Response of of hot pepper (C*apsicum annum* L.) to urea and NPS fertilizers under irrigation at Abergelle, Waghimra, eastern Amhara

Ewunetie Melak, Workat Sebnie, Tilahun Esubalew*

Sekota Dryland Agriculture Research Center

**Corresponding author: Ewunetie Melak, Email: ewunetie2017@gmail.com*

Abstract

*Hot pepper is one of the most important spice crops widely cultivated around the world. Due to nutrient deficiency and disease the productivity of hot pepper is very low as compared to the other country. Therefore, the experiment was conducted to investigate the response of green pod yield and yield component of hot pepper for urea and NPS fertilizers under irrigated condition. It was conducted during 2019 and 2020 irrigation season at Abergelle district of Wag-himra eastern Amhara Ethiopia consisting of four rates of urea (0, 100, 150 and 200 kg/ha urea) and three rates of NPS (0, 100, and 150kg/ha NPS) levels were used and laid out in randomized complete block design with three replications. Result of current study revealed that N and P_2O_5 fertilizer had significant effect on plant height, number of pod number, pod weight and green pod yield of hot pepper. Highest green pod yield (13.86 t ha^{-1}) was obtained from combined application of 97.5 $kgha^{-1}$ N and 57 $kgha^{-1}$ P_2O_5 followed by (*12.98 *t ha^{-1}*) was gained from 74.5 $kgha^{-1}$ N and 57 $kgha^{-1}$ P_2O_5. The cost benefit analysis also showed that application of 97.5 N and 57 P_2O_5 is the first and followed by 74.5 $kgha^{-1}$ N and 57 $kgha^{-1}$ P_2O_5 second appropriate rates for optimum green pod pepper yield in Abergelle district of saka irrigation command area under irrigation season.*

Keywords: hot pepper, green pod, urea, NPS

Introduction

Hot pepper (capsicum annuumL.) belongs to genus Capsicum and family Solanaceae. It is one of the most important spice crops widely cultivated around the world for its pungent flavor and aroma (Ikeh *et al.,* 2012). Fine spicy powder of the hot pepper ('berbere') is an indispensable flavoring and coloring ingredient in the daily preparation of different types of Ethiopian sauces(wot), the green pod also consumed as a vegetable with other food items (MARC, 2004). In Ethiopia, the total production share of green pod pepper was estimated to be 7449.59 ha total production of 45853.7 ton with the average productivity of 6.2 ton ha^{-1}. In Amhara National Regional State, it covers 1331.46 ha with a total production of 8521.1 ton and the average productivity of 6.4 ton ha^{-1} and in Waghimra zone , the total area under hot pepper for the green pod (Karia) was 27.65 ha with a total production of 68.2 ton in the average productivity of 2.5 ton ha^{-1} (CSA, 2016). This shows that the productivity of pepper in Waghimra is much lower than both from the national and regional production.

The productivity of hot pepper is constrained by lack of proper nursery and field agronomic management practices; these are lack of adequate and balanced nutrient supply, diseases, poor aeration, and absence of high yielding cultivars. Amongst these, nutrient deficiency is the most yield-limiting factor in vegetable crop production in Ethiopia (Alemu and Ermias, 2000)**.** Many scholars reported that chemical fertilizers are the major nutrient sources to improve crop productivity (Tamene *et al.,* 2017).

Soil fertility decline (nutrient deficiency) is one of the most limiting factor for vegetable production including hot pepper in different agro-ecology of Ethiopia. The main limiting nutrients are N, P and other macro and micronutrients such as K, S, B and Zn scarcities (Alemu and Ermias, 2000). The key problem in achieving the first growth and transformation plan (GTP) of doubling up agricultural production by the end of the five years plan period was lack of soil fertility map and absence of site and crop-specific fertilizer recommendation (IFDC, 2015). Plant nutrients have a vital role in improving crop production and productivity on a sustainable basis; fertilizers are an effective source of plant nutrients. Accordingly, (Akram *et al.,* 2007, Gezahegn *et al*., 2020) the application of NP fertilizer can boost the production of hot pepper in their work the higher yield and yield related traits were high in higher rates of NP fertilizers. Knowing crop and site-specific recommendations of fertilizer are ideal for the production of hot pepper. Hence, this study was aimed to determine optimum and economical feasible urea and NPS fertilizer rates for sustainable production of hot pepper in Abergelle district of the Waghimra zone in eastern Amhara.

Materials and methods

Description of the study area

The study was conducted for two years during 2019 and 2020 in Saka, Abergelle district, Waghimra Administrative Zone of the Amhara Region, by irrigation. The area is characterized by undulated topography, very shallow soil depth, high soil erosion, and scattered forest coverage. The major crops on the main season were sorghum, sesame, pearlmilet and lowland pulses and in irrigation Onion, tomato, and hot pepper are the main dominance horticulture crops are grown in the district. Sorghum is the leading crop in the district. The trial sites of the two consecutive years are located with 1426417 N latitude 494322.5 E longitude with the altitude of 1313 m.a.s.l and 1426352.36 N latitude, 494288.57 E and 1316 m.a.s.l (fig. 1).The climate of the area is categorized by unimodal rainfall characteristics, and the rainfall pattern has a high amount of rainfall occurring during the main rainy season of July and August the study area indicates that the mean annual rainfall is 622.37 mm with erratic and uneven distribution over seasons and years. The mean minimum and maximum annual air temperatures of the area are 19.19°C and 36.08°C, respectively, with a mean annual air temperature of 24.54°C. The geology of the area also is characterized by a Precambrian basement unconformable overlain by a Paleozoic–Mesozoic sedimentary succession capped by Tertiary volcanics (Sembroni et al. 2017)

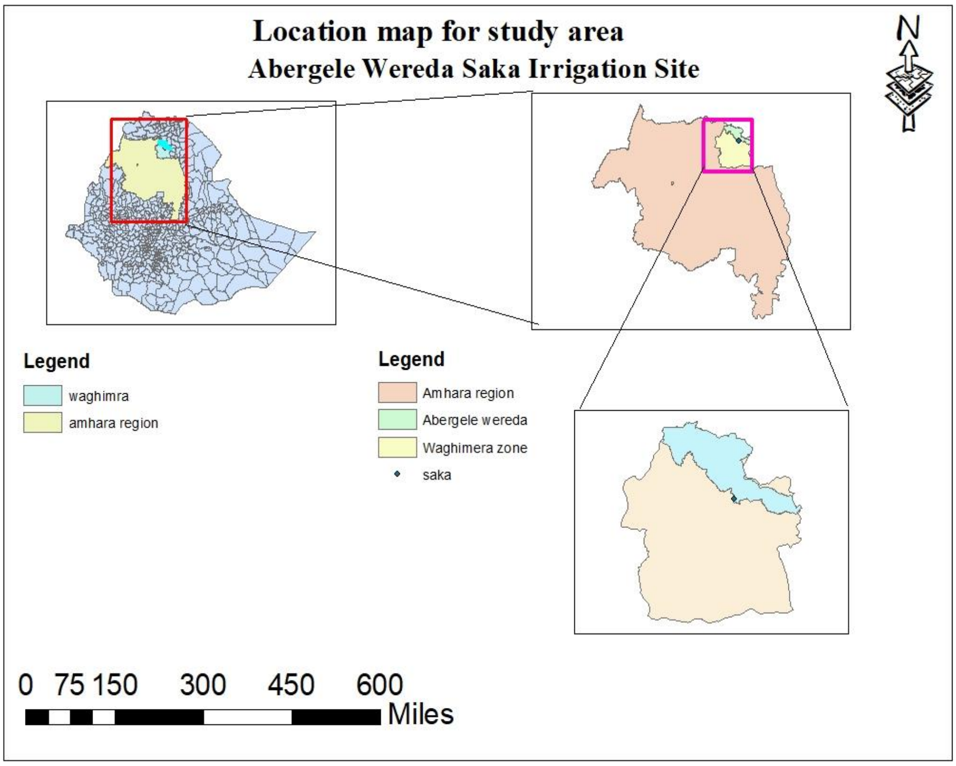

Figure 1. Location map of Abergele wereda and Saka irrigation scheme

Soil sampling, pre-processing and analysis

The representative composite soil samples were collected before planting from a depth of 0-20cm. It was sun dried under shadow, grinded and sieved for the analysis of texture, pH, organic matter, total nitrogen, and available P following with the standard procedure. The determination of particle-size distribution was done using the hydrometer procedure (Sahlemedhin and Taye, 2000). Organic carbon was determined by wet digestion method (Walkley and Black, 1934). Total nitrogen contents were analyzed by the Micro-Kjeldahl method (Horneck et al., 2011). The pH of the soil was determined using a 1:2.5 soil sample to water ratio using a digital pH meter (FAO, 2009), and Available phosphorous was determined by Olsen's method (Olsen et al., 1954).

Table 1**.** Properties of the soil at the experimental field

Soil properties	Values	Rating
pH (by 1:2.5 soil water ratio)	7.05	Neutral. (Murphy, 1968, and Tekalgn, 1991)
Total nitrogen (%)	0.01	Very low (Murphy, 1968 Tekalign, 1991 and Berhanu, 1980)
Available phosphorus(ppm)	0.84	Low. (Olsen *et al.* 1954)
Organic carbon (%)	1.05	Low (Murphy 1968, Tekalgn, 1991 and Berhanu 1980
Electrical conductivity(ms/cm	0.42	Low

Seedling management and transplanting

The seedlings were raised on a seedbed with 5 m length and 1 m width by hand drilling the seeds at the inter-row spacing of 15 cm and mulched with grass. After planting 3-4 leaf stages, healthy and vigorous seedlings were transplanted to the well managed and prepared farmland.

Design of the experiment and treatments

The experiment was organized in a randomized complete block design (RCBD) with three replications. The fertilizer levels were, four levels of urea (0,100,150.200), and three levels of NPS (0, 100,150) kg ha^{-1} arranged a factorial and have a total of 12 treatments (Table 2). Mareko Fana hot pepper variety was used as a test crop which is adapted to the agro-ecology and high yielder in the study area. The plot size of the experiment was 17.64 m^2 (4.2m wide and 4.2 m long), with the spacing of 0.5m and 1m between plots and blocks respectively and the spacing between plant and row was 0.3m and 0.7m respectively, which were six rows per plot and 14 plants per row with a total of 84 plants per plot. Data was collected from net harvestable 4 rows.

Table 2. Fertilizer amount in kg ha^{-1} applied to each treatment was

Treatment NO.	Treatment	$N:P_2O_5:S$
1	Urea 0+NPS 0	0:0:0
2	Urea 0+ NPS100	19 : 38:7
3	Urea 0+NPS150	28.5:57:10.5
4	Urea 100+NPS0	46:0:0
5	Urea 100+NPS100	65:38:7
6	Urea 100+NPS150	74.5:57:10.5
7	Urea 150+NPS0	69:0:0
8	Urea 150+NPS100	88:38:7
9	Urea 150+NPS150	97.5:57:10.5
10	Urea 200+NPS0	92:0:0
11	Urea 200+NPS100	111:38:7
12	Urea 200+NPS150	120.5:57:10.5

Data Collection

The agronomic data were collected from the representative samples. The collected parameters were growth parameters (plant height) and yield and yield component parameters (number of pods per plant, average pod weight (gm.), green pod yield (t ha^{-1}).

Partial Budget Analysis

To consolidate the analysis of variance (ANOVA) of the agronomic data, an economic analysis was used for every treatment. For economic valuation, cost and return, and benefit to cost ratio was calculated according to the procedure given by CIMMYT (1988). The actual green pod yield was adjusted down by 10% .The costs that vary among all the treatments was fertilizer cost. The economic analysis was done based on the formula developed by CIMMYT (1988). Treatments (dominance analysis) were carried out first by listing the treatments in order of increasing cost variation to identify the economically preferable treatment.

Data Analysis

Analysis of variance was carried out for the growth, yield, and yield components using R-software version 4.0.5. Whenever treatment effects were significant, the mean separation was done by Duncan multiple range tests (DMRT) at 5% level of significance.

Results and discussion

Table 3. Response of green pod yield, plant height. number of pod per plant, and pod weight of hot pepper to urea and NPS fertilizers in 2019 and 2020.

NPS rate	Urea rate (Kg/ha)			
	Green pod yield (kg ha^{-1})			
	Urea 0	Urea100	Urea150	Urea200
NPS 0 (0 P_2O_5)	6407^{e}	8867^{cde}	10274^{ab}	7960^{cde}
NPS 100 (38 P_2O_5)	7025^{e}	10978^{abc}	7813de	9143^{cde}
150 (57 P_2O_5)	7542de	12980^{ab}	13841^{a}	12176^{ab}
P level (0.05)	**			
CV (%)	24.28			
	Plant height(cm)			
NPS 0 (0 P_2O_5)	44.75^{f}	54.57^{e}	61.02^{bc}	57.97^{cd}
NPS 100 (38 P_2O_5)	50.23^{c}	63.27^{ab}	56.46^{cd}	63.87^{ab}
150 (57 P_2O_5)	58.4^{d}	63.9^{ab}	63.97^{ab}	65.98^{a}
P level (0.05)	**			
CV (%)	4.64			
	Number of pod per plant			
NPS 0 (0 P_2O_5)	15.48^{f}	20.57^{e}	19.47^{ef}	22.42^{de}
NPS 100 (38 P_2O_5)	21.69^{e}	29.47^{bc}	27.37^{bc}	31.20^{b}
150 (57 P_2O_5)	26.3^{cd}	35.97^{a}	29.47^{bc}	26.06^{cd}
P level (0.05)	**			
CV (%)	14			
	Average pod weight (g)			
NPS 0 (0 P_2O_5)	5.9^{e}	6.18^{e}	6.07^{e}	6.44^{e}
NPS 100 (38 P_2O_5)	7.29^{d}	8.14^{b}	6.41^{e}	7.26^{d}
150 (57 P_2O_5)	7.4^{cd}	8.4^{ab}	8.5^{a}	7.94^{bc}
P level (0.05)	**			
CV (%)	6.8			

*Means within a column sharing common letter(s) are not significantly different. NPS are Fertilizer that contains nitrogen, phosphorous and sulfur, Ns non significance, ** highly significant level (P= 0.05), CV (%) = Coefficient of variation in percent.

Response of Green pod yield to urea and NPS fertilizers

The current investigation revealed that the green pod yield was highly significantly ($P < 0.001$) affected by rates of nitrogen, phosphorus (Table 3). Based on the analysis, the highest total green pod yield (13.84 t ha^{-1}) was attained by the rate of (Urea 150 plus NPS 150) kg ha^{-1} followed by 12.98 t ha^{-1} (Urea100 with NPS 150) kg ha^{-1}. Whereas the lowest (6.41t ha^{-1}) was recorded form 0 kg $ha^{-1}$of urea and NPS. There is no significantly different from the rate of (100kg with 150 kg, 200kg with 150 kg, 150kg with 0kg, and 100 with 100) kg ha^{-1} urea and NPS respectively. The difference in green pod yield might be due to varying levels of fertilizer treatment and the nutrient status of the cultivated area. The application of 150 kg ha^{-1} urea and 150 kg ha^{-1} NPS increases the green pod yield by 7.45 t ha^{-1} or increased by 116% the over the control treatment. Research conducted in many parts of Ethiopia shows those applications N and P_2O_5 increase the dry pod of hot pepper (Tesfaw & Sadik, 2013, Gezaheg *et. al.*, 2020, Hintsa et.al. 2019, Wakuma et al., 2021).

In the contrary extra increases in applied fertilizers from 150 Urea and 150 NPS to 200 urea and 150 NPS kg ha^{-1} reduced green pod yield. This work is supported by Mebratu *et al*., (2014) further increases in applied nitrogen from 100 to 150 kg N ha^{-1} reduced marketable yield by about 42%. Similarly, Nimona *et.al.* (2018) stated that the more increases in applied fertilizers from 150 to 200 NPSBZn kg ha^{-1} reduced marketable pod yield. Likewise, Hintsa *et.al.* (2019) they reported that more increase NPS fertilizer decreases the marketable yield of hot pepper.

Response plant height for urea and NPS fertilizer

The application of urea and NPS fertilizer were highly significantly ($p < 0.001$) increase the plant height of the hot pepper as compared with unfertilized one (Table 3). The highest plant height was recorded at the rate of Urea 200+NPS 150 kg ha^{-1} about 65.98cm but not significantly different from (150+ 150, 100+ 150 , 200+ 100 , 100+ 100) kg ha^{-1} urea and NPS respectively, whereas 44.75 cm was the lowest plant height recorded from control plot. This implies the application of urea and NPS fertilizer can increase the plant height to 21.23 cm. This might be shows that the soil nutrient status of the experimental area is deficiency or low fertility levels. The nutrient NP used for cell division and elongation. Many scholars stated that application of N and P fertilizer increase the plant height of hot pepper (Ayodele, 2017). Kassa *et.al*. (2018) reported that the tallest and shortest plants were observed in plots that received high amount of NP fertilizer plus FYM and unfertilized plot, respectively.

Similarly, Fufa *et al*., (2018a) says that application of high rate of blended fertilizer increase the plant height of the hot pepper compared with the unfertilized plots. Gezahegn *et.al*. (2020) also reported that the highest plant height recorded from the plots they received maximum amounts of NP fertilizers.

Response of number of pod per plant and average pod weight on urea and NPS fertilizer

Application of urea and NPS fertilizer had highly significant (*P*=0.001) effect on the number of pod per plant and on average pod weight of hot pepper (Table 3). The highest number of pods was recorded as 35.97 at a rate of (Urea100 plus NPS 150) kg ha^{-1}, but not statically difference at a rate 200 with 100 kg ha^{-1} Urea and NPS correspondingly and the lowest pod number also recorded from unfertilized plot which were 15.48. This showed that urea and NPS fertilizer used for pod production. It was increased the pod number by 20.49 in number and 132.4%. Similarly, Mebratu et al., (2014) reported that Plants that received nitrogen at the rates of 50, 100, and 150 kg N ha^{-1} produced a higher number of pods and about 60, 133, and 152%, yield improvement over the unfertilized treatments respectively. Gezahegn Assefa *et al., (*2020), showed that the maximum number of pod recorded from the maximum NP treatment. The highest pod weight also observed from Urea 150 combined with NPS 150 about 8.5g, but non-significant with 100 with 150 kg ha^{-1} urea and NPS whereas the smallest pod weights recorded from control or unfertilized plot which was 5.9g.

Correlation of agronomic parameters

Green pod of hot pepper was significant and positively correlated with plant height (r=0.0.65**), NPPP (r=0.0.6**) and APW (r=0.58**) (Table 4). This indicates that every increases green pod yield with the increase in PH, NPPP, GP and APW of hot pepper. This work par with Gezahegn A *et.al.* (2020), and Munda & Shumbulo (2020), stated that an increase in dry fruit weight due to increase the fruit number per plant fruit weight and plant height of hot pepper.

Table 4; Correlation of PH, NPPP, GP and APW of hot pepper

Parameters	GP	PH	NPPP	APW
GP	1			
PH	0.65**	1		
NPPP	0.6**	.51**	1	
APW	0.58**	.59	0.47**	1

*PH implies plant height, NPPP, no of pod per plant, GP: green pod yield, APW: average pod weight, and *** very highly significance

Partial Budget Analysis

The partial budget analysis of the research showed that 150 with 150 kg ha^{-1} Urea and NPS earned the maximum net benefit of 493809 ETB ha^{-1} with MRR of 4083% and followed by 100 with 150 and 100 with 100 kg ha^{-1} Urea and NPS with a net benefit of 463554 and 392230 ETB respectively and MRR of 3240% and 3256.82% (Table 5).

Table5. Cost benefit analysis for the application of urea and NPS fertilizers rates on hot pepper production at Abergelle, Waghimra Eastern Amhara.

Urea	NPS	GPY	TVC	APY	GB	NB	MRR%
0	0	6407	0	5766.3	230652	230652	
100	0	8867	1482	7980.3	319212	317730	5875.71
0	100	7025	1496	6322.5	252900	251404	D
150	0	10274	2223	9246.6	369864	367641	6735.63
0	150	7542	2244	6787.8	271512	269268	D
200	0	7960	2964	7164	286560	283596	D
100	100	10978	2978	9880.2	395208	392230	3256.82
150	100	7813	3719	7031.7	281268	277549	D
100	150	12980	3726	11682	467280	463554	9535.29
200	100	9143	4460	8228.7	329148	324688	D
150	150	13841	4467	12456.9	498276	493809	4082.99
200	150	12176	5208	10958.4	438336	433128	D

*GPY =green pod yield, AGPY=adjusted green pod, GB gross benefit, TVC=total variable cost NB= net benefit MRR=marginal rate of return

Conclusion and Recommendation

Soil fertility problem is one of the yield limiting factors of crops, including hot pepper in Ethiopia. Optimum levels of fertilizer applications and sustaining soil fertility improvement can enhance for higher crop yields.

The results with our research showed that most of the agronomic parameters considered were highly significant affected by both N and P nutrients. Most of the yield and yield components were significantly enhanced when N and P_2O_5 fertilizer rate of 97.5 and 57 kg ha^{-1} respectively. Whereas the lower yield and yield-related parameters was recorded at control (unfertilized) plot. Generally, from this work, it could be concluded that using 97.5 and 57 kg ha^{-1} N and P_2O_5 fertilizer rate was the most appropriate rate on hot pepper green pod yields. Based on net benefit 493809 Eth birr followed by 463554 Eth birr could be achieved by the application of (150:150 and 100:150) kg ha^{-1} urea and NPS fertilizer level and their respective MRR% of this rate was 4083% and 9535.294% (Table 5). Therefore, the first appropriate fertilizer rate for hot pepper at Abergelle, Waghimra and similar agro-ecology to be 97.5 and 57 kg ha^{-1} N and P_2O_5, and the second most appropriate was also 74.5 and 57 kg ha^{-1} N and P_2O_5 fertilizer respectively. Additional research should be also conducted on yield limiting nutrient and times of nitrogen fertilizer application at different vegetative stages to enhance the productivity of hot pepper.

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