Response of Irrigated Onion to Nitrogen and Phosphorus Fertilizers at Ribb, Koga, Megech, and Gurmbaba Irrigation Schemes in Amhara Region

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Abstract

Nitrogen (N) and phosphorus (P) fertilizer recommendations for irrigated onion production is lacking for the different irrigation schemes in the Amhara region. Four different experiments were conducted at Ribb, Koga, Megech and Gurmbaba irrigation schemes to determine the N and P fertilizer levels for irrigated onion. Experiments were conducted in the years 2010 and 2011. At Ribb and Koga treatments were comprised of factorial combinations of five N levels (50, 100, 150, 200 and 250 kg N ha^{-1}) and three P levels (20, 40 and 60 kg P ha^{-1}) with one satellite control treatment (0/0 N/P) replicated three times in Randomized Complete Block Design. At Megech, factorial combinations of four N levels (0, 50, 100, and 150 kg N ha^{-1}) and four P levels (0, 20, 40, 60 kg P ha^{-1}) were replicated three times in Randomized Complete Block Design. At Gurmbaba five levels of N (0, 50, 100, 150 and 200 kg N ha^{-1}) were replicted three times in Randomized Complete Block Design. Bombay Red in Ribb and Koga, and Adam Red in Megech were onion varieties used for the study. Results showed that at Ribb application of 150 kg N ha^{-1} and 20 kg P ha^{-1} as the first recommendation and 250 kg N ha^{-1} and 20 kg P ha^{-1} as a second recommendation; at Koga application of 100 kg N ha^{-1} and 60 kg P ha^{-1} as the first option and application of 50 kg N ha^{-1} and 60 kg P ha^{-1} as a second option; at Megech application of 100 kg N ha^{-1} and 60 kg P ha^{-1}; and at Gurmbaba application of 200 kg N ha^{-1} along with the recommended phosphorus fertilizer rate (20 kg P ha^{-1}) were found high yielding and economically profitable and are recommended.

Key words: Onion, N and P fertilizers, Irrigation, Ribb, Koga, Megech, Gurmbaba

Introduction

In most irrigable lands, horticultural crops in general and vegetables in particular, play an important role in contributing to the household food security and income. Vegetables being cash crop, with high nutritional value, generate income for the poor households.

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Higher profits can be achieved by increasing the production of a particular vegetable throughout the year when efficient irrigation system is used. Onion (*Allium cepa* L.) is one of the most popular vegetables in the world. It is fourth in world production of vegetables with a volume of 57.9 million tons (FAO, 2005). In Ethiopia, it contributes substantially to the national economy apart from overcoming local demand. Onion is among the largest production and highly commercialized vegetable crops in Amhara region grown under irrigation. Currently farmers in most irrigable areas of the Amhara region produce large amount of onion bulbs every year. For instance, in 2005/06 production year the region contributed 70,652.6 tons of onion bulb from 5,338 hectares of land covered by the crop (Tadesse, 2008). In the Amhara region irrigated agriculture is expanding since recent years. Currently, more than 6,200 small scale irrigation schemes of which 95% are traditional exist in the region (Melisew, 2012). Interestingly, the irrigation schemes are owned by more than 330,000 households (or more than 1.9 million people) with an average irrigated land holding of 0.2 ha (Melisew, 2012). Further more, several new and modern irrigation schemes such as Ribb, Megech, Koga, Kobo, Robit, Gumara, etc are under development which will increase the significance of irrigation agriculture in the region. However, farmers are growing most of the irrigated crops with very limited use of improved technologies, which kept the production and productivity of the irrigated system not better than the rainfed system. For instance, in Megech and Ribb areas, only 5 and 4 percent of the households that cultivated during the dry season using irrigation used chemical fertilizers and compost, respectively. The proportion is higher for households in the Megech project area (14% vs 4%) compared with Ribb area (World Bank/DIME, 2012). For the irrigated production system appropriate agronomic technologies have rarely been developed. Therefore, this experiment was conducted with the objective of determining the optimum rates of nitrogen and phosphorus fertilizers for onion for four irrigation schemes in the region.

Materials and Methods

Description of Study Sites

Experiments were conducted at Ribb, Koga, Megech, and Gurmbaba irrigation schemes in the 2010 and 2011 production seasons. Ribb irrigation scheme is found in Fogera

district situated at 11^0 52 !up! 23^0 13 !O! mbujuvef! boe! 48^0 3: ! up! 48^0 6: !F! mpoh juvef! bulbo! altitude of 1800 m a.s.l. Koga irrigation scheme is found in Mecha district situated at 11^o36 31 !O! mbujuvef! boe! 48^o21 31‘ !F! mpoh juvef! bulbo! bmjuvef! pg! 2: 71! n ! b/s.l. Megech research site is found in Dembia district situated at 12^o31 62‘ !O! mbujuvef! boe! 48^o31 34‘ ! E longitude at an altitude of 1786 to 1800 m a.s.l. Gurmbaba irrigation scheme is found in West Belessa district situated at 12^o3: 6: ‘ !O! mbujuvef! boe! 48^o47 4: ‘ !F! mpoh juvef ! boe! an altitude ranging from 1777 to 1806 m a.s.l.

The soil at the Ribb experimental site is fluvisol (an alluvial deposit). According to Bruce and Rayment (1982), the soil has high phosphorus and very low to low total nitrogen contents (Table 1). The CEC is high according to the category by Hazelton and Murph (2007). The soil at the Koga experimental site is Nitosol. The soil is strongly acidic with high exchangeable acidity and high exchangeable Al^{3+} content. It has very low organic matter content. Available phosphorus content is low according to the category by Clements and McGowen (1994). It has medium total nitrogen contents (Table 2).

At Megech experimental site the soil is dominantly Vertisol (>65% coverage) with few coverage of Luvisols. The top 60 cm soil of the experimental site is clay in texture with 11% sand, 38% silt and 51% clay content. It has 0.1% total nitrogen, 1.1% organic carbon, 24.2 ppm available phosphorous and a pH of 8. The soil is also characterized by 1.41g cm^{-3} bulk density, 44.5% field capacity, and 27.5% permanent wilting point. At Gurmbaba, the soil is sandy clay loam in texture with 42% sand, 27% silt and 31% clay contents. The soil has 9.6 cation exchange capacity, 0.74% organic carbon, 0.11% total nitrogen and pH of 7.5.

Table 1. Chemical properties of the soils of Ribb irrigation command area, 2011

Sample	**Av. P (ppm)**	**Total N (%)**	**CEC** (cmol kg^{-1})
Gbsn fst !gjfmet	24.32-29.89	0.007-0.18	33.40-36.25
Trial site	36.71	0.003	33.00

Table 2. Chemical properties of the soils of Koga irrigation command area, 2011

pH	Exch. Al3+ (cmol kg^{-1})	Exch. H^+ (cmol kg^{-1})	Exch. acidity (cmol kg^{-1})	Total N (%)	Available P (ppm)	Organic matter (%)
5.1-5.3	0.92-2.88	0.62-2.35	1.54-5.23	0.18-0.24	3.54-8.69	2.34-4.44

Experimental Design and Procedures

At Ribb)Gphfsb! boe! Mjc p! L fn l fn ! x fsfe bt ! ui f! usjbmx bt! dpoevduf e! po! gbsn fst ! gjfmet! whereas at Koga it was conducted inside the research station. At Ribb and Koga factorial combinations of five N fertilizer levels (50, 100, 150, 200 and 250 kg N ha^{-1}) and three P levels (20, 40 and 60 kg P ha^{-1}) with one satellite control treatment (0/0 N/P) for comparison constituted the treatments. The experimental design was randomized complete block in three replications. Onion variety, Bombay Red was used. After raising seedlings on seedbed for 50 days, healthy and uniform seedlings were transplanted to the experimental plots. Spacing between furrow, rows and plants were 40cm, 20cm and 10cm, respectively in a net plot size of 1.2 m^2. Distances between plots and blocks were 1m. Urea and TSP/DAP were used as a source of nitrogen and phosphorus fertilizers, respectively. Phosphorus was band-applied at planting in rows 2 cm below seedlings. While nitrogen was applied in split, half at transplanting and the remaining half at 45 days after transplanting on both sides of the rows of 2-3cm away from plants. Plants were cultivated four times in the cropping season. Irrigation water was supplied weakly using furrow irrigation method.

At Megech (Dembia wereda), the experiment was conducted at on-farm. Treatments were factorial combinations of four N fertilizer levels (0, 50, 100, and 150 kg N ha^{-1}) and four P levels (0, 20, 40, 60 kg P ha^{-1}). The plot size was 2m by 3m, the spacing between blocks, rows and plants were 1.5m, 20cm and 10cm respectively. The experimental design was randomized complete block in three replications. Onion variety Adam Red was used. Urea and TSP were used as a source of nitrogen and phosphorus fertilizers, respectively. Phosphorus was band-applied at planting, while nitrogen was applied in split, half at planting and the remaining half at 45 days after transplanting. Irrigation water was supplied every four days with furrow irrigation method.

At Gurmbaba (West Belesa) the experiment was conducted on gbsn fst !gjfmt. The plot size was 3m by 3m, the spacing between blocks, rows and plants were 1.5m, 20cm and 10cm respectively. Treatments were comprised of five levels of N fertilizer (0, 50, 100, 150 and 200 kg N ha^{-1}). Phosphorus at the rate of 20 kg P $ha^{-1}$was applied uniformly for each plot at planting. The experimental design was randomized complete block replicated three times. Nitrogen was applied by spliting, half at planting and the other half at 45 days after transplaning. Onion variety of Adama-Red was used. Irrigation water was supplied every four days with furrow irrigation method.

Composite soil samples for the determination of physicochemical properties of the experimental plots were collected prior to planting. Data on plant height, maturity date, leaf number, bulb weight, bulb length, bulb diameter, marketable and unmarketable yield and total yield were recorded.

In order to identify economically feasible recommendations partial budget analysis was done based on the manual developed by CIMMYT (1988). The analysis was based on data collected from respective district office of Trade and Transport, Cooperatives and from onion field experiment. At Fogera, the mean price of onion, urea and DAP from 2009-2011 was 3.40 ETB kg^{-1}, 7.74 ETB kg^{-1} and 8.90 ETB kg^{-1}, respectively. While at Koga, the mean price of onion, urea and DAP were 2.62 ETB kg^{-1}, 7.41 ETB kg^{-1} and 8.60 ETB kg^{-1} respectively. At Megech, during 2010-2011 production season, the mean price of Onion, urea and DAP were 3 ETB kg^{-1}, 9.87 ETB kg^{-1} and 10.7 ETB kg^{-1} respectively. Data were subjected to analysis of variance using SAS statistical package (SAS Institute, 2002)

Results and Discussion

Results of Ribb Irrigation Scheme

Results at Ribb indicated that nitrogen has significant ($P<0.01$) effect on the marketable and total yields of onion and bulb diameter, but phosphorus and the interaction of N and P did not show significant effect (Table 3). As compared to the control (0/0 N/P_2O_5), application of 20 kg ha^{-1} P has 3.89 ton ha^{-1} marketable yield advantage over the zero fertilizer application. This result shows that application of 20

in combination with 20 kg P ha^{-1} are recommended for onion production at Ribb irrigation scheme as first and second option, respectively. The farmers at Fogera and Libokemkem woredas did not apply fertilizer at all for onion production; however this finding revealed that application of fertilizer has contributed much to boost yield. This has positive implication for onion production increment.

Table 3. Combined ANOVA for the effect of N and P fertilizers on the marketable and total yield of onion at Ribb irrigation scheme

Sources of variation	Df	Mean square values							
		Marketable yield	Pr > F	Total bulb yield	Pr > F	Bulb diameter	Pr > F	Bulb length	Pr > F
Rep	2	4047.30	0.0143	4162.41	0.0114	18.08	<.0001	0.42	0.002
N	4	4826.35	0.0009	4882.36	0.0007	4.20	0.022	0.089	0.200
P	2	133.42	0.8592	74.51	0.9165	1.098	0.424	0.021	0.680
Year	1	292419.60	<.0001	289736.79	<.0001				
N x P	8	846.76	0.4728	816.35	0.4796	1.52	0.3176	0.044	0.602
Error	52	874.17		850.78					

Table 4. Effect of nitrogen fertilizer on the marketable and total bulb yield of onion at Ribb combined over two years (2010 and 2011).

N rate (kg ha^{-1})	Marketable yield (t ha^{-1})	Total yield (t ha^{-1})	Bulb diameter (cm)	Bulb length (cm)
0	19.74[c*]	19.91[c]	17.92[ab]	4.37[a]
50	21.87[bc]	21.95[bc]	17.06[c]	4.41[a]
100	22.54[ab]	22.55[abc]	17.5[bc]	4.32[a]
150	24.76[ab]	24.86[a]	18.68[a]	4.54[a]
200	24.30[ab]	24.33[a]	17.52[bc]	4.33[a]
250	25.87[a]	25.93[a]	18.41[ab]	4.51[a]
LSD (0.05)	**	**	*	NS
CV (%)	14..07	13.72	6.25	5.32

*Means folmpx fe!cz!ui f!tbn f!mfuufst!bsf!opu!t jho jgjdbouz!e jggfsfou!bu 1/16/

Table 5. Effect of phosphorus fertilizer on the marketable and total bulb yield of onion at Ribb combined over two years (2010 and 2011).

P rate (kg ha^{-1})	Marketable Yield (t ha^{-1})	Total Yield (t ha^{-1})	Bulb diameter (cm)	Bulb length (cm)
0	19.74[a]	19.91[a]	17.92[a]	4.37[a]
20	23.63[a]	23.75[a]	17.71[a]	4.43[a]
40	24.04[a]	24.06[a]	18.45[a]	4.39[a]
60	23.93[a]	23.96[a]	17.65[a]	4.46[a]
LSD (0.05)	NS	NS	NS	NS
CV (%)	14..07	13.72	6.25	5.32

*Means followed by ui f!tbn f!mfuufst!bsf!opu!t jho jgjdbouz!e jggfsfou!bu 1/16/

Table 6. Partial budget analysis for the effect of nitrogen fertilizer on the yield of onion at Ribb irrigation scheme

N level (kg ha^{-1})	Unadjusted yield (t ha^{-1})	Adjusted yield (t ha^{-1})	Gross benefit (ETB ha^{-1})	Total variable cost (ETB ha^{-1})	Net benefit (ETB ha^{-1})	MRR (%)
0	19.74	17.766	35309.93		35309.93	D*
50	21.87	19.683	39119.96	932.61	38187.35	308.5
100	22.54	20.286	40318.43	1865.22	38453.21	D
150	24.76	22.284	44289.45	2797.83	41491.62	325.8
200	24.3	21.87	43466.63	3730.435	39736.19	D
250	25.87	23.283	46274.96	4663.043	41611.92	201.1

Results of Koga Irrigation Scheme

According to Hazelton and Murph (2007), suitable pH range for onion is 6-6.5. However, the soil pH at Koga (5.09 to 5.3) is far below the optimum range which indicates that the performance of onion at Koga irrigation scheme could be affected by soil acidity, especially with Al^{3+} toxicity. Onion is very sensitive to soil acidity, especially for Al^{3+} toxicity. Exchangeable Al^{3+} becomes significant at pH levels less than 5.5 in water or about 4.7 in CaCl2. The critical level of exchangeable Al^{3+} for onion is 0.4-0.8 extracted by $CaCl_2$ (Hazelton and Murph, 2007) while exchangeable Al^{3+} at Koga is 0.92-2.88 which is above the critical level. This result indicates that onion production was affected by aluminum toxicity at Koga irrigation scheme. The soil at Koga has very low organic matter content. Available phosphorus content is also low according to the category by Clements and McGowen (1994).

The interaction effect of N and P fertilizers had significant ($P<0.01$) effect on the marketable and total yield of onion at Koga (Table 7). However, there was no interaction effect of N and P fertilizer ($P<0.05$) on bulb diameter and length. Significantly higher marketable bulb yields were recorded with the application of 100 kg N ha^{-1} with 60 kg P ha^{-1} followed by application of 150 kg N ha^{-1} with 40 or 60 kg P ha^{-1}. Similarly, significantly higher total bulb yields were recorded with the application of 250 kg N ha^{-1} with 40 kg P ha^{-1} followed by application of 100 kg N ha-1 with 60 kg P ha^{-1} (Table 8). This result indicated that application of N and P fertilizer has highly significant influence on the bulb yield and vegetative growth of onion which is in harmony with the findings of Rizk (1997) who concluded that increasing the application

rate of N increased growth of onion. In addition, the result indicates that higher bulb diameter was recorded by applying 150 kg N ha^{-1}.

According to Rizk (1997), in irrigated agriculture use of chemical fertilizer can increase the yield of onion more than 10 tons per hectare as compared to without fertilizer application. It is observed that maximum bulb yields were recorded at maximum phosphorus applications. This could be an indication that the applied phosphorus might have been fixed due to the strongly acidic soils. Thus, such studies need to be conducted with the application of lime to understand the readily available phosphorus applied.

Table 7. Combined ANOVA for the effect of N and P fertilizers on the marketable and total yields of onion at Koga irrigation schemes.

Sources of variation	df	Mean square values							
		Marketable yield	Pr > F	Total yield	Pr > F	Bulb diameter	Pr>F	Bulb length	Pr>F
Rep	2	2.30	0.998	318.57	0.813	1.54	0.69	6.391	<.0001
Nitrogen (N)	4	2487.82	0.160	2929.22	0.123	3.58	0.49	0.238	0.70
Phosphorus (P)	2	46812.6	<.000	48816.28	<.0001	8.09	0.16	0.066	0.86
Year	1	207526.5	<.000	325141.08	<.0001				
N x P	8	5005.93	0.002	5595.25	0.001	6.96	0.14	0.370	0.57
Error	52	1448.15		1534.19		4.11		0.436	

Table 8. Effect of N and P fertilizers on the marketable bulb yield of onion at Koga over two years (2010 and 2011)

P/N rate (kg ha^{-1})	**Marketable yield (t ha^{-1})**	**Total yield (t ha^{-1})**	**N rate (kgha^{-1})**	**Bulb dia. (cm)**	**Bulb length (cm)**	**P rate (kgha^{-1})**	**Bulb dia. (cm)**	**Bulb length (cm)**
0/0	19.74^{f*}	20.00^{g*}	0	18.21^{b}	6.53^{a}	0	18.21^{b}	6.53^{a}
20/50	24.41^{def}	25.48^{ef}	50	21.32^{a}	6.97^{a}	20	20.84^{a}	6.74^{a}
20/100	24.30^{cde}	27.68^{def}	100	22.02^{a}	6.91^{a}	40	22.21^{a}	6.84^{a}
20/150	23.34^{de}	25.90^{ef}	150	20.75^{a}	6.67^{a}	60	21.99^{a}	6.87^{a}
20/200	24.46^{cde}	34.79^{abc}	200	22.03^{a}	6.62^{a}			
20/250	25.89^{bcd}	33.93^{bc}	250	22.28^{a}	6.92^{a}			
40/50	21.86^{ef}	22.33^{f}						
40/100	24.13^{cde}	29.58^{de}						
40/150	27.74^{ab}	27.84^{ef}						
40/200	26.04^{bcd}	33.89^{bc}						
40/250	24.93^{bcd}	38.04^{a}						
60/50	25.68^{bcd}	28.91^{def}						
60/100	29.22^{a}	35.09^{ab}						
60/150	26.79^{abc}	29.04^{def}						
60/200	26.18^{abcd}	30.91^{cd}						
60/250	25.39^{bcd}	29.03^{def}						
LSD(0.05)	**3.05**	**3.42**		1.96	0.63		1.52	0.49
CV (%)	**13.64**	**12.97**		9.36	9.68		9.36	9.68

**Means followed by the same letters are not significantly different at P<0.05.*

The results of the partial budget analysis (Table 9) showed that applying 100 kg N ha^{-1} and 60 kg P ha^{-1} had the highest net benefit (65247 ETB ha^{-1}) and MRR (1996 %) followed by 150 kg N ha^{-1} and 40 kg P ha^{-1} with net benefit of 61498 ETB ha^{-1} and MRR of 1711% (Table 9). Therefore, 100/60 and 150/40 kg N/P ha^{-1} are recommended as first and second options, respectively for onion production at Koga irrigation scheme. The studies at both sites indicate that fertilizer application will increase marketable and total bulb yield for onion production under irrigation; hence farmers and other onion growers should apply N and P fertilizers to increase their income and as well the dpvousz t!HE /

Table 9. Partial budget analysis for the effect of N and P fertilizers on the yield of onion at Koga irrigation scheme.

N / P (kg ha^{-1})	Unadjusted yield (t ha^{-1})	Adjusted yield (t ha^{-1})	Gross benefit (ETB ha^{-1})	Total variable cost (ETB ha^{-1})	Net benefit (ETB ha^{-1})	MRR (%)
0/0	19.74	17.77	46546.92	0	46546.92	
50/20	24.41	21.97	57558.78	1513.35	56045.42	690.41
50/40	21.86	19.67	51545.88	2140.22	49405.66	D
50/60	25.68	23.11	60553.44	2838.00	57715.44	1309.973
100/20	24.3	21.87	57299.4	2399.85	54899.55	706.9403
100/40	24.13	21.72	56898.54	3026.71	53871.83	D
100/60	29.22	26.30	68900.76	3653.57	65247.19	1996.114
150/20	23.34	21.01	55035.72	3286.34	51749.38	4043.096
150/40	27.74	24.97	65410.92	3913.20	61497.72	1710.609
150/60	26.79	24.11	63170.82	4540.06	58630.75	D
200/20	24.46	22.01	57676.68	4172.83	53503.85	1535.7
200/40	26.04	23.44	61402.32	4799.69	56602.62	543.7642
200/60	26.18	23.56	61732.44	5426.55	56305.88	D
250/20	25.89	23.30	61048.62	5059.32	55989.3	R
250/40	24.93	22.44	58784.94	5686.18	53098.75	D
250/60	25.39	22.85	59869.62	6313.05	53556.57	R

D Stands for dominated treatment. R stands for rejected treatment

Results of Megech Irrigation Scheme

Results of combined ANOVA showed that bulb diameter and bulb weight did not respond to the application of N and P at Megech. But, bulb yield responded to the effects of N and P (Table 10). The interaction effect of N and P on bulb yield and the yield comppofou t! x bt! opu t jho jgjdbou! Tjho jgjdbouzn!) 1 /l 2 ! i jhi fs! cvmc! zjfmeut! x fsf! obtained with the application of 100 and 150 kg N ha^{-1} and 60 kg P ha^{-1} (Table 11).

Table 10. Combined ANOVA for the effect of N and P fertilizers on the yield and yield components of onion at Megech (2010 and 2011).

Source of variation	df	Mean square		
		Bulb diameter	Bulb weight	Yield
Replication	2	0.03ns	9.3ns	0.55ns
Nitrogen (N)	3	0.76ns	272.8ns	655.0**
Phosphorus (P)	3	0.11ns	62.6ns	109.3**
N x P	9	0.01ns	16.6ns	19.9ns
Error	78	0.47	196.4	11.9

Table 11. Effect of N and P fertilizer on the yield and yield components of onion at Megech combined over years (2010 and 2011).

Treatment	Bulb Diameter (cm)	Bulb Weight (g)	Yield (t ha^{-1})
N Level (kg ha^{-1})			
0	4.3	53.0	19.2^{c*}
50	4.7	59.5	27.7^{b}
100	4.7	59.7	30.4^{a}
150	4.6	59.9	30.0^{a}
P Level (kg ha^{-1})			
0	4.5	55.6	24.4^{c}
20	4.6	58.6	26.0^{bc}
40	4.6	58.8	27.4^{b}
60	4.7	59.1	29.4^{a}
CV (%)	14.9	24.1	12.9
LSD (0.05)	0.39	8.05	1.98

**Means followed by the same letters were not statistically significant at P ≤0.05.*

Higher total yield in onion at higher N and P (80-120 kg N ha^{-1}and 60 kg P ha^{-1}) rates were reported (Sheikh et al.1987; Baloch et al. 1991; Bhardwaj, 1991; and Pandey et al. 1994), which is in agreement with the present finding. The higher marketable fruit yield under higher N and P rates might have been achieved probably because the higher N and P rates might have improved fruit size thereby contributing to greater marketable fruit yield. The results of the partial budget analysis also showed that applying 100 kg N ha^{-1} and 60 kg P ha^{-1} had the highest net benefit (89594 and 84922 ETB ha^{-1} for N and P) and marginal rate of return (806 and 571 % for N and P rate) and are found economically profitable for onion production at Megech (Table 12). Therefore, 100 kg N ha^{-1} and 60 kg P ha^{-1} is recommended for onion production at Megech in Dembia wereda and other similar areas.

Table 12. Partial budget analysis for the effect of N and P fertilizers on the yield of onion at Megech irrigation scheme.

Parameters	Nitrogen level (kg ha^{-1})				Phosphorous level (kg ha^{-1})			
	0	**50**	**100**	**150**	**0**	**20**	**40**	**60**
Mean yield (t ha^{-1})	19.2	27.7	30.4	30.0	24.4	26.0	27.4	29.4
Adjusted yield (t ha^{-1})	17.3	24.9	27.4	27.0	22.0	23.4	24.7	26.5
Total Revenue (ETB ha^{-1})	69120	99720	109440	108000	87840	93600	98640	105840
Total costs (ETB ha^{-1})	17700	17700	17700	17700	17700	17700	17700	17700
Gross field benefit (ETB ha^{-1})	51420	82020	91740	90300	70140	75900	80940	88140
Fertilizer cost (ETB ha^{-1})	0	1073	2146	3218	0	1073	2146	3218
Total costs that vary (ETB ha^{-1})	0	1073	2146	3218	0	1073	2146	3218
Net benefit (ETB ha^{-1})	51420	80947	89594	87082	70140	74827	78794	84922
Dominance Analysis				D				
Marginal cost (ETB ha^{-1})	0	1073	1073		0	1073	1073	1073
Marginal net benefit (ETB ha^{-1})	0	29527	8647		0	4687	3967	6127
Marginal rate of return (%)		2752	806			437	370	571

Results of Gurmbaba Irrigation Scheme

The results of the combined ANOVA showed that bulb weight and bulb yield had responded to the application of nitrogen fertilizer, but not bulb diameter (Table 13). Results indicated that onion bulb weight and bulb yield were significantly higher at the application of 150 and 200 kg N ha^{-1} (Table 14). The increase in yield in response to application of N fertilizers is probably due to enhanced availability of nitrogen which could enhance more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation.

Table 13. Combined ANOVA for the effect of N fertilizer on the yield and yield components of onion at Gurmbaba (2010 and 2011).

Source of variation	df	Mean square		
		Bulb diameter	**Bulb weight**	**Yield**
Replication	2	0.21^{ns}	222.7*	0.40^{ns}
Nitrogen	4	0.44^{ns}	1883.3**	27.4**
Error	8	0.61	24.1	0.78

Table 14. Effect of N fertilizer on the yield and yield components of onion at Gurmbaba in 2009 and 2010.

Nitrogen (kg ha^{-1})	Bulb diameter (cm)	Bulb weight (g)	Yield (t ha^{-1})
0	5.07	50.4^{d*}	5.8^{d}
50	5.37	72.3^{c}	7.6^{c}
100	5.52	83.2^{b}	9.2^{b}
150	5.80	93.5^{a}	10.2^{ab}
200	5.55	92.3^{a}	11.2^{a}
CV (%)	16.3	6.3	10.1
LSD (0.05)	0.94	5.9	1.06

* Means followed by the same letters were not statistically significant at (5%)

The results of the partial budget analysis indicated that applying 200 kg N ha^{-1} had the highest net benefit of 17818 ETB ha^{-1} and marginal rate of return of 202 % and is found economically profitable for onion production at Gurmbaba (Table 15). Application of 200 kg N ha^{-1} combined with 20 kg P ha^{-1} is recommended rate of fertilizers for onion production at Gurmbaba in West Belesa and other similar areas.

Table 15. Partial budget analysis for the effect of N fertilizer on the yield of onion at Gurmbaba irrigation scheme.

Parameters	Nitrogen fertilizer levels (kg ha^{-1})				
	0	**50**	**100**	**150**	**200**
Mean yield (t ha^{-1})	5.75	7.64	9.18	10.18	11.15
Adjusted yield (t ha^{-1})	5.18	6.88	8.26	9.16	10.04
Total Revenue (ETB ha^{-1})	20700	27504	33048	36648	40140
Total costs (ETB ha^{-1})	17700	17700	17700	17700	17700
Gross field benefit (ETB ha^{-1})	3000	9804	15348	18948	22440
Fertilizer cost (ETB ha^{-1})	0	1156	2311	3467	4622
Total costs that vary (ETB ha^{-1})	0	1156	2311	3467	4622
Net benefit (ETB ha^{-1})	3000	8648	13037	15481	17818
Dominance Analysis					
Marginal cost (ETB ha^{-1})	0	1156	1155	1156	1155
Marginal net benefit (ETB ha^{-1})	0	5648	4389	2444	2337
Marginal rate of return (%)		489	380	211	202

Conclusion and Recommendations

At Ribb, application of 150 kg N ha^{-1} and 20 kg P ha^{-1} as the first and 250 kg N ha^{-1} and 20 kg P ha^{-1} as second options are recommended for onion production. Onion did not

respond to P application at Ribb due to the high phosphorus content of the soil. Therefore, future phosphorus fertilizer recommendation for Ribb area needs to be developed based on soil test.

At Koga irrigation scheme application of 100 kg N ha^{-1} and 60 kg P ha^{-1} is recommended as the first option. As a second option application of 150 kg N ha^{-1} and 40 kg P ha^{-1} is recommended. The highest yield in response to the tested P fertilizer rates was not attained in the current study, therefore P rates above 60 kg P ha^{-1} needs to be studied for Koga irrigation scheme so as to attain the point of diminishing response. At Koga irrigation scheme fertilizer rate study needs to be done along with soil liming as the soil in the command area is acidic.

For onion production at Megech and similar agro-ecologies, based on the biological yield and partial budget analysis application of 100 kg N ha^{-1} and 60 kg P ha^{-1} which gave the maximum and profitable yield is recommended. Application of 200 kg N ha^{-1} along with the recommended 20 kg P ha^{-1} which gave the maximum and profitable marketable yield is recommended for onion production at Gurmbaba irrigation scheme and similar agro-ecologies in West Belesa.

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