Attributes

Combined application of urea fertilizer and post emergence herbicide resulted in a significant ($P<0.05$) difference on number of fertile tillers. The maximum number of tillers per plant (4.5) was recorded from the plot applied with 40 kg ha^{-1} urea, followed by those plants applied with 30 kg ha^{-1} (4.3) and 20 kg ha^{-1} (4.3) urea along with 0.5lt ha^{-1} Pallas uniformly (Table 6). The fewer tiller numbers per plant (3.6 and 3.8) were recorded from plants applied 50 kg ha^{-1} urea plus 0.5l ha^{-1} Pallas and 10kg ha^{-1} urea plus 0.5lt ha^{-1} Pallas foliar spray, respectively; whereas the plot without herbicide (weedy check) had the lowest (3) tiller number per plant (Table 6). From the result of the experiment, it was observed that as the rates of urea exceed to 50 kg ha^{-1} it affected plant growth and development due to might be phytotoxicity effects. On the other hand as the rates of urea become small it reduced the activities of the chemicals. As a result competition between crops and weeds become high and it reduced plant tillers by killing the late comers for survival. According to the report of Phillip *et al*. (2008), number of tillers (fertile and non fertile) depends on variety, the availability of nutrients, especially nitrogen, and seasonal conditions. These results are also in agreement with those of Njuguna (2011) and Rahman (2014) who reported better performance of wheat with foliar application of N. Ashenafi and Dawit (2014) also reported better tiller number in Pallas applied treatments.

The result of the study was also showed significant ($P < 0.05$) differences among treatments in non-fertile tillers. The maximum death of tiller per a single plant(2.5) was recorded in plants applied with 40kg ha^{-1} urea plus 0.5lt ha^{-1} Pallas foliar and minimum death of tillers (1) was recorded from the control and from the plot applied with 20kg ha^{-1} + 0.5lt ha^{-1} Pallas) (Table 6). Maximum number of tiller ware recorded on plots applied 40kg ha^{-1} urea plus 0.5lt ha^{-1} Pallas; similarly, maximum number of non fertile tillers (death of tillers) was seen on the same treatment. This is may be due to moisture stress during the crop growing period. Usually the last emerging tillers are dying first when nutrient deficiency and moisture stress is occurred (Phillip *et al*., 2008). However, plant height measured at physiological maturity did not show significant ($P>0.05$) variation among treatments due to combined application of foliar urea and post emergence herbicide (Table 6).

Table 6: Comparison of the Means of Wheat Growth and Phonology of Treatments

Treatments	**Fertile tiller/plant**	**Non-fertile tiller/plant**	**Plant height (cm)**
T1 control (50kg ha^{-1} urea at sowing/solid + 0.5l ha^{-1} Pallas)	4.00^{A-C}	1.13^{C}	79.13
T2 (10kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	3.80^{BC}	1.40^{C}	78.73
T3 (20kg ha^{-1} urea + 0.5l ha^{-1} Pallas foliar)	4.30^{AB}	1.33^{C}	77.00
T4 (30kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	4.30^{AB}	2.26^{AB}	77.72
T5 (40kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	4.53^{A}	2.46^{A}	79.20

T6 (50kg ha^{-1} urea + 0.5 ha^{-1} Pallas foliar)	3.60^{C}	1.93^{B}	76.90
T7 (50kg ha^{-1} urea + pure water foliar/ weedy)	3.00^{D}	2.13^{AB}	77.00
LSD (0.05)	0.69*	0.358*	NS
CV(%)	9.91	11.14	2.44

***Highly significant, *Significant, NS-non significant. Means with the same letter are not significantly different.*

3.2.2. Effect of Urea Fertilizer and Herbicide on Wheat Yield and Yield Attributes

Number of spike is among the yield components, which was significantly ($P<0.05$) affected by the combined foliar applied urea fertilizer and herbicide. The maximum number of spikes (529) per m^2 was recorded from plants sprayed with 20kg ha^{-1} urea along herbicide, followed by those applied with 40kg ha^{-1} and 30kg ha^{-1} urea rates along herbicide which produced 528 and 524 spikes per meter squares, respectively, and the lowest spike number (426) was produced from plants grown on weedy untreated check (foliar spray of 50kg ha^{-1} urea along pure water) (Table 7). Many researchers approved that foliar spray of urea fertilizer increased number of spikes per m^2; which might be due to relatively more numbers of fertile tillers per plant and the optimum utilization of nitrogen fertilizer by the crop (Gooding and Devies, 1992; Emam *et al*., 2000; Rahman, 2014). Because high rate of urea encourages weed competence and causes burning injury on plant tissues that retards growth and physiological functioning of plants. Unless best management and appropriate application rate, time and methods are followed, nitrogen by itself increases weed plant competition for resources (Ali, 2013; Bekalu and Arega, 2016). Alam (2010) was found similar results that some times higher rates of nitrogen foliar application have a negative results in plant development.

Significant ($P<0.05$) differences were also observed in number of grains per spike due to the combined fertilizer and herbicide application. The result of the study indicated that maximum number of grains per spike (36.66) was recorded from plants applied with 40kg urea along 0.5lt Pallas ha^{-1} foliar spray which was statistically at par with 50kg urea along 0.5lt Pallas ha^{-1} applied plot; and significantly differed from other treatments (Table 7). The higher result might be because of the availability of nitrogen to the crop at later growth stages which might have resulted in more number of grains per spike. The increased in number of grains per spike was due to the increased in spikelet numbers per spikes. The number and size of spikelet were increased as the level of nitrogen increased but reduction in number of grain per spikes in the weedy check were due to competition for nutrient and other resources. The positive result was due to optimum nutrient availability and efficient weed control capacity of the combined effects of urea and herbicide. The findings are in agreement with those of Gooding and Devies (1992), Emam *et al*. (2000), Soltani and Saeedipour (2015) and Rahman (2014), who found better performances of wheat crop due to foliar application of nitrogen. Significantly increased in grain number per spike with increasing N rates up to certain limit was also reported by Njuguna *et al.* (2011), and Ashenafi and Dawit (2014) reported more grains per spikes in Pallas applied plots.

Total grain yield of wheat also showed significant differences ($P< 0.005$) due to urea fertilizer applied along Pallas herbicide in the form of foliar spray (Table 7). The highest grain yield (50.17 qt ha^{-1}) recorded from plants applied with 40 kg ha^{-1} of urea along 0.5l ha^{-1} Pallas foliar spray was at par with those grown by applying 30 kg ha^{-1} of urea along 0.5l ha^{-1} Pallas foliar sprayed; however, it was improved by 32% over the lowest grain yield of wheat (34.33qt ha^{-1}) produced from the weedy check plot. The highest yield resulted was might be due to the maximum number of spike per m^2, more numbers of grains per spikes and relatively higher thousand grain weight obtained from same treatment as compared to the rest treatments. The results are in consistent with the results obtained by Modhej and Kaihani (2013), who reported that the interactive effects of nitrogen and herbicide was a significant effects on grain yield and yield components. The positive effects of foliar urea application on grain yield have been also reported by other scholars. According to Phillip *et al*. (2008) foliar application of urea might have been increased the availability of nitrogen to the crop which might have been improved photosynthesis and accumulation of grains. The result was also in line with Zhao-Hui Wang *et al.* (2008) and Njuguna *et al.* (2011), who reported that significantly increased in grain yield with application of foliar nitrogen to the rate of 40 kg ha^{-1}, even though application timing determine the magnitude of the yield response. However, non-significant ($P>0.05$) differences were observed in thousand grain weight due to urea fertilizer applied along pallas herbicide (Table 7).

Table 7: Comparison of the Means of Wheat Grain Yield and Yield Components of Treatments

Treatments	Number of Spikes m^{-2}	Grain per Spikes	Grain Yield (qt ha^{-1})	Thousand Grain Weight (g)
T1 control (50kg ha^{-1} urea at sowing 0.5l ha^{-1} Pallas)	506.5^{A}	34.00^{B}	47.17^{AB}	35.12
T2 (10kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	515.8^{A}	34.00^{B}	44.33^{B}	31.53
T3 (20kg ha^{-1} urea + 0.5l ha^{-1} Pallas foliar)	528.8^{A}	34.33^{B}	45.67^{B}	32.33
T4 (30kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	524.3^{A}	35.00^{B}	49.66^{A}	33.73
T5 (40kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	528.2^{A}	36.66^{A}	50.17^{A}	32.34
T6 (50kg ha^{-1} urea + 0.5 ha^{-l} Pallas foliar)	508.3^{A}	36.33^{A}	44.83^{B}	32.35
T7 (50kg ha^{-1} urea + pure water foliar weedy)	425.7^{B}	34.33^{B}	34.33^{C}	32.90
LSD(0.05)	3.22**	2.07*	3.78**	NS
CV(%)	29.01	1.28	3.075	4.66

Application of foliar urea along Pallas herbicide on wheat was significantly ($P<0.005$) influenced biological yield and straw yield but mot harvest index (Table 8). Maximum biological yield (151.33qt ha^{-1}) was recorded from plants applied with 40kg urea along 0.5lt Pallas ha^{-1} foliar which was followed by those treated with 10, 20 and 30 kg urea along 0.5lt Pallas ha^{-1} foliar spray; whereas, lowest biological yield was produced from plants applied with 50kg urea foliar spray without herbicide combination (weedy check; 100.50 qt ha^{-1}). The increment of yield parameters (biological yield, grain yield, straw yield) in response to the application of foliar nitrogen fertilizer is might be due to the enhanced leaf area resulted in higher photo assimilates and thereby resulted in more dry matter accumulation (Ousman *et al*., 2013). Biological yield was increased when foliar urea application level was become increased up to 40 kg ha^{-1} as compared to the control and check plots. The result was also in agreement with the findings of Emam *et al.* (2000) and Rahman *et al*. (2014). On the contrary Dariusz and Williams (2001) reported that combined application of nitrogen fertilizer with herbicide had no effect on biological yield.

Straw yield was directly related to biological yield which shown highly significant ($P<0.05$) difference to the foliar applied urea fertilizer along the pallas herbicide. The highest straw yield (101.44 qt ha^{-1}) was obtained from plants applied with 40kg ha^{-1} urea along foliar herbicide spray followed by those plants applied with 10, 20 and 30 kg ha^{-1} of urea along with herbicide foliar spray (Table 8). The lowest straw yield was recorded from a weedy check (66.17 qt ha^{-1}) plot which was treated with only 50kg ha^{-1} of urea foliar application but not included Pallas post emergence herbicide. The control plot gave also the lowest straw yield (74 qt ha^{-1}) as compared to the other foliar applied plants. Highest straw yield was obtained from higher rates of nitrogen (urea) fertilizer application and better weed control efficiency by limiting competition between crops and weeds for nutrients (Damene, 2003). However, harvest index showed non-significant ($P<0.05$) differences among the treatments (Table 8).

Table 8: Comparison of the Means of Yield Components of Treatments

Treatments	**Biological Yield (qt ha^{-1})**	**Straw Yield (qt ha^{-1})**	**Harvest Index**
T1 control (50kg ha^{-1} urea at sowing 0.5l ha^{-1}Pallas)	121.33^{C}	74.16^{CD}	0.39
T2 (10kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	132.33^{B}	88.00^{B}	0.33
T3 (20kg ha^{-1} urea + 0.5l ha^{-1} Pallas foliar)	128.00^{BC}	82.33^{B}	0.36
T4 (30kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	135.50^{B}	85.83^{B}	0.36
T5 (40kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	151.33^{A}	101.44^{A}	0.29
T6 (50kg ha^{-1} urea + 0.5 ha^{-1} Pallas foliar)	130.00^{C}	80.17^{BC}	0.38
T7 (50kg ha^{-1} urea + pure water foliar weedy)	100.50^{D}	66.17^{D}	0.34
LSD(0.05)	9.14**	9.10**	NS
CV(%)	3.99	6.14	3.96

*** Highly significant, * Significant, NS - non significant. Means with the same letter are not significantly different*

3.2.3. Effect of Combined Application of Fertilizer and Herbicide on the Crop Injury and Phytotoxicity

Leaf scorch (plant injury and phytotoxicity impacts) of the different rates of urea solution along Pallas herbicide was observed. But there was no significant symptom in all treatments except plants applied with 40 and 50 kg ha^{-1} urea as a trace level observation and soon after a day the crops recover and leave back to deep green colour. This might be because of the incident of rain after hours of spraying. According to Turley *et al.* (2001) foliar N application rates of 30-40 kg ha^{-1} N can cause scorch; scorch is a potential problem particularly where concentrated urea solutions are used. Nader (2012) reported that using UAN (liquid urea) fertilizer with some herbicide causes greater injury. But Turley *et al.* (2001) revealed that urea fertilizer can cause minimum injury compared to liquid fertilizer. Injury problem can be also corrected by increasing the volume of water during preparation of a spray solution. Philip *et al.* (2009) also recorded that, there is no serious scorching effects when UAN was mixed with herbicides or fungicides applied either early (five leaf) or late (flag leaf emergence) and there were no significant effects on yield from the application of UAN in mixes with various herbicides and fungicides.

3.3. Effect of Foliar Application of Urea Fertilizer and Pallas Herbicide on Weeds Activity

3.3.1. Weed Density m^{-2}

The analysis of the data on weed density showed that there were significant ($P<0.05$) differences in the applied treatments among broad leaves and grass family before post-emergence herbicides application (Table 9). The data collected after 26 days (26 DAS) was showed that plants applied with 50 kg ha^{-1} urea granular at planting (control) have an average of 92.33 various grass weeds and 124.67 various broad leaves weeds. The lowest grass (56.00) and broad leaved (97.33) weeds density were recorded in treatment received 10 kg ha^{-1} urea foliar sprayed, respectively. The result of the study showed that both the grass and broad leaves weed densities in the control treatment (50 kg ha^{-1} granular urea at planting) were higher. The result indicated that urea fertilizer applied at planting favored early emergence of both grass and broad leaved weeds as compared to post foliar sprayed. The results of this study was in line with the works of Ashenafi and Dawit (2014) who reported that application of Pallas herbicide on weeds significantly reduced their occurrence and growth. Dominant grass families were *Avenafatua, Phalarisparadoxa, Cynodondactylon, Snowdeniapolystachya, Cyprus spp*. Bromus; whereas dominant broad leave families were *Argemon Mexicana, Daturastramonium, Bidenspitola, Guizotiascabra, Gallium spp, Galinsogaparviflora, Plantagolanceolata, Amaranthus spp* ones.

3.3.2. Weed Control Efficiency

The impacts of applying nitrogen fertilizer at planting and weed control efficiency of combined application of urea fertilizer and post emergence herbicide was evaluated. The data of the study indicated that before herbicide application plots applied with 50kg ha^{-1} granular urea at sowing (control plot) had the highest weed density (217 m^{-2}) and plots applied with 10kg ha^{-1} urea foliar spray had the lowest ($166m^{-2}$) weed densities (Table 9). Post application assessment data of the experiment on the other hand revealed that, the combined application of foliar urea and post emergence herbicide resulted in high weed control efficiency in plots applied with 50kg ha^{-1} urea along Pallas foliar spray (81%) as compared to the control plots applied along Pallas only (50kg ha^{-1} granular urea at sowing). Whereas, plots without herbicide (weedy check) showed negative weed control efficiency; foliar urea application encouraged weed population and competitiveness. The result was correlated with the findings of Rajender (2014).

Table 9: Mean Comparison of Different Weed Component Parameters

Treatments	**PaTWD**	**PoTWD**	**PaWCE**	**PoWCE**
T1 control(50kgha^{-1} Urea at sowing 0.5lha^{-1}Pallas)	217.00^{A}	111.67^{B}	0.00^{B}	0.00^{B}
T2 (10kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	153.33^{B}	33.33^{C}	29.07^{A}	69.67^{A}
T3 (20kg ha^{-1} urea + 0.5l ha^{-1}Pallas foliar)	163.67^{B}	29.00^{C}	24.16^{A}	74.00^{A}
T4 (30kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	156.67^{B}	29.00^{C}	27.91^{A}	73.33^{A}
T5 (40kg ha^{-1} urea +0.5l ha^{-1}Pallas foliar)	158.67^{B}	26.33^{C}	26.7^{A}	77.33^{A}
T6 (50kg ha^{-1} urea + 0.5 ha^{-1}lPallas foliar)	159.67^{B}	22.00^{C}	26.44^{A}	81.00^{A}
T7 (50kg ha^{-1} urea +water foliar weedy)	166.00^{B}	315.67^{A}	23.30^{A}	-194.33^{C}
LSD (0.05)	21.35*	17.59**	9.82*	40.76**
CV (%)	7.15	12.21	24.53	88.62

PaTWD= Pre-application Total Weed Density, PoTWD=Post- application Total Weed Density, PaWCE= Pre-application Weed Control Efficiency, PoWCE= Post-application Weed Control Efficiency.

*** Highly Significant, * Significant, NS - Non Significant*

3.3.3. Dry Weight and Relative Density Weeds

The data showed that weed dry weight was shown highly significant ($P<0.05$) differences due to urea fertilizer along Pallas herbicide application (Table 9). The highest weed dry weight (1.21 kg m^{-2}) was recorded from weedy check plot which applied with 50 kg ha^{-1} urea combined with Pallas foliar spray followed by the control plot (those applied with 50 kg solid urea at planting) (0.45 kg m^{-2}). The lowest weed dry weights were recorded from plots applied with 10, 20, 30 and 40 kg ha^{-1} urea along 0.5l t ha^{-1} Pallas as a foliar (Table 9). Unsprayed weedy check has the highest biomass of weed and measured the highest mass which might be due to there was no treatment and no control measure was taken to manage weeds. According to Modhej and Kaihani (2013) without any treatment, weeds were grown spontaneously as resource availability was not a limiting factor. However, the result of the experiment also indicated that the relative dry weight of weed for both grass and broad leaved families were shown non-significant ($P>0.05$) differences due to urea applied along Pallas herbicide (Table 10).

Table 10: Mean Comparison of Different Weed Component Parameters

Treatments	PaGWRD	PaBWRD	GWDW	BLDW	TDW
T1 control (50kgha^{-1}Urea at sowing 0.5lha^{-1}Pallas)	42.5^{A}	57.52^{A}	0.61^{B}	0.28^{B}	0.45^{B}
T2 (10kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	36.5^{B}	63.50^{A}	0.04^{C}	0.17^{C}	0.22^{C}
T3 (20kg ha^{-1} urea + 0.5l ha^{-1}Pallas foliar)	34.3^{B}	65.70^{A}	0.08^{C}	0.13^{CD}	0.21^{C}
T4 (30kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	36.6^{B}	63.40^{A}	0.073^{C}	0.12^{CD}	0.19^{C}
T5 (40kg ha^{-1} urea +0.5l ha^{-1}Pallas foliar)	36.5^{B}	63.45^{A}	0.073^{C}	0.13^{CD}	0.20^{C}
T6 (50kg ha^{-1} urea + 0.5 ha^{-1}lPallas foliar)	36.6^{B}	63.34^{A}	0.07^{C}	0.11^{CD}	0.18^{C}
T7 (50kg ha^{-1} urea +water foliar weedy)	35.5^{B}	64.45^{A}	0.52^{A}	0.7^{A}	1.21^{A}
LSD (0.05)	NS	NS	0.07**	0.063**	0.07**
CV (%)	7.22	4.29	26.84	15.03	1.23

***PaGWRD**= Pre-application Grass Weed Relative Density, **PaBWRD**= Pre-application Broad leave Relative Density, **GWDW**=Grass Weed Dry Weight, **BLDW**= Broad leave Dry Weight, **TDW**= Total Dry Weight*

*** Highly significant, * Significant, NS - non significant.*

3.3.4. Necrosis and Chlorosis

The results of the experiment showed that there was non-significant ($P>0.05$) differences between treatments regarding necrosis and chlorosis (Table 11). Treatments with higher rates of urea fertilizer showed sign of necrosis and chlorosis, but soon recovered and became green even though the treatments were statistically non-significant. Dariusz and William (2001) also reported that there is no significant necrosis and chlorosis problem in using combination of UAN fertilizer and post emergence herbicide to control weeds in Wheat grass pastures.

Table 11: Mean Comparison of Different Weed Component Parameters

Treatments	**DWRDG**	**DWRDB**	**DWRDT**	**CLO**	**NEC**
T1 control (50kg ha^{-1} Urea at sowing 0.5l ha^{-1}Pallas)	36.70	63.30	68.35	0.00	0.00
T2 (10kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	22.63	77.37	61.32	0.00	0.00
T3 (20kg ha^{-1} urea + 0.5l ha^{-1}Pallas foliar)	37.02	62.97	68.51	0.00	0.03
T4 (30kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	37.21	62.78	68.61	0.00	0.05
T5 (40kg ha^{-1} urea +0.5l ha^{-1}Pallas foliar)	38.55	61.45	69.27	0.02	0.09
T6 (50kg ha^{-1} urea + 0.5 ha^{-1}lPallas foliar)	38.04	61.96	69.02	0.09	0.34
T7 (50kg ha^{-1} urea +water foliar weedy)	42.56	57.44	71.28	0.08	0.13
CV (%)	21.4	12.08	5.67	212	168
Level of Significance	NS	NS	NS	NS	NS

DWRDG= *Dry Weight Relative Density of Grass Weed,* ***DWRDB=*** *Dry Weight Relative Density of Broad leave Weed,* ***DWRDT=*** *Dry Weight Relative Density of Total Weed****, CLO=*** *Clorosis,* ***NEC=*** *Necrosis. ** Highly significant, * Significant, NS - non significant*

3.4. Economic Analysis

Combined application of urea and post emergence herbicide increased economic returns in all treatments except the plants produced on weedy unsprayed check plot. The average increasing percentage in gross income, net income, benefit/costs ratio with the combined application of fertilizer and herbicide were recorded in plots applied with 40kg, 30kg, 20kg, 10kg and 50kg urea with post emergence herbicide foliar spray, respectively and were accordingly shown high economic benefits as compared to the control treatment (Table 12). The weedy check (foliar application of urea without herbicide) were gave the least economic returns than the other treatments including the control treatment. The wheat profitability became increased with the application of 40 kg ha^{-1} and 30 kg ha^{-1} along with Pallas herbicide in the form of foliar spray than the other treatments which might be due to the increased productivity of the crop by the applied nutrient and controlled weeds, and reduction of competition for different growth factors between the crop and weeds by the combined application of nutrient and herbicide (Modhej and Kaihani, 2013).

Table 12: Economic Analysis of Combined Application of Urea Fertilizer and Post Emergence Herbicide on Wheat Crop

Treatments	Total Cost	Gross Income	Net Income	Net Benefit	Profitability %
T1 control (50kg ha^{-1} urea at sowing 0.5l ha^{-1}Pallas)	25299	56604	31305	1.23	123
T2 (10kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	23407	53196	29789	1.27	127
T3 (20kg ha^{-1} urea + 0.5l ha^{-1} Pallas foliar)	23545	54804	31259	1.33	133
T4 (30kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	23683	59592	35909	1.51	151
T5 (40kg ha^{-1} urea +0.5l ha^{-1} Pallas foliar)	23821	60204	36383	1.52	152
T6 (50kg ha^{-1} urea + 0.5 ha^{-l} Pallas foliar)	23959	53796	29837	1.25	125
T7 (50kg ha^{-1} urea + pure water foliar /weedy)	22459	41196	18737	0.83	83

4. Summary, Conclusion and Recommendations

4.1. Summary and Conclusion

Wheat is one of the four most important food grains in Ethiopia. As a source of calories in the diet, wheat is second to maize. In terms of the area of production, wheat is fourth, after teff, maize, and sorghum. In terms of the value of production, it is 4th or 5th, after teff, enset, and maize, and approximately tied with sorghum. Nitrogen is an essential nutrient required for plant growth, and has an impact on root development which in turn affects shoot growth, access to water and other essential nutrients. Water is a vital role for physiological processes and nutrient transport.

Fertilizer application is an important field management factor that determines yield and yield attributes of most field crops. The efficiency of N fertilizer as a top dressing in wheat is influenced by timing, fertilizer rate, and rainfall. Maximum efficiency would be achieved by the right application time when the growing plant is at stage of capability of the crop to rapidly N uptake. This would avoid unnecessary vegetative growth and the risk of lodging and also reduce N loss through weed competition, leaching, denitrification, volatilization, and runoff. In a mechanized large scale farms top dressing nitrogen (urea) fertilizer is not an easy task because of environmental and other logistic problems. In modern agriculture aerial application of nitrogen fertilizer and different agrochemicals (herbicide, fungicides and insecticides) would facilitate field operations and reduce work burden for farmers as well as safe for environments. Most herbicides and fungicides are compatible with inorganic nitrogen fertilizers that enhance the activities of the chemical as the same time used as a nutrient to the growing crops. Most herbicides like Pallas 45OD have a greening effect for cultivated crops. Therefore, combined applications of these important agricultural inputs have an advantage as long as the fertilizer and herbicide are compatible in a tank mix and a convenient application method is available. Combined foliar urea and post emergence herbicide rate exhibited notable effects on the yield, and yield parameters as well as economic benefits relative to the other factors. Number of Spikes, grain per spikes, biological and straw yield increased in response to foliar urea applied from the rates of 10 kg ha^{-1} to 40 kg ha^{-1}, even though the results of the experiments have shown non-significant difference on plant height and thousand grain weights. The highest mean values of productive spikes, grain per spikes and grain yield were produced by the 40 kg and 30kg per ha urea with 0.5l t Pallas ha^{-1} foliar application. As much as better weed control efficiency was recorded from plots treated with 50kg ha^{-1} urea combined with post emergence herbicide foliar spray, this rate caused some injury problems on the crop. Urea fertilizer at the rate of 40kg and 30kg ha^{-1} with post emergence herbicide have shown more significant difference for most agronomic parameters and have better economic advantages over other plots treated with urea and post emergence herbicide, which improved the economic yield by 21%. Thus, it could be concluded that application of urea fertilizer at either 30/40 kg ha^{-1} rate along with post emergence herbicide Pallas improves the productivity of wheat crop and weed controlling efficiency.

4.2. Recommendations

The results of this study may not be representative of the entire zone. Therefore, there is a need for conducting extensive research on the following aspects: evaluation of soil fertility status and plant nutrient requirements based on nutrient status of the soils and plants; determination of recommended rate of inorganic fertilizers along with organic materials is and development of appropriate practices for managing soil acidity; economic analysis of fertilizer applications, taking into account the existing nutrient status of soils and crop rotation practices being followed in the area; and studies on different varieties of wheat crop at different areas of the zone and the country is very important for recommendation of the exact rate along the post emergency Pallas application.

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