Response of Nutrient Omission and Irrigation Scheduling on Growth and Productivity of Maize  

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Abstract  
An experiment was conducted for response of nutrient omission to irrigation scheduling in hybrid maize during winter season of 2015 at farmer’s field Khajura, Banke where intense summer and severe winter occurs. Soil is sandy loam and climatically humid sub-tropical with average annual rainfall of 1000-1500 mm. The experiment was replicated 3 times with split plot design having plot size of 3 x 3.6 m². There were three irrigation level as main plot; (30-35 DAS, tasseling stage), (30-35 DAS, tasseling, grain filling stage), (tasseling stage) and six level of fertilizer dose as sub-plot; farmer fertilization practice (27.6:27.6:18 N-P-K kg ha⁻¹), recommended dose of fertilizer (160:60:40 N-P-K kg ha⁻¹), 50 percent above recommended dose (240:90:60 N-P-K kg ha⁻¹), NPK (60:40 P-K kg ha⁻¹), NPK (160:40 N-K kg ha⁻¹), NPK (160:60 N-P kg ha⁻¹). 3 level of irrigation increased the grain yield (4333 kg ha⁻¹) by 33.7% than 2 level of irrigation (3240.6 kg ha⁻¹) and 78.4% than single irrigation (2428.8 kg ha⁻¹). Similarly, 182.4% grain yield could be increased with RDF (4994.9 kg ha⁻¹) than NPK (1768.6 kg ha⁻¹). Grain nutrient uptake was recorded 80.4% N (56.3 kg ha⁻¹), 79% P (18.8 kg ha⁻¹), 88.8% K (15.1 kg ha⁻¹) higher with three levels of irrigation than single irrigation N (31.2 kg ha⁻¹), P (10.5 kg ha⁻¹), K (8 kg ha⁻¹) and 184% N (64.6 kg ha⁻¹), 183.7% P (21 kg ha⁻¹) and 188% K (17 kg ha⁻¹) was recorded higher with RDF than (N0PK) N (22.7 kg ha⁻¹), P (7.4 kg ha⁻¹), K (5.9 kg ha⁻¹).

Introduction  
Maize (Zea mays L.) is the only member of the genus Zea, under the family Gramineae. It is one of the most efficient crops which can give high biological yield as well as grain yield in a short period of time due to its unique photosynthetic mechanism. Maize grain has greater nutritional value; it contains 72 percent starch, 10 percent protein, 8.5 percent fibre, 4.8 percent oil, 3 percent sugar and 1.7 percent ash (Chaudhary, 1983). It ranks after wheat and rice as the third most important cereal crop in the world considering total area and production. It is the second most important cereal crop after rice in terms of area and production in Nepal. Maize (Zea mays L.) is cultivated in 954158 ha area of land and is the second most important cereal crop after rice 1469545 ha area in Nepal (MoALD, 2018). Out of the total cereal production (10012742 Mt) of the country, maize production alone contributes to about 26% (2555847 Mt). The national average productivity of maize is 2679 kg ha⁻¹. Out of the total cereal crops
Most of the farmers are not attracted towards judicious use of fertilizers due to high costs, uncertainty about the economic returns fertilizing food crops, and more often lack of technical know how about the optimum rate and application time of fertilizers (Hopkins et al., 2008). Nutrient deficiency is the major constraint for the development of an economically successful agriculture (Fageria et al. 2006). Higgs et al. (2002) reported that 30 to 50 percent of the increase in world food production since 1950s is attributable to fertilizer use. Nitrogen uptake occurs maximum during the time prior to tasseling and silking (Hammons, 2009). Nitrogen stress reduced poor kernel formation, increased barrenness and finally low grain yield (Andrade et al., 2000). Proper time and supplemental irrigation should be realized in irrigation scheduling for the most effective use of available water in optimizing maize production. Water deficit has little effect on timing of emergence, number of leaves per plant but delayed tasseling initiation and silking, reduced plant height and vegetation growth of maize. All the vital physiological processes of a plant like cell division, cell elongation, cell wall synthesis, NO3-reductase activity, protein synthesis, photosynthesis, and translocation of assimilates are very sensitive to water stress. This shows that plant water status plays a key role for attaining potential yield by enabling a genetic variable to exploit fully its physical environment. So, one of the biggest problems in crop production over the globe is “how to maintain optimum plant/soil moisture status during crop growing season?” which signifies the scope of irrigation scheduling as a single limiting factor in crop production. The lack of high-yielding and stress tolerant varieties, lower plant populations and lower level of fertilization are the main reasons in farmer’s field for the less production of maize. Inadequate knowledge regarding scheduling of irrigation in winter maize and its interaction with nutrient levels is the constraint of improving maize productivity and profitability. This research attempts to address these gaps in knowledge through on-farm experiments in the mid-western region of Nepal. In the terai, inner terai and low-lying river basin areas the maize is grown in the winter and spring with partial irrigation (Paudyal et al., 2001).

**Material and Methods**

The experiment was carried out at farmer’s field of Janaki Gaupalika -4, Khajura, Banke in winter season 2015. The climatic condition of the experimental location was intense summer and intense winter with sandy loam and climatically humid sub-tropical with average annual rainfall of 1000 -1500 mm. It is located at 81° 37’ East longitudes and 28° 06’ North latitude and an altitude of 181 masl. The maximum and minimum temperature at the site is 46°C and 5.4°C respectively, with relative humidity ranging between 27 to 94%. Humidity remains low in most parts of the year. The experiment was replicated 3 times with split plot design having plot size of 3 x 3.6 m². Three irrigation times were allotted to main plots and six fertilizer doses with NPK omission plot allotted as sub plots. Row to row spacing for each plot was maintained at 60 cm so that every plot received 6 rows of maize where two outer rows was for destructive sampling, and four rows were net plot. The plant to plant spacing was maintained at 25 cm. The net plot area was 7.2 m² consisting of 4 rows of 3-meter length consisting 12 plants row⁻¹. Fertilizer in the form of di-ammonium phosphate (DAP) and murate of potash (MoP) was applied at the time of sowing while half of urea was top dressed at 30 -35 days after sowing and the next half dose was top dressed at the time of tasseling stage. All cultural practices like irrigation, application of herbicides, pesticides and other operations were uniformly carried out. Rajkumar hybrid was sown on 25 October, 2015 at the farmer’s field.

| SN | Particulars |
|---|---|
| **Main plot (Irrigation level)** | |
| 1 | 30 -35 DAS + Tasseling stage |
| 2 | 30 -35 DAS + Tasseling stage + Grain filling stage |
| 3 | Tasseling stage |
| **Sub plot (Fertilizer dose)** | |
| 1 | Farmer practice (27.6:27.6:18 N-P-K kg ha⁻¹) |
| 2 | Recommended dose (160:60:40 N-P-K kg ha⁻¹) |
| 3 | 50% above recommended dose (240: 90: 60 N-P-K kg ha⁻¹) |
| 4 | N₀PK (60:40 P-K kg ha⁻¹) |
| 5 | NP₀K (160:40 N-K kg ha⁻¹) |
| 6 | K₀NP (160:60 N-Pkg ha⁻¹) |
Result and Discussion

Plant Height

The analysis data (Table 2) revealed that the difference in plant height at different time interval influenced by irrigation and fertilizer dose with NPK omission technique at 90 days after sowing was significantly (p<0.05) higher (102.6 cm) when the irrigation supplied 3 times (30-35 DAS, tasseling and grain filling stage) followed by (94 cm) from 2 times irrigation supplied (30-35 DAS and tasseling stage) while the least (80.2 cm) height was measured from single irrigation (tasseling stage) supplied plot. At 120 days after sowing, plant height to irrigation was significantly (p<0.01) higher (118.3 cm) from 3 times irrigation supplied plot (30-35 DAS, tasseling and grain filling stage) followed by (110.9 cm) from 2 times irrigation supplied (30-35 DAS and tasseling stage) plot. The lowest (89.9 cm) was recorded from single irrigation at tasseling stage but the difference in plant height influenced by fertilizer dose was non–significant. Similar result was also reported by (Sadeghi and Bahrami, 2002) that increase in nitrogen had no significant effect of plant height. But in contrast (Sharma et al. 1991) reported a significant increase in the plant height and number of leaves plant$^{-1}$ with successive increase of fertilizer. Similarly, Prasad et al. (1987) also reported that increase in maize growth with increasing level of nitrogen application from 0 to 120 kg ha$^{-1}$ and 0 to 150 kg ha$^{-1}$ respectively.

Analysis of data (Table 3) revealed that interaction effect of irrigation with fertilizer dose at 120 days after sowing was significantly (p<0.05) higher (145.2 cm) with the interaction effect of potassium omission plot and 2 times irrigation (30-35 DAS and tasseling stage) which was at par (128.4 cm) with farmer fertilization practice and 3 times irrigation (30 -35 DAS, tasseling and grain filling stage), similarly (126 cm) from potassium omission plot and 3 times irrigation (30 -35 DAS, tasseling and grain filling stage) and (121.9 cm) from phosphorus omission plot and 3 times irrigation (30 -35 DAS, tasseling and grain filling stage) while the lowest (80.9 cm) height was recorded from potassium omission plot with single irrigation (tasseling stage).

Yield Components

Analysis of data (Table 4) revealed that number of plants at harvest ha$^{-1}$, number of ear harvested ha$^{-1}$ and sterility percentage were non-significant to each level of irrigation though higher number of plants and ears were recorded from three level of irrigation, likewise less irrigation also increased sterility% of the crop. But the number of ears
harvested ha$^{-1}$ and sterility percentage significantly (p<0.001) influenced by the effect of fertilizer dose with NPK omission plot technique. Higher number of ears (40740.7) was recorded from recommended and 50 percent above recommended dose of fertilizer as compared to other treatments. Under optimum water and nutrient supply, high plant density can result in an increased number of cobs per unit area, with eventual increase in grain yield (Bavec and Bavec, 2002).

Lower (8.1%) sterility was recorded from 50 percent above recommended fertilizer dose and the highest (13.7%) sterility observed from nitrogen omission plot (N$_0$PK) followed by recommended dose of fertilizer (10.3%), NP$_0$K (10.3%), farmer fertilization practice (10.8%) and NP$_0$K (11.4%). From this result; with adequate nitrogen supply sterility could be reduced. It could be suggested that absence of nitrogen increases sterility and ultimately limits the optimum growth of crop resulting low grain yield and biomass production.

Table 2: Plant height influenced by irrigation and fertilizer dose with NPK omission

| Main plot: Irrigation | Plant height at 30 days interval from 30 to 150 days after sowing (cm) |
|-----------------------|---------------------------------------------------------------|
|                       | 30       | 60       | 90       | 120      | 150      |
| 30 -35 DAS + tasseling stage | 34.0     | 83.0     | 94$^a$   | 110.9$^a$ | 92.9     |
| 30 -35 DAS+ tasseling + grain filling stage | 34.6     | 82.3     | 102.6$^a$ | 118.3$^a$ | 100.8    |
| Tasseling stage       | 35.1     | 75.7     | 80.2$^b$ | 89.9$^b$  | 84.7     |
| F-test                | ns       | ns       | *        | **       | ns       |
| LSD (0.05)            | -        | -        | 13.7     | 8.5      | -        |
| CV %                  | 22.5     | 14.6     | 16.0     | 8.7      | 15.5     |

Sub plot: Fertilizer dose

|                      | Plant height at 30 days interval from 30 to 150 days after sowing (cm) |
|----------------------|---------------------------------------------------------------|
| Farmer practice      | 31.9               | 80.2               | 91.8               | 106.3               | 90.9               |
| Recommended dose     | 34.0               | 80.3               | 89.2               | 98.7               | 90.3               |
| 50% above recommended dose | 36.1               | 78.9               | 88.0               | 102.1               | 87.8               |
| N$_0$PK              | 35.0               | 80.6               | 92.1               | 104.5               | 93.8               |
| NP$_0$K              | 34.1               | 79.3               | 95.6               | 109.4               | 96.0               |
| NPK$_0$              | 36.2               | 82.6               | 96.9               | 117.4               | 97.9               |
| F-test               | ns                 | ns                 | ns                 | **                 | ns                 |
| LSD (0.05)           | -                  | -                  | -                  | -                  | -                  |
| CV %                 | 2.0                | 12.4               | 16.6               | 15.6               | 11.9               |

Grand mean

| Plant height at 30 days interval from 30 to 150 days after sowing (cm) |
|---------------------------------------------------------------|
| 30       | 60       | 90       | 120      | 150      |
| 34.6     | 80.3     | 92.3     | 106.4    | 92.8     |

Note: Treatment means followed by common letter(s) within columns are not significantly different among each other at 5% level. Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 3: Plant height at 120 days after sowing of maize influenced by interaction effect of irrigation and fertilizer dose with NPK omission

| Treatments                  | 30 -35 DAS + tasseling stage | 30 -35 DAS+ tasseling + grain filling stage | Tasseling stage |
|-----------------------------|-----------------------------|---------------------------------------------|-----------------|
| Farmer practice             | 102.6$^{bde}$              | 128.4$^{ab}$                                | 88$^{de}$       |
| Recommended dose            | 92.3$^{cde}$               | 112.2$^{bcd}$                               | 91.5$^{cde}$    |
| 50% above recommended dose  | 90.3$^{de}$                | 112.6$^{bcd}$                               | 103.6$^{cde}$   |
| N$_0$PK                     | 113.2$^{bcd}$              | 112$^{bcd}$                                 | 88.3$^{de}$     |
| NP$_0$K                     | 121.9$^{ab}$               | 118.9$^{abc}$                               | 87.3$^{de}$     |
| NPK$_0$                     | 145.2$^{a}$                | 126$^{ab}$                                  | 80.9$^{e}$      |
| F-test                      | *                           |                                             |                 |
| LSD (0.05)                  | 27.8                        |                                             |                 |
| CV %                        | 15.6                        |                                             |                 |

Grand mean

| Plant height at 120 days after sowing (cm) |
|------------------------------------------|
| 106.4                                    |

Note: Treatment means followed by common letter(s) within columns are not significantly different among each other at 5% level. Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Amanullah and Khaliq (2010) observed that irrigation strongly influenced grain and stover yield. The interaction effect of nitrogen and phosphorus omission plot (Table 5). The highest grain and stover yields were increased significantly with the increment in nitrogen level from 0 to 150 kg ha\(^{-1}\). Singh et al. (1993) also reported response of increase in maize yield and attributes up to 150 kg ha\(^{-1}\) of nitrogen application. Tyagi et al. (1998) reported that a grain yield of maize increased from 61 to 137 percent with the increment of nitrogen from 75 to 250 kg ha\(^{-1}\) as compared to nitrogen omission soil. Padmaja et al. (1999) also recorded similar type of findings that the grain and stover yields were increased significantly with the increment in nitrogen level from 0 to 150 kg ha\(^{-1}\). Similar trend of findings were also reported by Singh et al. (2000), Survanshvi et al. (2008) and Mahmood et al. (2001). Water supply plays a significant role in the utilization of fertilizer active substances especially that of nitrogen. Due to the changing precipitation, the effect of fertilization experiment results of Hank and Frank (1951) have proved that irrigation increases the efficiency of fertilization and the water supply of a plant. The irrigation and fertilization experiment results of Hank and Frank (1951) have proved that irrigation increases the efficiency of fertilization. The efficiency of fertilizers also depends on agroecological conditions (Lang, 1981).

### Table 4: Number of plants at harvest, number of ear harvested and sterility% of maize influenced by irrigation and fertilizer dose with NPK omission

| Treatment combination                        | Number of plants at harvest ha\(^{-1}\) | Number of ear harvested ha\(^{-1}\) | Sterility % |
|----------------------------------------------|----------------------------------------|-----------------------------------|-------------|
| Irrigation                                   |                                        |                                   |             |
| 30 -35 DAS + tasseling stage                 | 64969.1                                | 33796.3                           | 10.6        |
| 30 -35 DAS+ tasseling + grain filling stage  | 65432.1                                | 38734.5                           | 9.4         |
| Tasseling stage                              | 65046.3                                | 31790.1                           | 12.3        |
| F-test                                       | ns                                     | ns                                | ns          |
| LSD (0.05)                                   | -                                      | 25.0                              | 55.7        |
| CV %                                         | 2.6                                    |                                   |             |
| Fertilizer dose                              |                                        |                                   |             |
| Farmer practice                              | 64660.5                                | 33487.6\(b\)                      | 10.8\(b\)  |
| Recommended dose                             | 65277.8                                | 40740.7\(a\)                      | 10.3\(b\)  |
| 50% above recommended dose                   | 65740.7                                | 40740.7\(a\)                      | 8.1\(c\)   |
| N\(_0\)PK                                    | 64969.1                                | 29320.9\(b\)                      | 13.7\(a\)  |
| NP,K                                        | 65123.4                                | 32407.4\(b\)                      | 11.4\(b\)  |
| NPK\(_0\)                                    | 65123.4                                | 31944.4\(b\)                      | 10.3\(b\)  |
| F-test                                       | ns                                     | ***                               | ***        |
| LSD (0.05)                                   | -                                      | 4643.3                            | 1.8         |
| CV %                                         | 2.5                                    | 13.8                              | 17.3        |
| Grand mean                                   | 65149.2                                | 34773.6                           | 10.7        |

Note: Treatment means followed by common letter(s) within columns are not significantly different among each other at 5% level. Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

**Grain Yield**

The effect of the irrigation and fertilizer dose significantly (p<0.01) affected grain yield of maize (Table 5). The grain yield of maize under 3 times irrigation (30 -35 DAS, tasseling, grain filling stage) was significantly higher (4333 kg ha\(^{-1}\) than irrigation supplied 2 times (30 -35 DAS, tasseling) (3240.6 kg ha\(^{-1}\) and (2428.8 kg ha\(^{-1}\)) as compared to single irrigation (tasseling stage). The grain yield of maize influenced by three levels of irrigation (30 -35 DAS, tasseling, grain filling stage) recorded 33.7% higher than two level of irrigation (30 -35 DAS, tasseling) and 78.4% higher than single irrigation (tasseling stage). The grain yield of maize was significantly (p<0.001) higher (4994.9 kg ha\(^{-1}\) with the application of recommended dose and (4870 kg ha\(^{-1}\) with 50 percent above recommended dose of fertilizer than nitrogen omission (1768.6 kg ha\(^{-1}\) plot. It was 182.4% higher with recommended dose and 173.3% higher with 50 percent above recommended dose of fertilizer than nitrogen omission plot (Table 5). The highest grain yield was observed under surplus irrigation conditions which suggest that a reduced irrigation volume can result in a significantly reduced yield. This indicates that limiting nitrogen reduces light interception decreasing leaf area index resulting in lower grain yield. Higher yield response was obtained for maize with increasing nitrogen application under adequate soil water condition (O’Neil et al., 2004). Nour and Lazzin (2000) reported that nitrogen and phosphorus combination affected grain yield significantly. Malik et al. (1976) also reported that the interaction effect of nitrogen and phosphorus increased grain yield significantly. Amanullah and Khalil (2010) observed that increased level of phosphorus produced higher grain and stover yield that might be due to increase in yield and yield components. Ibrikci et al. (2005) reported that the deficiency of phosphorus limited the growth and yield of maize. Singaram and Kothandaraman (1994) also recorded increment in phosphorus increases the yield. Nandals and Agrawal (1991) reported a linear response of maize to nitrogen application up to 200 kg ha\(^{-1}\) than that of (0 to 150 kg ha\(^{-1}\)). Singh et al. (1993) also reported response of increase in maize yield and attributes up to 150 kg ha\(^{-1}\) of nitrogen application. Tyagi et al. (1998) reported that a grain yield of maize increased from 61 to 137 percent with the increment of nitrogen from 75 to 250 kg ha\(^{-1}\) as compared to nitrogen omission soil. Padmaja et al. (1999) also reported similar type of findings that the grain and stover yields were increased significantly with the increment in nitrogen level from 0 to 150 kg ha\(^{-1}\). Similar trend of findings were also reported by Singh et al. (2000), Suryavanshi et al. (2008) and Mahmood et al. (2001). Water supply plays a significant role in the utilization of fertilizer active substances especially that of nitrogen. Due to the changing precipitation, the effect of fertilization strongly varies on an annual basis. The irrigation and fertilization research results of Nagy (1995, 1997, 1999) have indicated that irrigation improves the efficiency of fertilization and there is a strong correlation between fertilizer utilization and the water supply of a plant. The irrigation and fertilization experiment results of Hank and Frank (1951) have proved that irrigation increases the efficiency of fertilization. The efficiency of fertilizers also depends on agroecological conditions (Lang, 1981).
Analysis of data (Table 5) revealed that stover yield of maize was significantly (p<0.01) influenced by the effect of irrigation. Stover yield of maize influenced by 3 times irrigation (30-35 DAS, tasseling, grain filling stage) was 15.6% and 38.7% higher (5403.7 kg ha⁻¹) than 2 times irrigation (30-35 DAS, tasseling stage) (4556.8 kg ha⁻¹) and irrigation at tasseling stage (3307.6 kg ha⁻¹). Stover yield of maize was significantly (p<0.01) influenced by the effect of fertilizer dose. Recommended dose (5798.7 kg ha⁻¹) was 49.3% and 48.7% higher as compared to nitrogen omission plot (2970.7 kg ha⁻¹). From this result, stover yield could be increased with surplus availability of nitrogen in the soil. Similar result was reported by Nimje and Seth (1988) and Nunes et al. (1996) that biomass production increased with increasing nitrogen level.

The harvest index of maize influenced by irrigation was non–significant (Table 5). Harvest index was significantly (p<0.01) influenced by the effect of fertilizer dose with NPK omission technique. Higher percentage of harvest index was 45.8, 45.6 and 43.6 with the recommended dose, 50 percent above recommended dose (5870.8 kg ha⁻¹) were recorded from recommended dose, 50 percent above recommended dose and potassium omission plot which was at par with fertilizer dose (37.1) and nitrogen omission plot (37.2) and nitrogen omission plot (37.1). Lawrence (2008) also reported higher nitrogen dose increases harvest index in maize. With appropriate N-supply, a fast increase of leaf area in the early phase of development can be promoted, and thus the optimal LAI value can be sustained longer, which means an advantage from the aspect of assimilate flow to the grain yield as well as a favorable harvest index value (Berzsenyi, 1993).

### Nutrient Uptake in Stover

Irrigation scheduling significantly (p<0.05) influenced stover nitrogen uptake. The highest (42 kg ha⁻¹) nitrogen uptake was recorded with (30-35 DAS, tasseling, grain filling stage) and (30-35 DAS, tasseling stage) (40.6 kg ha⁻¹) while the least (24.5 kg ha⁻¹) with single irrigation (tasseling stage). Irrigation significantly (p<0.01) influenced stover phosphorus uptake. The highest (44.7 kg ha⁻¹) phosphorus uptake was recorded with (30-35 DAS, tasseling, grain filling stage) and (30-35 DAS, tasseling stage) (33.8 kg ha⁻¹) while the least (24.8 kg ha⁻¹) with the single irrigation (tasseling stage). Irrigation significantly (p<0.05) influenced stover potassium uptake. The highest (21.7 kg ha⁻¹) potassium uptake was recorded with (30-35 DAS, tasseling, grain filling stage) and (30-35 DAS, tasseling stage) (19.4 kg ha⁻¹) while the least (11.7 kg ha⁻¹) with the single irrigation (tasseling stage) (Table 6).

Fertilizer dose significantly (p<0.01) affected stover nitrogen uptake. The highest (49.8 kg ha⁻¹) nitrogen uptake was recorded with 50 percent above recommended dose (240: 90: 60 N-P-K kg ha⁻¹) and recommended dose (160: 60: 40 N-P-K kg ha⁻¹) (48.7 kg ha⁻¹) and the lowest (22.4 kg ha⁻¹) with nitrogen omission (NPK). Fertilizer dose significantly (p<0.001) affected stover phosphorus uptake. The highest (46.2 kg ha⁻¹) phosphorus uptake was recorded with 50 percent above recommended dose (240: 90: 60 N-P-K kg ha⁻¹) and recommended dose (160: 60: 40 N-P-K kg ha⁻¹) (45.6 kg ha⁻¹) while the lowest (20.3 kg ha⁻¹) with nitrogen omission (NPK). Fertilizer dose significantly (p<0.001) affected stover potassium uptake. The highest (24.9 kg ha⁻¹) potassium uptake was recorded with 50

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**Table 5:** Grain yield, stover yield and harvest index of maize influenced by irrigation and fertilizer dose with NPK omission

| Treatment combination                  | Grain yield (kg ha⁻¹) | Stover yield (kg ha⁻¹) | HI%   |
|----------------------------------------|-----------------------|------------------------|-------|
| Main plot: Irrigation                  |                        |                        |       |
| 30-35 DAS+ tasseling stage             | 3240.6ᵇ                 | 4556.8ᵇ                | 41.1  |
| 30-35 DAS+ tasseling + grain filling stage | 4333ᵃ                  | 5403.7ᵃ                | 43.5  |
| Tasseling stage                        | 2428.8ᶜ                | 3307.6ᶜ                | 40.5  |
| F -test                                | **                     | **                     | ns    |
| LSD (0.05)                             | 631.2                  | 753.7                  | -     |
| CV %                                   | 20.4                   | 18.4                   | 18.1  |
| Sub plot: Fertilizer dose              |                        |                        |       |
| Farmer practice                        | 2577.6ᵇ                | 4194.2ᵇ                | 37.2ᵇ |
| Recommended dose                       | 4994.9ᵃ                | 5870.8ᵃ                | 45.8ᵃ |
| 50% above recommended dose             | 4870ᵃ                  | 5798.7ᵃ                | 45.6ᵃ |
| NPK                                    | 1768.6ᶜ                | 2970.7ᶜ                | 37.1ᵇ |
| NPK₀                                   | 2795.2ᵇ                | 3857.4ᵇ                | 40.9ᵇ |
| NPK₀                                   | 2998.4ᵇ                | 3844.5ᵇ                | 43.6ᵃ |
| F -test                                | ***                    | ***                    | **    |
| LSD (0.05)                             | 734.3                  | 787.5                  | 5.6   |
| CV %                                   | 22.8                   | 18.4                   | 14.0  |
| Grand mean                             | 3334.1                 | 4422.7                 | 41.7  |

Note: Treatment means followed by common letter(s) within columns are not significantly different among each other at 5% level. Significant codes: 0 **** 0.001 *** 0.01 ** 0.05 * 0.1 ′ 1

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percent above recommended dose (240: 90: 60 N-P-K kg ha\(^{-1}\)) and recommended dose (160: 60: 40 N-P-K kg ha\(^{-1}\)) (22.3 kg ha\(^{-1}\)) while the lowest (10.9 kg ha\(^{-1}\)) with nitrogen omission (N0PK) (Table 6).

**Nutrient Uptake in Grain**

Grain nitrogen uptake was significantly (p<0.01) influenced by the main effects of irrigation scheduling. The highest (56.3 kg ha\(^{-1}\)) was recorded with three level of irrigation (30 -35 DAS, tasseling, grain filling stage) while the lowest (31.2 kg ha\(^{-1}\)) with single irrigation (tasseling stage). Grain phosphorus uptake was significantly (p<0.01) influenced by the main effects of irrigation scheduling. The highest (18.8 kg ha\(^{-1}\)) was recorded with three level of irrigation (30 -35 DAS, tasseling, grain filling stage) while the lowest (12.7 kg ha\(^{-1}\)) and (10.5 kg ha\(^{-1}\)) with two level of irrigation (30 -35 DAS, tasseling) and single irrigation (tasseling stage) respectively. Grain potassium uptake was significantly (p<0.01) influenced by the main effects of irrigation scheduling. The highest (15.1 kg ha\(^{-1}\)) was recorded with three level of irrigation (30 -35 DAS, tasseling, grain filling stage) while the lowest (8 kg ha\(^{-1}\)) with single irrigation (tasseling stage) (Table 7).

**Table 6:** Nutrient uptake in stover of maize influenced by irrigation and fertilizer dose with NPK omission

| Treatment combination | Nitrogen uptake (kg ha\(^{-1}\)) | Phosphorus uptake (kg ha\(^{-1}\)) | Potassium uptake (kg ha\(^{-1}\)) |
|-----------------------|----------------------------------|------------------------------------|----------------------------------|
| **Main plot: Irrigation** |                                  |                                    |                                  |
| 30 -35 DAS + tasseling stage | 40.6\(^a\)                      | 33.8\(^b\)                        | 19.4\(^a\)                      |
| 30 -35 DAS+ tasseling + grain filling stage | 42\(^a\)                      | 44.7\(^a\)                        | 21.7\(^a\)                      |
| Tasseling stage | 24.5\(^b\)                      | 24.8\(^b\)                        | 11.7\(^b\)                      |
| F - test | *                                | **                                 | *                                |
| LSD (0.05) | 14.3                            | 7.0                                | 6                                |
| CV % | 43.4                            | 22                                 | 37.1                            |
| **Sub plot: Fertilizer dose** |                                  |                                    |                                  |
| Farmer practice | 32.9\(^b\)                      | 33.9\(^b\)                        | 16.6\(^b\)                      |
| Recommended dose | 48.7\(^a\)                      | 45.6\(^a\)                        | 22.3\(^a\)                      |
| 50% above recommended dose | 49.8\(^a\)                      | 46.2\(^a\)                        | 24.9\(^a\)                      |
| N\(_0\)PK | 22.4\(^c\)                      | 20.3\(^c\)                        | 10.9\(^c\)                      |
| N\(_P\)K | 29.6\(^bc\)                     | 30.2\(^b\)                        | 14.6\(^bc\)                     |
| NPK\(_0\) | 31\(^bc\)                       | 30.8\(^b\)                        | 16.1\(^b\)                      |
| F - test | ***                              | ***                                | ***                              |
| LSD (0.05) | 8.9                             | 9.1                                | 4.3                              |
| CV % | 26                              | 27.6                               | 25.6                             |
| Grand mean | 35.7                            | 34.4                               | 17.5                             |

Note: Treatment means followed by common letter(s) within columns are not significantly different among each other at 5% level. Significant codes: 0 **** 0.001 *** 0.01 ** 0.05 * 0.1 1

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Table 7: Nutrient uptake in grain of maize influenced by irrigation and fertilizer dose with NPK omission

| Treatment combination | Nitrogen uptake (kg ha\(^{-1}\)) | Phosphorus uptake (kg ha\(^{-1}\)) | Potassium uptake (kg ha\(^{-1}\)) |
|-----------------------|----------------------------------|-----------------------------------|----------------------------------|
| **Main plot: Irrigation** |                                  |                                   |                                  |
| 30 -35 DAS + tasseling stage | 42.2\(^{b}\)                      | 12.7\(^{b}\)                      | 11.4\(^{b}\)                     |
| 30 -35 DAS+ tasseling + grain filling stage | 56.3\(^{a}\)                      | 18.8\(^{a}\)                      | 15.1\(^{a}\)                     |
| Tasseling stage | 31.2\(^{c}\)                      | 10.5b                             | 8c                               |
| **F-test** | ***                              | ***                               | ***                              |
| LSD (0.05) | 7.5                               | 3.9                               | 2.9                               |
| CV % | 18.7                             | 30.3                              | 27.4                              |
| **Sub plot: Fertilizer dose** |                                  |                                   |                                  |
| Farmer practice | 33.7\(^{c}\)                      | 11.1\(^{b}\)                      | 9.6\(^{a}\)                      |
| Recommended dose | 64.6\(^{a}\)                      | 21\(^{a}\)                        | 17\(^{a}\)                       |
| 50% above recommended dose | 62.9\(^{a}\)                      | 20\(^{c}\)                        | 16.4\(^{a}\)                     |
| N,P,K | 22.7\(^{c}\)                      | 7.4\(^{c}\)                       | 5.9\(^{c}\)                       |
| NP\(_a\)K | 39.2\(^{b}\)                      | 12.3\(^{b}\)                      | 10.1\(^{b}\)                      |
| NPK\(_a\) | 36.3\(^{b}\)                      | 12.4\(^{b}\)                      | 9.9\(^{b}\)                       |
| **F-test** | ***                              | ***                               | ***                              |
| LSD (0.05) | 11.6                             | 3.3                               | 2.9                               |
| CV % | 27.9                             | 24.9                              | 26.4                              |
| Grand mean | 43.2                             | 14.0                              | 11.5                              |

Note: Treatment means followed by common letter(s) within columns are not significantly different among each other at 5% level. Significant codes: 0 '****' 0.001 '***' 0.01 '**' 0.05 '*' 0.1 ' ' 1

In other words, grain nutrient uptake was recorded 80.4% nitrogen (56.3 kg ha\(^{-1}\)), 79% phosphorus (18.8 kg ha\(^{-1}\)) and 88.8% potassium (15.1 kg ha\(^{-1}\)) higher with three levels of irrigation (30 - 35 DAS, tasseling, grain filling stage) than single irrigation (tasseling stage) nitrogen (31.2 kg ha\(^{-1}\)), phosphorus (10.5 kg ha\(^{-1}\)) and potassium (8 kg ha\(^{-1}\)). Likewise, 184% nitrogen (64.6 kg ha\(^{-1}\)), 183.7% phosphorus (21 kg ha\(^{-1}\)) and 188% potassium (17 kg ha\(^{-1}\)) was recorded higher with recommended dose and 177% nitrogen (62.9 kg ha\(^{-1}\)), 170% phosphorus (20 kg ha\(^{-1}\)) and 177.9% potassium (16.4 kg ha\(^{-1}\)) higher with 50 percent above recommended dose of fertilizer than nitrogen omission plot (N0PK) nitrogen (22.7 kg ha\(^{-1}\)), phosphorus (7.4 kg ha\(^{-1}\)) and potassium (5.9 kg ha\(^{-1}\)).

The higher nutrient uptake from 50 percent above and full dose of fertilizer plot might be due to increase in balanced and surplus nutrient concentration with better plant growth. Nitrogen uptake in grain and stover could be enhanced with increased phosphorus applications (Jiang et al., 2006) and potassium application (Saifullah et al., 2002). The lowest nitrogen uptake (22.7 kg ha\(^{-1}\)), phosphorus uptake (7.4 kg ha\(^{-1}\)) and potassium uptake (5.9 kg ha\(^{-1}\)) in grain and nitrogen uptake (22.4 kg ha\(^{-1}\)), phosphorus uptake (20.3 kg ha\(^{-1}\)) and potassium uptake (10.9 kg ha\(^{-1}\)) in stover were observed in nitrogen omission plot (N0PK). It could be suggested that absence of nitrogen limits the optimum growth of crop resulting low yield and biomass production. These results are also in accordance with Ghesyari et al. (2009) who reported that irrigation and nitrogen in maximum amount facilitate to uptake of nitrogen which increase grain yield, biological yield and growth all parameters in maize. The reason behind the higher yield of both winter and spring maize could be attributed to longer duration of crop growth, higher rate of photosynthesis and assimilates utilization (Singh and Zaidi, 1989) and higher efficiency in the uptake and use of nutrients by crops (Shrestha, 2007). Winter maize has been observed to be highly responsive to fertilization, results in healthy crop and also helps in protecting against cold damage. Proper time and supplemental irrigation should be realized in irrigation scheduling for the most effective use of available water in optimizing maize production.

Singh et al. (1991) reported that with the successive increment of nitrogen level from 50 kg ha\(^{-1}\) to 150 kg ha\(^{-1}\) nitrogen uptake by winter maize significantly increased. Bhaskaran et al. (1992) also reported same trend of higher NPK uptake with increase in nitrogen. Gaur et al. (1992), Shivay et al. (1999), Selvaraju and Iruthayaraju (1995) also reported similar findings. Padmaja et al. (1999) observed that the increase in nitrogen had a significant effect on the uptake of nitrogen by grain and stover as compared to lower level of fertilization. Phosphorus and potassium uptake by stover and grain also increased with the increased rate of nitrogen. Shivay and Singh (2000), Vadivel et al. (2001), Singh and Totawat (2002), Kumar and Singh (2003) reported a significant increase in nitrogen with each successive increase in nitrogen level from 0 to 120 kg ha\(^{-1}\). Various researchers also reported similar findings. Lakshmi (2010), Mercy et al. (2012), Venkata Rao (2012) and Reddy et al. (2012) reported increase of nitrogen had significant influence on nutrient uptake by grain and stover up to the higher level of 240 kg ha\(^{-1}\) nitrogen as compared to lower level of nitrogen.

**Soil Moisture Percentage**

Soil moisture under irrigation and fertilizer with NPK omission plot were non-significant to each other at every 15

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days interval of data recording but the difference in soil moisture with irrigation scheduling was significant (p<0.05) at 75 days after sowing (Table 8). Soil moisture under three times irrigation (30 -35 DAS, tasseling and grain filling stage) was 29.2 percent higher (12.3%) than one-time irrigation at tasseling stage (8.7%) which was at par (12%) with two times irrigation (30 -35 DAS, tasseling stage). Irrigation at frequent interval improves the soil carbon. Improvement in soil carbon increases the water holding capacity of the soil (Fabrizzi et al., 2005; Mupangwa et al., 2007). Maize yield development is sequential process in which the potential number of ears plant\(^{-1}\) is determined first, followed by grain number per inflorescence and by grain size. Therefore, variations in the level of carbon and nitrogen induced by different planting rates or any other factor can strongly influence yield and its components sequentially (Jacobs and Pearson, 1991). The amount of precipitation, or the moisture stored in the soil, modifies the need and effect of fertilizers. Fertilizer effect increases when activities leading to optimal water supply and decreases when reaching harmful levels of excess water (Nagy, 1994). Fertilization is decisive both in macro and micro element uptake (Nemeth and Buzas, 1991).

Interaction effect of irrigation and fertilizer dose at 120 days after sowing of soil moisture content indicated that interaction of 50 percent above recommended dose (240: 90: 60 N-P-K kg ha\(^{-1}\)) with three times irrigation (30 -35 DAS, tasseling, grain filling stage) resulted in higher moisture (18.5%) as compared to other treatment combination (Table 9). Carbon accumulates in the soil only when nitrogen balance is positive (Bayer et al., 2000; Sisti et al., 2004; Alves et al., 2006). It could be due to positive nitrogen balance from sufficient application of nitrogen and surplus irrigation provide to the experimental field.

### Table 8. Soil moisture content influenced by irrigation and fertilizer dose with NPK omission

| Treatment combination                      | Soil moisture at 15 days interval from 45 to 120 DAS (%) |
|-------------------------------------------|--------------------------------------------------------|
|                                           | 45    | 60    | 75    | 90    | 105   | 120   |
| Main plot: Irrigation                     |       |       |       |       |       |       |
| 30 -35 DAS + tasseling stage              | 10.9  | 12.2  | 12.4  | 8.9   | 9     | 13.7  |
| 30 -35 DAS+ tasseling + grain filling stage| 9.9   | 13.8  | 12.3  | 9.9   | 7.9   | 13.4  |
| Tasseling stage                           | 9.7   | 8.9   | 8.7   | 8.2   | 6.7   | 14.9  |
| F -test                                   | ns    | ns    | *     | ns    | ns    | ns    |
| LSD (0.05)                                | -     | -     | 2.0   |       |       |       |
| CV %                                      | 25.3  | 50.7  | 20.2  | 25.3  | 37.5  | 25    |
| Sub plot: Fertilizer dose                 |       |       |       |       |       |       |
| Farmer practice                           | 10    | 11.8  | 11.6  | 9.2   | 7.8   | 13.1  |
| Recommended dose                          | 10.4  | 12.5  | 11.2  | 8.3   | 7.9   | 13.8  |
| 50% above recommended dose                | 10    | 11.3  | 10.9  | 9.2   | 8.6   | 13.6  |
| N\(_{2}\)PK                               | 9.9   | 12.2  | 10.2  | 8.7   | 7.2   | 14.1  |
| NP\(_{2}\)K                               | 9.9   | 10.6  | 10.8  | 8.9   | 8.4   | 13.9  |
| NPK                                       | 10.8  | 11.5  | 11.1  | 8.2   | 7.2   | 15.2  |
| F -test                                   | ns    | ns    | ns    | ns    | ns    | ns    |
| LSD (0.05)                                | -     | -     | -     | -     | -     | -     |
| CV %                                      | 18.9  | 23.7  | 20    | 23.4  | 29.5  | 22.3  |
| Grand mean                                | 10.2  | 11.7  | 11.0  | 8.8   | 7.9   | 14.0  |

Note: Treatment means followed by common letter(s) within columns are not significantly different among each other at 5% level. Significant codes: 0 '****' 0.001 '***' 0.01 '*' 0.05 '.' 0.1 ' ' 1

### Table 9. Soil moisture (%) at 120 DAS influenced by interaction effect of irrigation and fertilizer dose with NPK omission

| Treatment combination | 30 -35 DAS + tasseling stage | 30 -35 DAS + grain filling stage | Tasseling stage |
|-----------------------|-------------------------------|-----------------------------------|-----------------|
| Farmer practice       | 11.4\(\text{a}\)             | 13\(\text{b}\)                   | 14.9\(\text{abc}\) |
| Recommended dose      | 13.5\(\text{abc}\)           | 13.1\(\text{b}\)                | 15\(\text{bc}\)  |
| 50% above recommended dose | 10.9\(\text{a}\)            | 18.5\(\text{a}\)                | 11.4\(\text{a}\)  |
| N\(_{2}\)PK            | 13.4\(\text{abc}\)           | 11.6\(\text{bc}\)               | 17.2\(\text{ab}\) |
| NP\(_{2}\)K            | 15.7\(\text{abc}\)           | 11\(\text{c}\)                  | 15.1\(\text{abc}\) |
| NPK                   | 17.1\(\text{abc}\)           | 13\(\text{bc}\)                 | 15.6\(\text{abc}\) |
| SEm(\+\-)             | 9.8                           |                                   |                 |
| F -test               | *                             |                                   |                 |
| LSD (0.05)            | -                             |                                   |                 |
| CV %                  | 22.3                          |                                   |                 |
| Grand mean            | 14                            |                                   |                 |

Note: Treatment means followed by common letter(s) within columns are not significantly different among each other at 5% level. Significant codes: 0 '****' 0.001 '***' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Conclusion
A research was conducted at the farmer’s field of Khajura, Banke for the response of nutrient omission to irrigation scheduling in hybrid maize during winter season. Three level of irrigation; 30 -35 days after sowing, tasseling and grain filling stage increased the yield by 78.4% than single irrigation at tasseling stage and 182.4% by applying recommended dose (160: 60: 40 N-P-K kg ha$^{-1}$) than with nitrogen omission. Nutrient uptake was also higher 80.4% (nitrogen), 79% (phosphorus) and 88.8% (potassium) in grain and 71.4% (nitrogen), 80.2% (phosphorus) and 85.4% (potassium) in stover with 3 level of irrigation (30 -35 days after sowing, tasseling and grain filling stage) than single irrigation at tasseling stage. Similarly, 184.5% (nitrogen), 183.7% (phosphorus) and 188% (potassium) in grain and 117.4% (nitrogen), 127.5% (phosphorus) and 104.5% (potassium) in stover with recommended dose (160: 60: 40 N-P-K kg ha$^{-1}$) of fertilizer than nitrogen omission. From this research, we can conclude that nitrogen was the most limiting nutrient for growth and yield of maize followed by phosphorus and potassium at recommended amount and irrigation at proper critical time at 30 -35 days after sowing, tasseling and grain filling stage also enhance the growth and productivity of maize.

Authors’ Contribution
N.R. Acharya, S.K. Sah, A.K. Gautam, A.P. Regmi designed the research plan; N.R. Acharya performed experimental works, collected the data & prepared the manuscript. All authors critically revised, finalized & approved the manuscript.

Conflict of Interest
The authors declare that there is no conflict of interest with present publication.

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