

Determination of Optimum Nitrogen and Phosphorus Fertilizer Rates on Bulb Yield of Onion (Allium cepa L.) at Bako, Western Oromia, Ethiopia

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Abstract
Field experiment was conducted to evaluate bulb yield of onion (Allium cepa L.) under different levels of nitrogen and P_2O_5 for two years (2013-2014) at Bako, Western Oromia. Treatments comprised of three levels of nitrogen (46, 92, 138 kgha^{-1}) and three levels of P_2O_5 (46, 92,138 kgha^{-1}) and including check 0, 50 and 0,100 kgha^{-1} P_2O_5 and nitrogen respectively. The experiment was designed in RCBD and replicated three times. The variety bombe red is used as test material. Fertilizer rates were applied in split applications two times for nitrogen and once for P_2O_5. Combined analysis of variance showed as highly significant differences were observed among the treatments. So, an optimum fertilizer rates for nitrogen & P_2O_5 which gave the highest marketable bulb yield ha^{-1} was recommended for the study area and for similar agro-ecologies. The result showed that application of nitrogen significantly increased the average bulb yield of red bulb onion after harvest but application of the main effect P_2O_5 alone, year * nitrogen, year * P_2O_5 and year * P_2O_5 * nitrogen has no significant effect on bulb yield of onion. The interaction of 138kgha^{-1} P_2O_5 with 138kgha^{-1}nitrogen can significantly increases total bulb yield of onion (28.07 tha^{-1}) and recommended for the study area. Besides, it is possible to produce and obtain reasonable bulb yield of 20.58 tha^{-1} bulb onion with the interaction of 92kgha^{-1}nitrogen and 92kgha^{-1} P_2O_5. During vegetative growth stage and at its maturity it was observed that there is disease reaction of purple blotch recorded. Eventually, it is also possible to recommend from the result that onion bulb yield was more responsive to the main effect of nitrogen and its interaction with P_2O_5 but not much respond to the main effect P_2O_5 application alone. We can conclude that rather than application of 92 kgha^{-1}N*138kgha^{-1} P_2O_5 and 46kgha^{-1}N*92kg ha^{-1} P_2O_5, application of 100 kgha^{-1} N alone gave remarkable bulb yield. This directly indicated that bulb yield of onion production is more responsive to nitrogen application than P_2O_5 fertilizer rates. As this experiment was conducted during the main rainy season disease infestation (purple blotch) was the main problem encountered especially in the second year followed the humid environment. So, application of chemical (Orious) 2 litha^{-1} 2-3 times with in fourteen days interval is very crucial to check/control this diseases.
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1. Introduction

The allium group (onion, garlic, and shallot) are important bulb crops produced by small farmers and commercial growers for both local use and export. Among these crops onion is recently introduced but it is rapidly becoming a popular vegetable among consumers. Statistics on the production extents of these crops are not available, except that they are grown in substantial amount and are spread thorough out the country under both irrigation and rain fed conditions in different agro-climatic regions. It is believed that onion (*Allium cepa* L.) was domesticated in the southern parts of central Asia about 6000 years ago, possibly in the Iran-West Pakistan region. Its growing area has been expanding ever since, so that now it is grown in almost all inhabited parts of the world and also recently introduced in to Ethiopia. Onion is considered as one of the most important vegetable crops produced on small scale in Ethiopia. It also occupies an economically important place among vegetables in the country. The area under onion is increasing from time to time mainly due to its high profitability per unit area and ease of production, and the increases in small scale irrigation areas. The crop is produced both under rain fed in the "Meher" season and under irrigation in the off season. In many areas of the country, the off season crop (under irrigation) constitutes much of the area under onion production when diseases are less prevalent (FAO, 2006).

Currently it is widely grown in the rift-vally belt and lake regions of the country mostly under irrigation (Lamma *et al*., 2006). The crop is biennial herb normally grown for its bulb as annual and grown second season for its seed. It is valued for its distinct pungent or mild flavors and form essential ingredients of the cuisine of many foods. Pungency is due to the presence of the volatile oil (allypropyl disulphide). The crop is also widely used as condiment in preparation of soups, meat dishes, salads, sandwiches and cooked alone as vegetable. It is also processed as pickle, chutney, and sauces and consumed in dehydrated. It has also medical and dietic value since ancient times. It also lowers the cholesterol content in blood serum and thus is of values against heart trouble. The mature bulbs contain some starch, appreciable quantities of sugar, some protein, vitamin A, B and C. Depending on the species and the variety, the alliums can be used as food or as seasoning. Despite areas increase, the productivity of onion is much lower than other African countries because of so many factors.

The objective of onion production is high quality dry bulb yield production that could be attained through various growth and development process and applying optimum management practices. Onion plants require organic and inorganic fertilizers for high quality bulb yield production. The productivity of onion can be increased by using well adapted, appropriate verities and supplying adequate plant nutrients. The crop is produced by small scale farmers who have limited knowledge on production practices. To this effect, various agronomic packages such as plant spacing, fertilizer rates, seed, and bulb production practices for onion have been recommended by Melkasa Agricultural Research Center to improve the performance of released varieties. In the last few years, six varieties were developed and released from the national research system(Lemma *et al.*,2006) and recently about nine hybrid varieties are registered by foreign seed companies(APHRD, 2012) for production in Ethiopia.

In Western Oromia where this study was initiated, small holder farmers and other private bulb onion producers (investors) produce low bulb onion. Since the low productivity could be attributed to the limited availability of improved varieties**,** lack/no recommended quantity of nitrogen and phosphorus fertilizer rates diseases and lack of other agronomic practices. So, due to these problems producers of the study area could obtain very low onion bulb yield. Scanty of information on optimum fertilizer application (nitrogen and phosphorus) rates to the red onion variety (Bombay red) under agro-climatic areas of Western Oromia is paramount important to optimize onion bulb yield. To this effect, this research was initiated with the objective of to determine optimum nitrogen and phosphorus fertilizer rates on bulb yield of onion production in Western Oromia.

2. Materials and Methods

2.1. Description of the study area

A field experiment was carried out at Bako Agricultural Research Center (BARC). It is located in East Wollega Zone of Western Oromia and located at 3709’E and 0906’N, East longitude and latitude respectively. The mean annual temperature and rainfall of the study area is 21.1^{0}c and 1067mm, respectively. The altitude of the trial site is1650 m.a.s. (source: Bako Agricultural Research Center Metrological Data).This trial was implemented on station for two years at Bako Agricultural Research Center). The soil of the experimental site (BARC) is nito-soil (clay loam) which is slightly acidic on the basis of composite soil analysis collected before planting.

2.2. Experimental materials and design

The treatments consists of three levels of nitrogen (46, 92, 138 kgha$_-$^{1}) and three levels of P_2O_5 (46, 92, 138kgha^{-}1). Zero (0) and 100kgha^{-1} for nitrogen and zero (0) and 50kgha^{-1} for P_2O_5 was included as check. (100 kgha^{-1}N and 50kgha^{-1}P) is a blanket recommendation used for the area. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications in factorial arrangement. A gross plot size of 3.2 m^2 consisted of 8 rows used. A distance of 1m and 1.5m were left between plots and blocks respectively. Spacing of 40x20x10 cm was used between furrows, rows and plants respectively. Seed of the Bombay Red variety was obtained from Melkassa Agricultural Research Center and was used as test material for conducting the experiment.

2.3. Management Practices

After proper seed bed preparation seed rate of 4 kg ha^{-1} was used for the trial and sown on seed bed then transplanted to permanent field while it reached transplanting stage. All crop management practices weed and weed management options were applied during its growing seasons. Fertilizer was applied to all pots according to its treatment arrangements i.e. nitrogen were applied in two split applications at planting and after one and half months of transplanting but a full dozen of P_2O_5 were applied once during planting. For data measurements the two central double rows were harvested for yield and yield components at physiological maturity when 50% of the leaves fall down.

2.4. Data collection

The effect of nitrogen and P_2O_5 levels on the growth, yield and yield components were evaluated depending on yield and yield related traits. Data on vegetative growth were collected such as stand count (SC) at 1and 1/2 months and at harvest, Number of leaves at maturity (NLM), Plant height (PH) at maturity, the two double central rows was evaluated for yield and yield related traits. Marketable yield, marketable weight, unmarketable yield, unmarketable weight, Bulb fresh weight, were recorded at harvest, Bulb dry matter content (%) was recorded by calculating the ratio of bulb dry matter weight to fresh bulb weight and multiplied by 100. Bulb diameter and length, Total bulb yield, disease reaction (severity and incidence) all these parameters were evaluated for two years at Bako Agricultural Research Center.

2 .5. Data analysis
The mean values of the measured parameters were calculated for all treatments and the means were subjected to ANOVA using SAS statistical procedures was calculated only when the analysis of variance F-test was significant at P<_0.05 probability level for comparing all the treatment means.

3. RESULTS AND DISCUSSIONS
3.1. Total bulb yield
From the result the main effect of nitrogen and its interaction effect with phosphorus showed highly significant differences. The highest mean onion bulb yield (28.07 $tha^{-}1$) was obtained from the interaction of $138kgha^{-1}N$ interaction with$138kgha^{-1}P_2O_5$. As another options the interaction of $92kgha^{-1}N$ with $92kgha^{-1}$ P_2O_5 showed significant differences and the highest bulb yield (20.58$tha^{-}1$) was obtained and recommended for the study area and other areas having similar agro-ecologies. It is also possible to recommend from the result that onion bulb yield was not much respond to P_2O_5 like that of nitrogen alone and its interaction effect with P_2O_5. From the graphical representation of mean bulb yield, we can conclude that rather than application of $92kgha^{-1}N$*138kg $P_2O_5ha^{-1}$ and $46kgha^{-1}N$*92kg $P_2O_5ha^{-1}$, application of $100kgha^{-1}$ N alone only gave remarkable yield. This result directly indicates that bulb yield of onion production is more responsive to nitrogen application than P_2O_5 fertilizer rates to produce an optimum bulb yield. This result is directly agreed with Henriksen (1987) and Kumar *et al*. (1998) reported that the yield of marketable onion bulbs increased with nitrogen application up to 100-$120kgha^{-1}$ and the result also confirm the idea of nitrogen application to the soil is important to increase bulb yield of onion. To the opposite, the lowest total bulb yield was recorded from the interaction of control treatments $0kgha^{-1}N$ * $50kgha^{-1}P_2O_5$ application which is blanket recommendation rates used in the center). Previously similar study was conducted at central riftvally area (MARC) and the highest bulb yield was obtained by application of $92kgha^{-1}$ N but without responding to phosphorus and its interaction with nitrogen. The variation created is assumed to be due to environmental factors existing between central riftyvally area (MARC) and the humid environments exist in Western parts of Oromia.

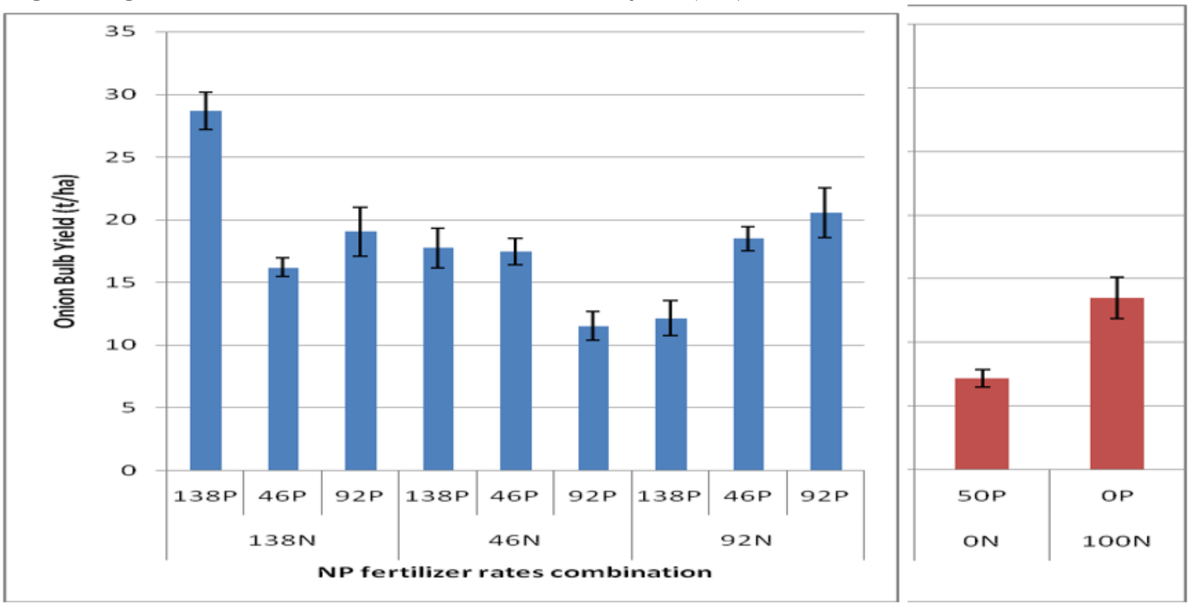
Table.1. *Over all summary of onion bulb yield data recorded for two years (2013-2014) at BARC on station*

	Year 2013			Year 2014				
Treatments	Marketable yield(t/ha)	Unmarketable yield(t/ha)	Total bulb yield(t/ha)	Marketable Yield(t/ha)	Unmarketable yield(t/ha)	Total bulb yield(t/ha	Mean Yield(t/ha)	
0NX50P	7.00	3.25	10.25	12.50	1.00	13.50	11.88	
100Nx0P	11.75	4.63	16.38	11.75	0.88	12.63	14.51	
138Nx138P	29.08	2.38	31.46	13.00	0.88	13.88	28.68	
138Nx46P	19.13	1.75	20.88	10.88	1.25	12.13	16.51	
138Nx92P	20.25	2.25	22.50	10.00	1.75	11.75	17.13	
46Nx138P	16.88	3.38	20.26	15.50	0.75	16.25	18.26	
46Nx46P	15.88	3.00	18.88	11.75	1.00	12.75	15.82	
46Nx92P	14.88	2.13	17.01	18.00	1.13	19.13	18.07	
92Nx138P	19.00	2.25	21.25	14.25	0.75	15.00	18.13	
92Nx46P	17.13	1.88	19.01	15.88	1.25	17.13	18.07	
92Nx92P	21.38	2.63	24.01	13.38	1.38	14.76	19.39	

Table 2. *ANOVA for the combined analysis of the treatments*

	DF	Type III SS	Mean Square	Mean yield(t/ha)	Pr > F
Year	1	225.5022685	225.5022685	28.07	<.0001
N	2	317.7761778	158.8880889	19.78	<.0001
P	2	64.7068778	32.3534389	4.03	0.0269
N*P	4	828.7214444	207.1803611	25.79	<.0001
Year*N	2	6.4282815	3.2141407	0.4	0.6733
Year*P	2	37.5255593	18.7627796	2.34	0.1121
Year*N*P	4	8.5830074	2.1457519	0.27	0.897
Rep	2	1.0258778	0.5129389	0.06	0.9382

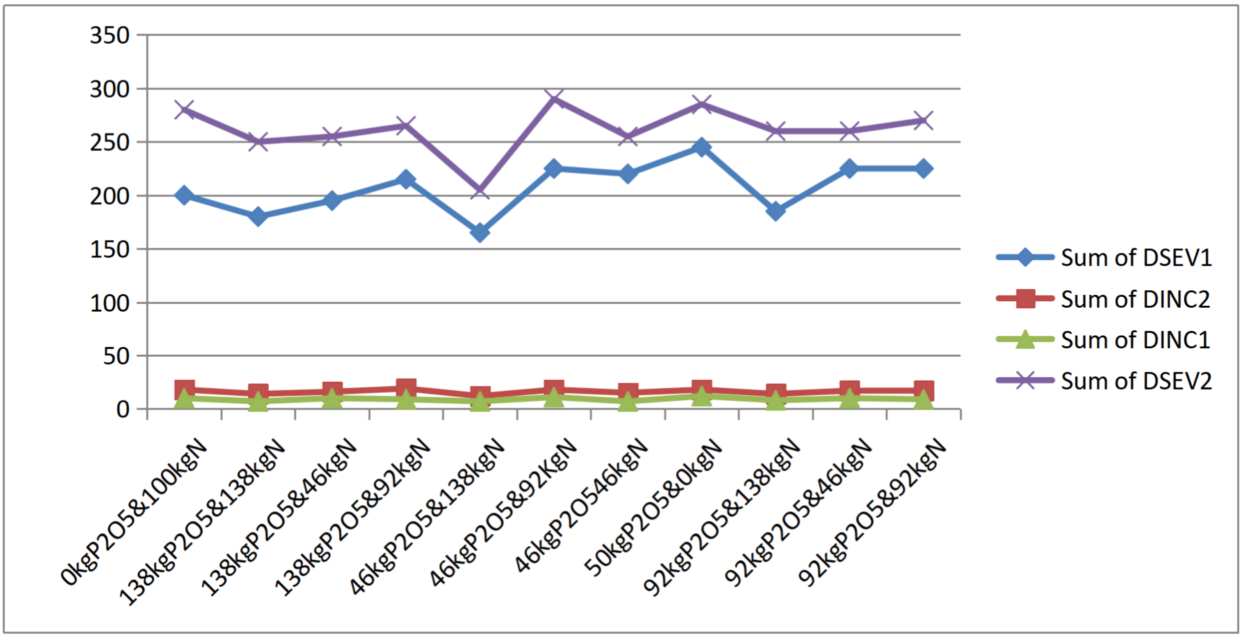
Graphical representation of the combined mean onion bulb yield (t/ha)



3.2. Disease reactions

Even though the intention were not to evaluate the vegetative parameters of bulb onion, as observed from the result different levels of nitrogen and phosphorus application rates has its own implications on the growth of vegetative parameters, and disease reactions(severity and incidences) as the experiment was conducted during the main rainy seasons. Treatments with the highest levels of nitrogen grew more vegetative and disease severity (purple blotch) were more recorded on the plots followed the humid environments. This indicated that as nitrogen application increases it intensify the growth and development of onion leaf and more densely populated. So, this increases the attack of onion leaf by diseases together with favorable humid environment for the development and growth of the diseases (purple blotch). In general, to control both disease severity and incidences of onion 2-3 times chemical application (Orious 2 lit/ha) within 10-15 days interval was recommended to check the slight increase of disease incidence and oscillation of disease severity of onion purple blotch which is alarmingly increasing during the humid environment in the study area and similar agro-ecologies.

Graphical representation of sum of disease severity and incidence recorded for two years (2013-2014).



Keys, DSEV1 (disease severity recorded at first), DSEV2 (disease severity recorded at second), DIN1 (disease incidence at first), DIN2 (disease incidence at second phases).

4. Summary and Conclusions

The study was entitled on the effect of nitrogen and phosphorous for bulb yield and yield components of red onion (Bombay red). The main effect of nitrogen and its interaction with phosphorus significantly increased bulb yield of red onion. As the first option the highest bulb yield (28.07 tha^{-1}) was obtained from the interaction of 138 $kgha^{-1}$N *138 $kgha^{-1}$ Phosphorus in the study area. In the second case reasonable bulb yield (20.58 tha^{-1}) was obtained from the interaction of 92 $kgha^{-1}$N * 92 $kgha^{-1}$ phosphorous. This result clearly indicated that depending on their interest and economy intended to obtain the optimum onion bulb yield, the end users could utilize either of the two fertilizer interaction options. Total optimum bulb yield of onion production could be obtained at the study area and similar agro-ecologies with the appropriate fertilizer application rates both for nitrogen and phosphorous interactions. Eventually, it is possible to conclude and recommend that the highest onion bulb yield (28.07 tha^{-1}) for the variety Bombay red could be obtained with the interaction of 138 $kgha^{-1}$ N *138 $kgha^{-1}$ phosphorus fertilizer rates for the study area and similar agro-ecologies. But the study was limited at single location (BARC) on station for two years. So, it is very crucial to repeat the experiment with increasing locations and come up with conclusive results for further recommendations.

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