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Evaluation of Planting Date and Different Inorganic NP Fertilizer Rates for Irish Potato (*Solanum tuberosum L.*) Production at Bore, Southern Ethiopia

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Abstract: The experiment was conducted at Bore Agricultural Research Center on station for three consecutive years' main cropping seasons with the aim to adjust planting date and fertilizer rate for Irish Potato production. Four level of fertilizer rate (0, 61.5, 82, and 114 kg Nitrogen and 0, 69, 92, and 115kg P ha^{-1} and planting date Immediately rain season (T1), 7days after rain (T2), 15days after rain (T3), 3 weeks later (T4). The treatments were arranged in RCBD in factorial arrangement with 3 replications. Tubers were planted on plot size of 4 m x 5m at spacing of 1m between plot, 1.5m b/n block, 70 cm between rows and 30cm between plants. The variety used in this experiment was Gudane. Based on the combined analysis of variance treatments over three consecutive years indicated that interaction effect of Planting Date and Different Fertilizer Rate significantly ($P<0.001$) affected Days to 50% emergency, maturity, plant height, stem number, number of tubers, and fresh tuber yield. However, parameters days to flowering and average tuber weight are non-significant ($P<0.05$) difference between each treatment means. The combined effect of immediate planting date (T1) with control (no nutrient) treatment (R1) recorded shortest (9.55 days) to emergency and early days to maturity (104.22days). And also regarding plant height the maximum (74.28 cm) plant height was recorded for treatment planted at first planting date with combined nutrient application of 114 kg N* 115 kg P. The interaction effect of immediate planting date with 82 kg N*92 kg P_2O_5 shows significant ($P<0.05$) maximum (9.1) stem number of potato. The maximum number of tubers (9.88, 9.66 and 9.44) was observed when tubers were planted at first week and applied with 82 kg N+92 kg P; 114kg N+115 kg P and second week with 82 kg N+92 kg P of fertilizer rates respectively. The highest Total tubers yield (41821 kg ha^{-1} and 41395 kg ha^{-1}) were obtained from T_1R_3 (Immediate planting with combined nutrient of 82 kg N* 92 kg P_2O_5) and T_2R_3 (Immediate planting with combined nutrient of 82 kg N* 92 kg P_2O_5) respectively.

Keywords: Fertilizer Rate, Irish Potato, Planting Date, Planting Time

1. Introduction

In Ethiopia population is growing in more rate than the agricultural production does. To feed this increasing population the agricultural production should grow accordingly with the same pace or even more. Horticultural crops are the most important crops in the national strategy of food self-reliance and the national income earnings. So to increase the productivity of the farmers, it is crucial to increase the awareness of farmers towards the usage of different improved technologies that increase their production and accelerate food security through proper implementation. Access to new and improved agricultural technologies is highly limited in Guji zone of Oromia most probably due to remoteness from the center and inaccessibility of the area.

Agriculture is the basis of the Ethiopian economy and the main source of livelihood of the population. The potential for

developing agricultural production is high but despite this, Ethiopia is currently unable to produce enough food to meet the demands of its ever increasing population. According to the International Food Policy Research Institute [7], 5-7 million people in Ethiopia are chronically food insecure. The reasons for this are diverse and complex but declining soil fertility and soil degradation is a primary factor.

The originated in the highlands of the Andes in South America, potato was introduced to Ethiopia in 1859. Since its introduction potato remains important garden crop in many parts of Ethiopia and Western Oromia too. However, today potato production is at an increasing step in most highland parts of the country. Potatoes production is possible by rain fed, residual moisture and irrigation systems. Well-distributed rainfall between 600 to 1200mm over a period of three to four months is enough for potato cultivation. The optimum temperature for good potato tuber growth lies between 15-18 ^{o}c. sandy loams with slightly acidic soil is ideal for potato production. For production of economic yield potato performs best within the altitude ranges of 1500 to 3000 masl. It is one of the cheapest sources of starchy food and provides a source of low cost energy to human diet. It is also good source of income for many farmers in the country.

Potato (*Solanum tuberosum* L) is an annual, herbaceous, tuber crop of family Solanaceae that contains all the essential food ingredients required for proper health. Potato is the world's leading vegetable crop and is grown in 79% of the world's countries [5]. It is second to maize in terms of the number of producing countries and fourth after wheat, maize and rice in global tonnage. The average composition of the potato is about 80% water, 2% protein, and 18% starch. As a food, it is one of the cheapest and easily available sources of carbohydrates and proteins and contains appreciable amount of vitamins B and C as well as some minerals.

Both yield and quality of potato are affected by variety, environmental conditions, and cultural practices. Fertilizer application has important effects on the quality and yield of potato [13]. Potato is highly responsive to N fertilization and N is usually the most limiting essential nutrient for potato growth, especially on sandy soils [4]. Nitrogen supply also plays an important role in the balance between vegetative and reproductive growth for potato [1, 14]. Many previous studies have shown that fertilizer N applications can increase dry matter content, protein content of potato tubers, total and/or marketable tuber yield [3, 15] also reported similar effects of N doses on dry matter content and specific gravity of potato.

The potential of horticulture & spice crops is not exploited in this part of the region due to lack of improved varieties, poor management practices, biotic factors (weeds, diseases and insect pests etc.), a biotic factors (frost), high intensity and long duration of rainfall. So far the national and regional research institutions in the country have released many varieties adaptable to a wide range of environments for commercial production. However, these technologies did not reach the smallholder farmers living in inaccessible parts of Oromia such like Guji zone due to lack of testing sites and centers. Therefore, to overcome the above stated problems and to acquaint smallholder farmers with new technologies of widely grown Horticultural and Spice crops production. As mentioned earlier, absence of improved variety and management practices are the main production constraints of the area. Because the area has long rainy season and the fertility status of the soil is scientifically not well known, adjustment of planting dates and fertilizer rates is very crucial. Therefore the objective of this study was to determine the impact of planting date and NP fertilizer rate on Irish potato growth, yield and yield components and to determine an optimal planting date and NP fertilizer rate for Irish potato.

2. Material and Methodology

2.1. Description of the Study Area

The experiment was conducted in southern Ethiopia in one of the highland and high rainfall areas of the Oromia National Regional State. The site is found in Bore woreda about 8 km west of the town in Songo Bericha Kebele just on the side of the main Addis Ababa to Negelle Borena road via Hawassa. It is about 385 km south from Addis Ababa. Geographically, the experimental site is situated at latitude of 6°26'52" N, longitude of 38°56'21" E and at an altitude of 2736 masl. The climatic condition of the area is moist humid and sub humid, with relatively longer growing season. The area is found at the annual rainfall ranges from 900-1700 mm with a bimodal pattern that extended from April to December. The mean annual minimum and maximum temperature is 10.1°C and 20°C, respectively. The type of the soil of the experimental site is red basaltic soil (Nitosols). The soil is clay loam in texture and moderately acidic with pH around 6.5. The traditional farming system of the area is characterized by cultivation of enset as a major crop, maize, potato, head cabbage, barley, wheat and bean. As far as fruit and non-timber crops are concerned, apple and bamboo are the cash crops. Moreover, cattle are an integral part of the farming system.

2.2. Experimental Material and Methodology

The experimental materials were Planting dates seven days gap intervals Beginning from onset of main rain season from third week of March to the last week of April (T1)=Immediately at rain onset, (T2)=7 days after rain, (T_3)=15 days after rain, and (T_4)=3 weeks later and Four levels of combined N*P_2O_5 fertilizer rates (R1=(0*0), R2=(61.5*69), R3=(82*92), R4=(114*115 or Urea*DAP R1=(0*0), R2=(75*150), R3=(100*200), and R4=(150*250) kg ha^{-1}) used respectively. The treatments were factorial in RCBD arrangement with three replications. Tubers were planted on plot size of 3.75m x 2.1m with spacing of 1m between plot, 1.5m between block, 75cm between rows and 30cm between plants using Gudane variety.

2.3. Statistical Analysis

The collected data on various parameters of the crop under study were statistically analyzed using SAS statistical

package version 9.1.3 using Fishers' LSD [12]. The Least Significant Difference (LSD) test at 5% level of significance was used to separate the means when the ANOVA showed the presence of significant difference.

3. Results and Discussion

3.1. Phenological Parameters of Irish Potato

3.1.1. Days to 50% Emergency

Results indicated that planting date and different NP fertilizer rates significantly (P<0.05) influence potato seed emergency at both years. Planting date and application of NP fertilizers significantly influenced days to emergency. The main effects of planting date and different NP fertilizer rates as well as their interaction had significant (P<0.05) influence on days to 50% emergency in all consecutive three years (Table 1). From the ANOVA analysis the overall year mean show that the shortest days to emergency (9.55 and 9.66 days) was attained in immediate planting and last planting date with no nutrient application where the longest (15.22 days) duration was observed in the third planting date with control 114 kg N*115 kg P ha^{-1} treatment (Table 1).

Table 1. *Mean days to emergency of Irish potato as influenced by planting date and application of NP fertilizer rate.*

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
1	T1R1 (IMD+0*0)	13.66^{a}	16^{a}	18^{a}	9.55^{j}
2	T1R2 (IMD+61.5*69)	10^{cd}	13.66^{abc}	17.33^{bc}	11.22^{gh}
3	T1R3 (IMD+82*92)	8.33^{ef}	13^{bcd}	17^{c}	11^{hi}
4	T1R4 (IMD+114*115)	7^{g}	11.66^{cde}	17.66^{ab}	11.22^{gh}
5	T2R1 (AFWK+0*0)	14^{a}	13.33^{bcd}	13^{d}	13.44^{cd}
6	T2R2 (AFWK+61.5*69)	10^{cd}	15^{ab}	13^{d}	12.89^{de}
7	T2R3 (AFWK+82*92)	9.66^{cd}	15^{ab}	13^{d}	12.77^{def}
8	T2R4 (AFWK+114*115)	7.66^{fg}	11.66^{cde}	13^{d}	12^{fg}
9	T3R1 (2WKS+0*0)	14^{a}	11^{def}	17^{c}	14^{bc}
10	T3R2 (2WKS+61.5*69)	12.33^{b}	11^{def}	17^{c}	12.55^{ef}
11	T3R3 (2WKS+82*92)	8^{efg}	11^{def}	17^{c}	10.33^{ij}
12	T3R4 (2WKS+114*115)	9^{de}	10.33^{ef}	17^{c}	15.22^{a}
13	T4R1 (3WKS+0*0)	13.66^{a}	12^{cde}	10^{e}	9.66^{j}
14	T4R2 (3WKS+61.5*69)	10.33^{c}	8.66^{fg}	10^{e}	14.33^{b}
15	T4R3 (3WKS+82*92)	9.66^{cd}	7^{gh}	10^{e}	12.55^{ef}
16	T4R4 (3WKS+114*115)	7.33^{fg}	5^{h}	10^{e}	11.66^{gh}
LSD (0.05)		1.16	2.34	0.35	0.87
CV (%)		6.8	12.13	1.46	4.29

Means in columns and rows followed by the same letter (s) are not significantly different at 5% level of significance. LSD (0.05)=Least Significant Difference at 5% level; and CV=coefficient of variation in percent.

The result indicated that low doses of the nutrients hastened days to Emergency whereas the onset of days to Emergency was delayed in case of plants that received high rate of nutrients. Generally planting too early and late with un appropriate rate of fertilizer can lead to plant disease, slow emergence, and decreased plant vigor, which can slow tuber growth rates.

3.1.2. Days to 50% Flowering and Maturity

Analyzed data in table (2 and 3) indicated that planting date and application of different NP fertilizer rates significantly (P<0.05) influence days to flowering and maturity. For the days to flowering both in each year separately influenced by planting data and NP fertilizer application.

But the overall mean of ANOVA analysis result revealed that days to flowering not significantly (P<0.05) influenced by planting date and fertilizer rate.

Table 2. *Mean days to flowering of Irish potato as influenced by planting date and application of NP fertilizer rate.*

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
1	T1R1 (IMD+0*0)	65.66^{c}	62^{d}	45^{d}	57.44
2	T1R2 (IMD+61.5*69)	64^{cd}	63.33^{d}	56^{c}	61.22
3	T1R3 (IMD+82*92)	66^{c}	63.66^{d}	55.66^{c}	73.444
4	T1R4 (IMD+114*115)	65.33^{c}	64.66^{d}	56^{c}	62
5	T2R1 (AFWK+0*0)	64.33^{c}	73.33^{b}	63^{abc}	69
6	T2R2 (AFWK+61.5*69)	70.66^{ab}	73.33^{b}	63.66^{abc}	75.333
7	T2R3 (AFWK+82*92)	67^{bc}	69^{c}	67^{ab}	69.11
8	T2R4 (AFWK+114*115)	66.66^{bc}	69^{c}	53.66^{cd}	63.11
9	T3R1 (2WKS+0*0)	59.66^{d}	75.33^{b}	61^{bc}	65.33
10	T3R2 (2WKS+61.5*69)	64.33^{c}	73^{b}	57.33^{bc}	64.88
11	T3R3 (2WKS+82*92)	70.66^{ab}	73.66^{b}	58.33^{bc}	65.44
12	T3R4 (2WKS+114*115)	67^{bc}	73.33^{b}	58^{bc}	66.11
13	T4R1 (3WKS+0*0)	64^{cd}	101^{a}	58^{bc}	74.333
14	T4R2 (3WKS+61.5*69)	67^{bc}	98.66^{a}	57^{bc}	58.14
15	T4R3 (3WKS+82*92)	72^{a}	98.66^{a}	58.66^{bc}	72.000
16	T4R4 (3WKS+114*115)	71^{ab}	98.33^{a}	71.66^{a}	61.78

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
LSD (0.05)		4.64	2.98	10.52	Ns
CV (%)		4.18	2.33	10.74	10.89

Means in columns and rows followed by the same letter (s) are not significantly different at 5% level of significance. LSD (0.05)=Least Significant Difference at 5% level; and CV=coefficient of variation in percent.

The combined analysis of our data shows that in both consecutive three years planting date and fertilizer rate have significantly (P<0.05) different between each means on days to maturity, but non-significant different in year three. The overall mean of ANOVA analysis result revealed that early maturity value (103.77 and 104.22 days) was recorded for treatment treated at first and third week of planting with control treatment. And the longest days (119.55 day) to maturity was recorded for treatment treated at second planting date with combined application of NP 114 kg N+115 kg P ha^{-1}. The rate of applied nitrogen fertilizers is a key factor in soil fertility management, as its over-usage can delay plant maturity and directs dry matter storage into aerial parts rather than tubers [6]. Moreover, N applied in excess to crop requirement results in increased vegetative growth rather than in tuber production, delayed maturity [8].

Table 3. *Mean days to maturity of Irish potato as influenced by planting date and application of NP fertilizer rate.*

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
1	T1R1 (IMD+0*0)	99^{ef}	104^{g}	93.66	104.22^{d}
2	T1R2 (IMD+61.5*69)	111^{bcd}	110.66^{defg}	102.66	108.11^{bcd}
3	T1R3 (IMD+82*92)	117^{bc}	105.66^{fg}	100.66	112.33^{abc}
4	T1R4 (IMD+114*115)	128^{a}	113.66^{defg}	100.66	115.77^{ab}
5	T2R1 (AFWK+0*0)	95.66^{f}	122.66^{bcde}	102.66	107^{cd}
6	T2R2 (AFWK+61.5*69)	109.33^{bcd}	115^{defg}	104.33	113.22^{abc}
7	T2R3 (AFWK+82*92)	117.33^{b}	112^{defg}	102	109.22^{bcd}
8	T2R4 (AFWK+114*115)	127.66^{a}	110.33^{defg}	101.66	119.55^{a}
9	T3R1 (2WKS+0*0)	96.66^{f}	124^{bcd}	100.33	103.77^{d}
10	T3R2 (2WKS+61.5*69)	108.66^{cd}	120^{cdef}	98.66	107^{cd}
11	T3R3 (2WKS+82*92)	117^{bc}	108.38^{efg}	100.66	108.66^{bcd}
12	T3R4 (2WKS+114*115)	126^{a}	144.66^{a}	102	114.11^{abc}
13	T4R1 (3WKS+0*0)	96.33^{f}	114.33^{defg}	94.33	108.77^{bcd}
14	T4R2 (3WKS+61.5*69)	107.33^{de}	135.66^{ab}	91.66	114.55^{abc}
15	T4R3 (3WKS+82*92)	117^{bc}	134.66^{abc}	91	110.77^{bcd}
16	T4R4 (3WKS+114*115)	127.66^{a}	142^{a}	109.33	108.55^{bcd}
LSD (0.05)		8.41	15.55	Ns	7.81
CV (%)		4.48	7.78	9.22	4.24

Means in columns and rows followed by the same letter (s) are not significantly different at 5% level of significance. LSD (0.05)=Least Significant Difference at 5% level; and CV=coefficient of variation in percent.

3.2. Growth Parameters of Irish Potato

3.2.1. Plant Height

The main effects of planting date and different NP fertilizer rates as well as their interaction had significant (P<0.05) influence on Irish potato plant height in all three years (Table 4).

Our mean overall year ANOVA result demonstrated that plant height was significantly (P<0.05) different across the tubers sown on different planting date and fertilizer rate. Plants planted at first week with maximum (114kg N+115kg P) rate reached the highest plant height (74.28 cm) while plants planted following last planting date with control treatment attained the lowest plant height (47.01 cm). It might be due to the fact that plants receiving highest nutrient, might cause rapid performance on growth characters and release of nutrients of fertilizer for plant height and attained the highest plant height.

Table 4. *Mean plant height of Irish potato as influenced by planting date and application of NP fertilizer rate.*

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
1	T1R1 (IMD+0*0)	46.86	64.21^{def}	61.10^{cd}	57.39^{de}
2	T1R2 (IMD+61.5*69)	51.06	69.84^{cde}	73.61^{ab}	64.84^{bcd}
3	T1R3 (IMD+82*92)	57.53	81.07^{ab}	66.51^{bcd}	68.37^{ab}
4	T1R4 (IMD+114*115)	62.63	88.28^{a}	71.92^{ab}	74.28^{a}
5	T2R1 (AFWK+0*0)	52.26	62.99^{ef}	74.92^{ab}	63.39^{bcde}
6	T2R2 (AFWK+61.5*69)	55.10	70.13^{cde}	68.55^{ab}	65.65^{abcd}
7	T2R3 (AFWK+82*92)	46.40	70.40^{cde}	92.18^{a}	68.60^{ab}
8	T2R4 (AFWK+114*115)	59.86	70.99^{cde}	78.40^{ab}	69.75^{ab}
9	T3R1 (2WKS+0*0)	43.73	59.58^{f}	75.29^{ab}	59.5^{cde}
10	T3R2 (2WKS+61.5*69)	50.93	71.55^{cde}	68.05^{ab}	63.51^{bcde}
11	T3R3 (2WKS+82*92)	52.50	75.92^{bc}	66.44^{bcd}	64.95^{bcd}
12	T3R4 (2WKS+114*115)	58.70	72.55^{bcd}	73^{ab}	68.08^{abc}
13	T4R1 (3WKS+0*0)	42.63	46.62^{g}	51.77^{d}	47.01^{f}

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
14	T4R2 (3WKS+61.5*69)	46.20	60.10^{f}	66.66^{bcd}	57.65^{de}
15	T4R3 (3WKS+82*92)	38.96	60.18^{f}	68.88^{ab}	56.0^{e}
16	T4R4 (3WKS+114*115)	49.76	62.70^{ef}	75.96^{bc}	62.81^{bcde}
LSD (0.05)		Ns	9.26	15.92	8.56
CV (%)		15.37	8.17	13.48	8.01

Means in columns and rows followed by the same letter (s) are not significantly different at 5% level of significance. LSD (0.05)=Least Significant Difference at 5% level; and CV=coefficient of variation in percent.

3.2.2. Stem Number

The results of analysis of data revealed that main effects of planting date and different NP fertilizer rates and their interactions had significant (P<0.05) effect on stem number of Irish potato plant in both year 1 and 2, but not significant for year 3 (Table 5).

The mean overall year ANOVA result demonstrated that stem number was significant (P<0.05) on different planting date and fertilizer rate. Our data analysis showed that maximum number of stems per plant (9.1) was recorded in plants planted at the start of first week of rain with fertilizer rate of 82 kg N+ 92 kg P, meanwhile minimum number of stem per plant (5.44) was recorded for last week of planting versus untreated treatment. It may be due to favorable climate with optimum nutrient application. This parameter is of great importance because it is directly related with the total production of tubers. The more is the number of stems/plant the more will be the number of tubers per plant. Number of stems per plant is also important for tuber size. Less number of stems per plant had tubers of large size and vice versa. This parameter is primarily recorded to see the impact of total sun shine received as well as spread of the root system of the plant. Both these parameters are maximum if there is more number of stem per plant, extending the plant spread.

Table 5. *Mean stem number of irish potato as influenced by planting date and application of NP fertilizer rate.*

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
1	T1R1 (IMD+0*0)	4.66^{d}	6^{efg}	6	7.33^{de}
2	T1R2 (IMD+61.5*69)	5.33^{cd}	10.33^{ab}	8.66	8.77^{ab}
3	T1R3 (IMD+82*92)	8^{a}	11.33^{a}	8.33	9.1^{a}
4	T1R4 (IMD+114*115)	6.66^{abc}	8.33^{bcd}	8.66	8^{bcd}
5	T2R1 (AFWK+0*0)	4.66^{d}	7.33^{def}	7.66	7.1^{de}
6	T2R2 (AFWK+61.5*69)	6.66^{abc}	8^{cde}	8	7.77^{bcde}
7	T2R3 (AFWK+82*92)	7.33^{ab}	7.66^{cde}	9	8.55^{abc}
8	T2R4 (AFWK+114*115)	6.33^{abcd}	9.66^{abc}	7.66	8.11^{abcd}
9	T3R1 (2WKS+0*0)	5^{cd}	7.33^{def}	7.33	6.88^{e}
10	T3R2 (2WKS+61.5*69)	5.33^{cd}	8.66^{bcd}	6.66	7.22^{de}
11	T3R3 (2WKS+82*92)	6.33^{abcd}	10.33^{ab}	8.33	7.99^{bcd}
12	T3R4 (2WKS+114*115)	6.66^{abc}	7^{def}	8.33	7.22^{de}
13	T4R1 (3WKS+0*0)	5.33^{cd}	3.66^{h}	7.33	5.44^{f}
14	T4R2 (3WKS+61.5*69)	5.66^{cd}	4.66^{gh}	8.66	6.88^{e}
15	T4R3 (3WKS+82*92)	8^{a}	5.33^{fgh}	9.33	7.22^{de}
16	T4R4 (3WKS+114*115)	6.66^{abc}	8.66^{bcd}	9.66	7.55^{cde}
LSD (0.05)		1.76	2.03	Ns	1.12
CV (%)		17.13	15.67	18.04	8.91

Means in columns and rows followed by the same letter (s) are not significantly different at 5% level of significance. LSD (0.05)=Least Significant Difference at 5% level; and CV=coefficient of variation in percent.

3.3. Yield Components and Yield of Irish Potato

3.3.1. Average Tuber Weight

The main effects of planting date and NP fertilizer rate and their interaction data analysis in Table 6 describes that average tuber weight was not-significantly (P<0.05) different in all growing season and mean overall result.

Table 6. *Mean tuber weight of Irish potato as influenced by planting date and application of NP fertilizer rate.*

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
1	T1R1 (IMD+0*0)	82.13	143.00	169.2	131.43
2	T1R2 (IMD+61.5*69)	75.53	151.67	192.0	149.73
3	T1R3 (IMD+82*92)	93.81	204.33	156.0	164.71
4	T1R4 (IMD+114*115)	96.04	162.67	171.0	142.35
5	T2R1 (AFWK+0*0)	103.63	175.67	155.7	144.99
6	T2R2 (AFWK+61.5*69)	84.36	154.00	136.5	191.25
7	T2R3 (AFWK+82*92)	92.74	150.67	160.2	141.24
8	T2R4 (AFWK+114*115)	101.57	143.33	154.8	133.25
9	T3R1 (2WKS+0*0)	93.20	173.67	137.0	134.62

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
10	T3R2 (2WKS+61.5*69)	87.20	159.33	137.0	119.47
11	T3R3 (2WKS+82*92)	84.96	153.00	457.8	231.93
12	T3R4 (2WKS+114*115)	100.32	137.67	136.5	124.83
13	T4R1 (3WKS+0*0)	116.77	171.00	125.0	137.59
14	T4R2 (3WKS+61.5*69)	91.00	153.67	103.8	116.17
15	T4R3 (3WKS+82*92)	65.97	152.00	122.5	113.49
16	T4R4 (3WKS+114*115)	95.12	151.33	108.0	118.15
LSD (0.05)		Ns	Ns	Ns	Ns
CV (%)		22.61	16.45	90.50	43.55

Means in columns and rows followed by the same letter (s) are not significantly different at 5% level of significance. LSD (0.05)=Least Significant Difference at 5% level; and CV=coefficient of variation in percent.

3.3.2. Average Tuber Number Per Hill

The main effects of planting date and NP fertilizer rate and their interaction showed significant (P<0.05) different effect on average tuber number per hill in year 2 and 3, but not significantly different (P<0.05) for year 1, and the mean overall result describes both the main and interaction effect showed significant (P<0.05) different effect on tuber numbers (Table 7).

The maximum number of tubers (9.88, 9.66 and 9.44) was observed when tubers were planted at first week and applied with 82 kg N+92 kg P; 114kg N+ 115 kg P and second week with 82 kg N+92 kg P of fertilizer rates. It may be due to supply of adequate amount of moisture at onset of rain with optimum NP fertilizer rates and more aeration and also appropriate time of planting with optimum nutrient enhanced release of micro nutrients and promoted root growth and nutrient uptake, hence better root growth and tuber number and yield. While on the contrary, number of tubers per plant was minimum (6.11) when tubers were planted at fourth week of planting with control treatment. It might be due to more soil and nutrients erosion and less water availability to the plants when it was required and disease occurrence. Optimum time and rate enhanced release of nutrients from the soil promoted root growth and nutrient uptake, hence better root growth and tuber yield.

Table 7. *Mean tuber number per hill of Irish potato as influenced by planting date and application of NP fertilizer rate.*

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
1	T1R1 (IMD+0*0)	6.33	9^{bcde}	7.66^{ef}	7.66^{def}
2	T1R2 (IMD+61.5*69)	6.00	9.33^{abcde}	8^{def}	7.77^{cdef}
3	T1R3 (IMD+82*92)	7.00	9.66^{abcd}	12.33^{ab}	9.88^{a}
4	T1R4 (IMD+114*115)	8.66	11.33^{a}	10^{cd}	9.66^{a}
5	T2R1 (AFWK+0*0)	5.66	8.33^{def}	8.33^{def}	7.44^{efg}
6	T2R2 (AFWK+61.5*69)	7.33	9.33^{abcde}	10^{cd}	7.88^{bcdef}
7	T2R3 (AFWK+82*92)	7.00	10^{abcd}	13.33^{a}	9.44^{a}
8	T2R4 (AFWK+114*115)	9.00	10.66^{abc}	10^{cd}	9.33^{ab}
9	T3R1 (2WKS+0*0)	5.66	7.33^{ef}	8^{def}	6.99^{fg}
10	T3R2 (2WKS+61.5*69)	7.33	11^{ab}	8.33^{def}	9.22^{abc}
11	T3R3 (2WKS+82*92)	6.66	11.33^{a}	9.66^{cde}	9.22^{abc}
12	T3R4 (2WKS+114*115)	7.66	10.33^{abcd}	9.33^{cdef}	9.11^{abcd}
13	T4R1 (3WKS+0*0)	4.33	6.66^{f}	7.33^{f}	6.11^{g}
14	T4R2 (3WKS+61.5*69)	9.33	8.66^{cdef}	10^{cd}	9.33^{ab}
15	T4R3 (3WKS+82*92)	6.00	9.66^{abcd}	10.66^{bc}	8.99^{abcde}
16	T4R4 (3WKS+114*115)	6.66	8.66^{cdef}	10.66^{bc}	8.66^{bcde}
LSD (0.05)		Ns	2	2.14	1.58
CV (%)		23.65	12.73	13.37	11.01

Means in columns and rows followed by the same letter (s) are not significantly different at 5% level of significance. LSD (0.05)=Least Significant Difference at 5% level; and CV=coefficient of variation in percent.

The variation in tuber yield caused by the number of tubers per plot suggests that most of the factors that are likely to affect tuber yield are the nutrients in the soil and the number of tubers in an individual plant. Further to that, the number of tubers per plot is mostly determined by the plant population and the number of tubers in a hill. This argument suggests that the population of Irish potato plants is a very important factor to consider when a farmer is anxiously driven toward optimum yield.

3.3.3. Fresh Yield of Irish Potato

The analysis of variance shows that the main effects of planting date and NP fertilizer rate as well as their interaction had highly significant effects on fresh yield in both year 1, year 2 and year 3 (Table 8). The mean overall year ANOVA result demonstrated that planting date and NP fertilizer rate highly significantly (P<0.05) influenced Irish potato yield.

The data regarding this parameter was that planting on first week of rain onset with combined application of 82 kg N+92 kg P produced maximum (41821kg) tuber yield per hectare followed by planting on the second week with combine application of the same rate as above mentioned gives maximum (41395kg) tuber yield per hectare. The lowest (22503 kg) tuber yield obtained at last planting date with no

nutrient application that indicates the high demand of Irish potato to these essential nutrients.

The probable reason for higher yield may be due to the reasons of good emergence, excellent plant spread and more number of stems per plant. Due to good plant spread, more area was exposed to sunlight. It increased photosynthesis and thus increased starch accumulation, which led to high yield.

Table 8. *Mean fresh yield of Irish potato as influenced by planting date and application of NP fertilizer rate.*

R. No	Treatments	First Year	Second Year	Third Year	Overall Mean
1	T1R1 (IMD+0*0)	19353^{fg}	32377de	32536^{bcd}	29942^{def}
2	T1R2 (IMD+61.5*69)	34027^{bcde}	38462^{b}	35829^{abc}	37247^{ab}
3	T1R3 (IMD+82*92)	48307^{a}	52936^{a}	26080de	41821^{a}
4	T1R4 (IMD+114*115)	21873^{fg}	37103^{bd}	39541^{ab}	32167^{bcdef}
5	T2R1 (AFWK+0*0)	26680^{defg}	30229de	32777^{bcd}	32167^{bcdef}
6	T2R2 (AFWK+61.5*69)	36577^{bcd}	41182^{b}	34920^{abc}	30810^{cdef}
7	T2R3 (AFWK+82*92)	43583^{ab}	48889^{a}	40671^{ab}	41395^{a}
8	T2R4 (AFWK+114*115)	20597^{fg}	40860^{b}	41717^{a}	36525^{abc}
9	T3R1 (2WKS+0*0)	23273^{efg}	29440^{ef}	29630^{cde}	35313^{bcd}
10	T3R2 (2WKS+61.5*69)	23470^{efg}	37927^{b}	33686^{abcd}	27779^{fg}
11	T3R3 (2WKS+82*92)	38707^{abc}	40344^{b}	34571^{abcd}	33912^{bcde}
12	T3R4 (2WKS+114*115)	30183^{cdef}	35788^{bde}	29439^{cde}	30666^{cdef}
13	T4R1 (3WKS+0*0)	18517^{g}	22558^{f}	21186^{e}	22503^{g}
14	T4R2 (3WKS+61.5*69)	26400^{defg}	29109^{ef}	27978^{cde}	26406^{fg}
15	T4R3 (3WKS+82*92)	32897^{bcde}	30176de	30335^{cd}	33844^{bcde}
16	T4R4 (3WKS+114*115)	20877^{fg}	32120de	29002^{cde}	29835^{def}
LSD (0.05)		109.55	74.55	87.74	60.83
CV (%)		22.59	12.34	16.19	11.24

Means in columns and rows followed by the same letter (s) are not significantly different at 5% level of significance. LSD (0.05)=Least Significant Difference at 5% level; and CV=coefficient of variation in percent.

However, yield-increasing trend was observed with increasing application of nutrients but at a certain level after while decreases in all planting dates (Table 8). This implies that the application of higher rates or optimum NP fertilizer rates is required to get the highest tuber yield. Here the result shows the tuber yield increases at a certain level date and fertilizer rate beyond that decreases.

These results are in agreement with those obtained by the studies [2, 10, 11, 14, 15] who reported that the increase in nitrogen application amounts up to a definite point, increases growth parameters including tuber but beyond that, reversely decreases them. Over-application of nitrogen may result in a decrease in yield. This may attribute to the fact that in such conditions, vegetative growth of the aerial parts can be increased and hence, prevented transferring of photosynthetically matters into the storage parts (Tubers). The studies [1, 9] revealed that tuber yield per unit area was increased with increasing nitrogen fertilizer up to suitable/optimum level.

4. Conclusions and Recommendations

The study was conducted to evaluate four different planting dates and four combined fertilizer rates for potato production in bore area. An experiment was conducted to determine the best combination of planting date (IMD, 7days later, 15 days later and 3 weeks later) and combined application of NP_2O_5 rate (0, 61.5*69, 82*92, 114*115 kg·ha^{-1}) for Irish potato of Gudene variety produced on a clay loam soil during the year of 2011-2013. The results revealed that the interaction effect between N and FYM fertilizer application rates had highly significant ($P<0.05$) effect on days to 50% emergency, 50% maturity, plant height, number of tubers per hill, stem number per plant and fresh yield. On the other hand non-significant effect by the planting date and rate of fertilizer on days to flowering and average tuber weight.

In this study, there was a significant difference between date and rate of fertilizer in the phenological, growth and yields and yield components of potato produced. Such difference between date and rate of fertilizer could be attributed to weather difference between the date and rate of fertilizer besides other probable causes. This may be due to the weather difference between the three seasons in terms of rainfall, temperature so and so on. Our recommendation to planting date and rate of fertilizer provide a new opportunity to manipulate planting date and rate of fertilizer to maximize use of appropriate time and nutrient resources. Application of NP_2O_5 fertilizer rate of (82*92 kg ha^{-1}) has significantly and positively increased the tuber yield of Irish potato at Bore area. The highest economic yield was obtained from the combined application of 82 kg N *92 kg P_2O_5 ha^{-1}.

Therefore it can be concluded that different planting date and combined application of NP_2O_5 have remarkable effect on growth and development of Irish potato. Generally, as a conclusive and recommendation, potato growers at Bore and surrounding area need to plant immediately at the start of rain (mid of march) in combination with 82 kg N *92 kg P_2O_5 ha^{-1}, in order to maximize the yield of Irish potato on the study area. Therefore it is recommended that there is a need for verification and demonstration of 82 kg N *92 kg P_2O_5 ha^{-1} for potato production in Bore area of Southern Ethiopia.

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