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## The Impact of Seeding Rate and Locations on Some Grass Pea (*Lathyrus sativus*) Lines for Growth, Forage and Seed Yield in Sulaimani Region

### ABSTRACT

This study was carried out at two locations in Sulaimani governorate, Qlyasan and Kanipanka, during the winter season of 2017-2018 to evaluate the response of four lines of Grass pea *Lathyrus sativus* (IF 003, IF 133, IF 102, IF 067) lines and four seeding rates (80kg/h, 100kg/h, 120kg/h, 140kg/h). The experiment was conducted at (December 5th /2018) in Kanipanka and (December 6th /2018) at Qlyasan. The design of factorial experiment RCBD with three replications was conducted. Means comparison was carried out by the least significant difference (L.S.D) at a significant level of 5%. The results confirmed that the grass pea lines, as the average of both locations there were highly significant differences among lines due to plant height, days to %50 flowering, leaf dry weight, and number of bacterial nodules/plant, but significant differences were observed for the character stem dry weight... It was noticed that the effect of locations on growth and forage characters for grass pea was highly significant for the days to maturity, leaf dry weight, stem dry weight, leaf stem ratio and number of bacterial nodules/plant, while it was significant for the character plant height. It was indicated that the second location recorded the highest value for plant height, leaf dry weight, stem dry weight, leaf stem ratio and number of bacterial nodules/plant with 60.080cm, 1.970g, 1.850g, 2.600 and 16.390 respectively. At the average of both locations there were differences highly significant among lines due to days to maturity, leaf dry weight, stem dry weight, leaf stem ratio and number of bacterial nodules/plant. Line number IF067 produced the highest value for days to maturity and stem dry weight and number of bacterial nodules/plant with 155.6 days, 4.990 g and 14.27 respectively. The effect of seeding rate on seed yield and its components for grass pea at the average of both locations and there was highly significant for the number of pod/plant, seed yield, biological yield, and harvest index significant for 100 seed weight. As the average of both locations using 140 kg/h seeds produced maximum values for the most characters.

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## INTRODUCTION

Forage legumes such as grass pea and vetches are well adapted to local high altitude environments due to their tolerance and late growth habit. Forage legumes can play an important role in sustaining the productivity of the cereals-based farming system in the Mediterranean countries, especially under semiarid environment. It was found that the forage legume such as vetches and grass pea possess well yield ability, survival to the climatically conditions prevailing the region (Tawfiq,

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2000) (Rafaat, 2001). Grass pea is a winter season crop adapted to the subtropics or temperate regions (Mehta *et al.*, 1994). However, Extreme temperature and drought occurrence during grain filling have been identified as a major source of variation of seed quality characteristic (Agaalikhani *et al.*, 2014). *Lathyrus sativus* L. or grass pea called (khesari in India and Bangladesh, guaya in Ethiopia, san li dow in China, pois carré in France).

One of the factors that affect growth is Plant density. Development and plant growth adversely affects by high plant density, while sub-optimal plant density results in lower yield per unit area but high yield per plant (Singh *et al.*, 1992). Plant density is another important element for higher yield realization through light penetration in crop canopy (Idris, 2008).

The selected line 519 had the highest biological, 4681 kg/ha, and was among the best line in seeds yield, 885 kg/h. Several other selection lines were also very productive both in seed and biological yields such as 520 and 531, while the lines 522 and 527 had high biological yields only. These lines have a good potential as winter forage legumes under Rabi condition. The selected lines 508, 528 and 530 have a good potential for seed yield only (Al-Doss *et al.*, 1998).

In many Asian and African countries Grass pea seeds are common staple, food grass peas seeds are used in many dishes, as a accompanies the traditional (local flatbread) (Campbell, 1997).. *Lathyrus* (Fabacea; Papilionoideae) has importance as traditional foodstuffs in many cultures worldwide and is the largest genus in tribe Viciae (Kenicer *et al.*, 2005; Sammour *et al.*, 2007).. Grass pea is an annual cool-season legume, known as common chickling (Laghari *et al.*, 2016). . Grass pea is significant crop treasured for their place in crop rotations and as food and feed sources. Grass pea has high production potential, drought and salt tolerance, disease resistance of stored grains to pests (Agaalikhani *et al.*, 2014). Under adverse environmental conditions, easily grown on marginal land it is a popular crop in subsistence. The objective of this research was to study the effect of plant population density (PPD) on some line of grass pea. To evaluate some lines of *lathyrus sativus* L. for growth and seed yield ,and to select the line that are more adaptable to the region of Sulaimani .

## MATERIALS AND METHODS

This study was carried out in Sulaymaniyah region at two locations (Qlyasan and Kanipanka), during the winter season of 2017-2018. Four Grass pea ( *Lathyrus sativus*) Lines (IF003, IF133, IF102, IF067 ) were used to study the effect of plant density and Lines on growth characters and yield components .The seeds were sown for Agricultural Research in the Dry Areas ICARDA were selected for cultivation in 5/12/2017, 6/12/2017 for both location respectively. And four different plant densities were applied (80Kg/h, 100Kg/h, 120Kg/h, and 140Kg/h).

The experiments were designed in Factorial conducted in Randomized Complete Block Design with three replication according to the procedure outlined by (Steel and Torrie, 1986). Plots consisted of four rows, the row was (2) m long with a spacing of (0.25) m between the rows. All possible comparisons among the means would carry out by using L.S.D test (Least Significant Difference) at a significant level of 5%. The following characters were determined.

### Growth traits

- Plant height (cm)
- No. of Days to %50 flowering
- No. of Days to maturity
- No. of Branches/ plant
- leaf dry weight (g)
- Stem dry weight (g)
- Leaf stem ratio percent
- No. of bacterial nodules/plant

## Seed Yield and its components

- No. of pods/ plant
- No of seeds/ pods
- Pod length (cm)
- weight of seeds/pod (g)
- 100 seed weight (g)
- Seed yield (Kg/ha)
- Biological yield (Kg/ha)
- Harvest index: measured by separating the seeds from straw yield and weight to calculate the harvest index according to the following equation:

$$\text{Harvest index} = \frac{\text{Total seed yield}}{\text{Total biological yield} + \text{Total seed yield}} \times 100$$

## RESULTS AND DISCUSSION

Data represent in Table 1a and Appendix 1 illustrate the means of some growth and forage characters for grass pea lines at Qlyasan locations and their average. At Qlyasan location there are highly significant differences among lines for the plant height, leaf dry weight, stem dry weight, leaf stem ratio, and number of bacterial nodules/plant, but for days to %50 flowering was significant while the differences were not significant for number of branches/plant and days to maturity. At Kanipaka location the difference among lines were highly significant for the days to maturity, leaf dry weight and number of bacterial nodules/plant while it is significant for the character days to %50 flowering and not significant for the rest. As the average of both locations there were highly significant differences among lines due to the characters Plant height, days to %50 flowering, leaf dry weight, and number of bacterial nodules/plant, but significant difference was noticed among lines due to the character stem dry weight and for the rest differences among lines were not significant.

At Qlyasan location the line number 1 produced maximum value for the character leaf stem ratio reached 1.756, while exhibited the lowest values for the character plant height, leaf dry weight, number of bacterial nodules/plant and reached 39.42 cm, 0.695 g and 14.08 respectively. Line number 2 had the highest values for the character plant height reached 58.22 cm. The highest values for the character number of bacterial nodules/plant produced by line number 3 recorded 16.34 respectively and also produced the lowest values for the days to %50 flowering, and stem dry weight with 130.400 days and 0.805 g respectively. The highest value due to the character days to %50 flowering, leaf dry weight and stem dry weight were 131.9 days, 1.231g and 1.306 g respectively recorded by line number 4, and also recorded the lowest value for the leaf stem ratio with 0.375 see table 1a.

At Kanipanka location it was observed that line number 1 produced the lowest value for all characters except the character days to %50 flowering with 159.18, 1.526, and 15.617 for the days to maturity, leaf dry weight and number of bacterial nodules/plant respectively. Line number 2 showed the highest value for the character days to %50 flowering reached 120.187 days. Line number 3 exhibited the highest value due to the character number of bacterial nodules/plant with 17.650, while it recorded the lowest value for the days to %50 flowering with 118.822 days. The highest value for most characters recorded by line number 4 including the characters Plant height, days to maturity, leaf dry weight and stem dry weight reached 63.603cm, 164.583 days, 2.248g and 2.263g respectively.

Data in table 1c represent the value for grass pea lines as the average of both locations. The lowest value for the characters recorded by line number 1 including the characters Plant height, leaf dry weight; stem dry weight and number of bacterial nodules/plant with 48.21 cm, 1.111g, 1.243g and 14.848 respectively. Line number 3 produced maximum values for the character number of branch/ plant and number of bacterial nodules /plant reached 6.189 and 16.990 respectively, and

showed the lowest value for the character days to %50 flowering with 124.600 days. The highest value for most characters recorded by line number 4 including the character plant height, days to %50 flowering, leaf dry weight, stem dry weight and leaf stem ratio with 60.55cm, 126.1days, 1.739g, 1.784g and 2.32 respectively and recorded the lowest value for the character number of branch/plant with 5.595 branches. There are many factors that affect productivity in agriculture these factors are plant species and cultivars, agronomical technics, soil and climate factors. Even though all the conditions can be provided, yield level greatly depends on climate conditions in especially dry agricultural areas (Albayrak and TÖngel, 2006).

**Table (1a)** Means of growth and forage characters for grass pea lines at Qlyasan locations and their average

| Qlyasan Location                |                   |                     |                       |                  |                     |                     |                 |                                |
|---------------------------------|-------------------|---------------------|-----------------------|------------------|---------------------|---------------------|-----------------|--------------------------------|
| Line                            | Plant height (cm) | No. of branch/plant | Days to %50 flowering | Days to maturity | Leaf dry weight (g) | Stem dry weight (g) | Leaf stem ratio | No. of bacterial nodules/plant |
| L.1                             | 39.420            | 5.810               | 130.500               | 177.270          | 0.695               | 1.034               | 1.756           | 14.080                         |
| L.2                             | 58.220            | 6.080               | 131.000               | 180.262          | 1.128               | 1.205               | 0.746           | 14.410                         |
| L.3                             | 53.130            | 6.120               | 130.400               | 178.706          | 0.918               | 0.805               | 0.492           | 16.340                         |
| L.4                             | 57.510            | 5.640               | 131.900               | 172.100          | 1.231               | 1.306               | 0.375           | 15.090                         |
| <b>LSD</b><br>( $p \leq 0.05$ ) | <b>4.832</b>      | <b>n.s</b>          | <b>1.03</b>           | <b>n.s</b>       | <b>0.136</b>        | <b>0.251</b>        | <b>0.135</b>    | <b>0.877</b>                   |

n.s not significant L.1 means IF003, L.2 means IF133, L.3 means IF102, and L.4 means IF067.

**Table (1b)** Means of growth and forage characters for grass pea lines at Kanipanka Location and their average

| Kanipanka Location              |                   |                     |                       |                  |                     |                     |                 |                                |
|---------------------------------|-------------------|---------------------|-----------------------|------------------|---------------------|---------------------|-----------------|--------------------------------|
| Line                            | Plant height (cm) | No. of branch/plant | Days to %50 flowering | Days to maturity | Leaf dry weight (g) | Stem dry weight (g) | Leaf stem ratio | No. of bacterial nodules/plant |
| L.1                             | 57.000            | 5.458               | 119.637               | 159.189          | 1.526               | 1.453               | 2.388           | 15.617                         |
| L.2                             | 58.217            | 5.725               | 120.187               | 162.576          | 2.165               | 1.774               | 2.709           | 15.933                         |
| L.3                             | 60.970            | 6.258               | 118.822               | 163.102          | 1.935               | 1.924               | 2.808           | 17.650                         |
| L.4                             | 63.603            | 5.550               | 120.165               | 164.583          | 2.248               | 2.263               | 2.489           | 16.375                         |
| <b>LSD</b><br>( $p \leq 0.05$ ) | <b>n.s</b>        | <b>n.s</b>          | <b>0.882</b>          | <b>1.097</b>     | <b>0.307</b>        | <b>n.s</b>          | <b>n.s</b>      | <b>0.956</b>                   |

n.s not significant

**Table (1c)** Means of growth and forage characters for grass pea lines at Average of both locations.

| Average of both Locations       |                   |                     |                       |                  |                     |                     |                 |                                |
|---------------------------------|-------------------|---------------------|-----------------------|------------------|---------------------|---------------------|-----------------|--------------------------------|
| Line                            | Plant height (cm) | No. of branch/plant | Days to %50 flowering | Days to maturity | Leaf dry weight (g) | Stem dry weight (g) | Leaf stem ratio | No. of bacterial nodules/plant |
| L.1                             | 48.210            | 5.630               | 125.100               | 168.200          | 1.111               | 1.243               | 2.072           | 14.848                         |
| L.2                             | 58.218            | 5.902               | 125.600               | 171.400          | 1.647               | 1.489               | 1.727           | 15.171                         |
| L.3                             | 57.050            | 6.189               | 124.600               | 170.900          | 1.426               | 1.364               | 1.650           | 16.990                         |
| L.4                             | 60.550            | 5.595               | 126.100               | 168.300          | 1.739               | 1.784               | 2.320           | 15.732                         |
| <b>LSD</b><br>( $p \leq 0.05$ ) | <b>7.84</b>       | <b>n.s</b>          | <b>0.664</b>          | <b>n.s</b>       | <b>0.165</b>        | <b>0.329</b>        | <b>n.s</b>      | <b>0.635</b>                   |

n.s not significant

Data in Table 2a explain the effect of seeding rate on some growth and forage characters for grass pea. At Qlyasan location the effect of seeding rate was highly significant on all characters except the characters days to %50 flowering and days to maturity which were not significant, while at

Kanipanka location the effect of seeding rate was highly significant on the characters days to maturity leaf dry weight and leaf stem ratio and it was significant on the characters plant height, number of branch/plant and days to %50 flowering while, it non-significantly affected the characters stem dry weight and number of bacterial nodules/plant .

At Qlyasan location the application of 80 kg/h produce the lowest value for most characters excluding the number of branch/ plant, days to maturity, leaf dry weight, stem dry weight and number of bacterial nodules/plant with 4.858, 171.660, 0.603, 0.640 and 14.075 respectively. But, using 100 kg/h gave maximum value for the character plant height and leaf dry weight reached 56.808 cm and 1.142g respectively. However, the lowest value for character days to %50 flowering recorded 130.500 days. Maximum numbers of days to maturity produced by using 120 kg/h reached 181.230 days but, minimum value for the character leaf stem ratio recorded by the same level with 0.486. The highest value of most characters produced as 140 kg/h was used such as the number of branch/plant, stem dry weight, leaf stem ratio and number of bacterial nodules/plant reached 6.925, 1.522, 1.349, and 17.225 respectively. While the lowest value recorded by the application 140 kg/h for the character plant height with 47.294 cm.

At Kanipanka location, using 80kg/h recorded the lowest value for the leaf dry weight, leaf stem ratio and number of bacterial nodules/ plant reached 1.198g, 1.768, and 15.142 respectively, also the application 100kg/h for the number of branch/plant, days to maturity and stem dry weight was recorded with 5.325, 158.953, and 1.009 respectively. Using 120kg/h seeding rate gave the highest values of the plant height, days to %50 flowering and days to maturity were recorded 62.933, 120.214 and 165.609 respectively. The highest value for most characters produced as 140kg/h seeds were used including the number of branch/plant, leaf dry weight, leaf stem ratio and number of bacterial nodules/plant reached 6.450, 2.986g, 3.991 and 18.117 respectively.

However, the lowest value for plant height and days to %50 flowering recorded as 140kg/h was used 57.825cm and 119.016days respectively. As the average of both locations the lowest value for most characters such as number of branch/plant, leaf dry weight, leaf stem ratio and number of bacterial nodules/plant were recorded when 80kg/h was used with 5.100, 0.901g, 1.205 and 14.610, but using 100 kg/h recorded the highest value for plant height reached 59.00cm; however, the lowest value recorded by using 100kg/h for the character days to %50 flowering and stem dry weight with 124.994days and 0.903g. Using 120kg/h seeding rate the highest value of the days to %50 flowering and days to maturity were exhibited 125.543 and 173.419days respectively. The highest value for most characters were reached as 140kg/h seed rate was used including the characters number of branch/ plant, leaf dry weight, stem dry weight, leaf stem ratio and number of bacterial nodules/plant recording 6.450, 2.062, 2.243g, 2.670 and 17.670 respectively. In contrast the lowest value for the character plant height reached 52.600 cm table 3c. Increasing crop seeding rates can hasten and increase resource use, and thereby reduce the negative effect of weeds when herbicide use is curtailed (Berkowitz, 1988, Mohler, 1996).

**Table (2a)** Effect of seeding rate on growth and forage characters of grass pea at Qlyasan locations and their average

| Qlyasan Location                      |                   |                      |                       |                  |                     |                     |                 |                                 |
|---------------------------------------|-------------------|----------------------|-----------------------|------------------|---------------------|---------------------|-----------------|---------------------------------|
| Seeding rate                          | Plant height (cm) | No. of branch/ plant | Days to %50 flowering | Days to maturity | Leaf dry weight (g) | Stem dry weight (g) | Leaf stem ratio | No. of bacterial nodules/ plant |
| 80kg/h                                | 51.910            | 4.858                | 130.680               | 171.660          | 0.603               | 0.640               | 0.643           | 14.075                          |
| 100Kg/h                               | 56.808            | 5.683                | 130.500               | 177.660          | 1.142               | 0.796               | 0.890           | 14.158                          |
| 120Kg/h                               | 52.267            | 6.183                | 130.870               | 181.230          | 1.089               | 1.393               | 0.486           | 14.476                          |
| 140kg/h                               | 47.294            | 6.925                | 131.820               | 177.760          | 1.138               | 1.522               | 1.349           | 17.225                          |
| <b>LSD (<math>p \leq 0.05</math>)</b> | <b>4.832</b>      | <b>7.32</b>          | <b>n.s</b>            | <b>n.s</b>       | <b>0.136</b>        | <b>0.251</b>        | <b>0.135</b>    | <b>0.877</b>                    |

n.s not significant

**Table (2b)** Effect of seeding rate on growth and forage characters of grass pea at Kanipanka locations and their average

| Kanipanka Location                    |                   |                     |                       |                  |                     |                     |                 |                                |
|---------------------------------------|-------------------|---------------------|-----------------------|------------------|---------------------|---------------------|-----------------|--------------------------------|
| Seeding rate                          | Plant height (cm) | No. of branch/plant | Days to %50 flowering | Days to maturity | Leaf dry weight (g) | Stem dry weight (g) | Leaf stem ratio | No. of bacterial nodules/plant |
| 80kg/h                                | 58.334            | 5.350               | 120.087               | 162.143          | 1.198               | 1.178               | 1.768           | 15.142                         |
| 100Kg/h                               | 61.208            | 5.325               | 119.493               | 158.953          | 2.291               | 1.009               | 2.638           | 16.350                         |
| 120Kg/h                               | 62.933            | 5.867               | 120.214               | 165.609          | 1.399               | 2.264               | 1.997           | 15.967                         |
| 140kg/h                               | 57.825            | 6.450               | 119.016               | 162.745          | 2.986               | 2.963               | 3.991           | 18.117                         |
| <b>LSD (<math>p \leq 0.05</math>)</b> | <b>6.179</b>      | <b>0.823</b>        | <b>0.882</b>          | <b>1.097</b>     | <b>0.307</b>        | <b>n.s</b>          | <b>1.206</b>    | <b>n.s</b>                     |

n.s not significant

**Table (2c)** Effect of seeding rate on growth and forage characters of grass pea at Average of both locations.

| Average of both Locations             |                   |                     |                       |                  |                     |                     |                 |                                |
|---------------------------------------|-------------------|---------------------|-----------------------|------------------|---------------------|---------------------|-----------------|--------------------------------|
| Seeding rate                          | Plant height (cm) | No. of branch/plant | Days to %50 flowering | Days to maturity | Leaf dry weight (g) | Stem dry weight (g) | Leaf stem ratio | No. of bacterial nodules/plant |
| 80kg/h                                | 55.910            | 5.100               | 125.384               | 166.901          | 0.901               | 0.909               | 1.205           | 14.610                         |
| 100Kg/h                               | 59.000            | 5.500               | 124.994               | 168.306          | 1.717               | 0.903               | 1.760           | 15.250                         |
| 120Kg/h                               | 57.600            | 5.860               | 125.543               | 173.419          | 1.244               | 1.393               | 1.241           | 15.220                         |
| 140kg/h                               | 52.600            | 6.450               | 125.415               | 170.252          | 2.062               | 2.243               | 2.670           | 17.670                         |
| <b>LSD (<math>p \leq 0.05</math>)</b> | <b>3.84</b>       | <b>0.54</b>         | <b>n.s</b>            | <b>n.s</b>       | <b>0.165</b>        | <b>0.329</b>        | <b>0.594</b>    | <b>0.635</b>                   |

n.s not significant

Data represent in Table 3a illustrate the interaction effect between lines and seeding rate on some growth and forage characters for grass pea at both locations. At Qlyasan location the interaction effect was highly significant for the plant height, days to %50 flowering, leaf dry weight, leaf stem ratio and number of bacterial nodules/plant, while it was significant for the character stem dry weight and not significant for the character number of branches/plant and days to maturity.

The highest value for the character plant height was 71.533cm produced by the interaction between line number 3 and 100kg/h. While the lowest value was 27.843 cm exhibited by the association between line number 1 and 140kg/h. Concerning to the character days to %50 flowering the values were restricted between 128.400 days for line number 4 coupled with 120 kg/h to 134.067 days for also line number 4 associated with 140 kg/h. Regarding to the character leaf dry weight the highest value was 1.767g produced by the interaction between variety number 2 under 120kg/h while the lowest value was 0.087g recorded by the association between line number 1 with 80 kg/h.

Concerning to the character stem dry weight the values ranged between 0.5g for the interaction between line number 3 with 80kg/h to 1.940g recorded by the interaction between line number 4 under 140kg/h. The maximum value for the character leaf stem ratio was 3.573 recorded by the association between line number 1 under 140kg/h, while the lowest value was 0.133 for the association between line number 4 under 120kg/h. The interaction between line numbers 3 under 140kg/h produced the highest value for this character number of bacterial nodules/plant was 19.633. But, the lowest recorded by line number 1 coupled with 80kg/h was 11.667. From the same table it was observed that the interaction effect between lines and seeding rates were highly significant for the days to %50 flowering, days to maturity, leaf dry weight and number of bacterial nodules/plant, while it was not significant for the rest at Kanipanka location. Regarding to the character days to %50 flowering the values restricted between 116.613days for the interaction between lines number 3 with 140kg/h to 121.250 days recorded by the interaction between line number 2 coupled with 120kg/h.

**Table (3a)** Effect of interaction between lines and seeding rates on some growth and forage characters for grass pea at Qlyasan Location

| Qlyasan Location                      |                         |                            |                             |                     |                              |                           |                       |                                      |
|---------------------------------------|-------------------------|----------------------------|-----------------------------|---------------------|------------------------------|---------------------------|-----------------------|--------------------------------------|
| Seeding rate<br>*Line                 | Plant<br>height<br>(cm) | No. of<br>branch/<br>plant | Days to<br>%50<br>flowering | Days to<br>maturity | Leaf<br>dry<br>weight<br>(g) | Stem dry<br>weight<br>(g) | Leaf<br>stem<br>ratio | No. of<br>bacterial<br>nodules/plant |
| L1.*80kg/h                            | 44.833                  | 4.230                      | 129.437                     | 176.023             | 0.087                        | 0.507                     | 0.790                 | 11.667                               |
| L1. *<br>100kg/h                      | 40.567                  | 5.300                      | 131.343                     | 175.860             | 0.723                        | 0.640                     | 1.733                 | 14.267                               |
| L1. *<br>120kg/h                      | 44.433                  | 6.630                      | 129.627                     | 180.510             | 0.837                        | 1.330                     | 0.927                 | 11.933                               |
| L1. *<br>140kg/h                      | 27.843                  | 7.067                      | 131.550                     | 176.690             | 1.133                        | 1.660                     | 3.573                 | 18.467                               |
| L2. * 80kg/h                          | 59.833                  | 5.200                      | 130.197                     | 182.173             | 0.460                        | 0.773                     | 0.603                 | 17.433                               |
| L2. *<br>100kg/h                      | 55.833                  | 5.667                      | 128.473                     | 179.140             | 1.160                        | 0.760                     | 0.823                 | 13.067                               |
| L2. *<br>120kg/h                      | 61.200                  | 6.600                      | 132.700                     | 182.013             | 1.767                        | 1.433                     | 0.577                 | 14.667                               |
| L2. *<br>140kg/h                      | 56.000                  | 6.867                      | 132.733                     | 177.713             | 1.123                        | 1.853                     | 0.980                 | 12.467                               |
| L3. * 80kg/h                          | 54.667                  | 5.900                      | 131.430                     | 181.490             | 0.937                        | 0.500                     | 0.560                 | 13.167                               |
| L3. *<br>100kg/h                      | 71.533                  | 5.860                      | 128.500                     | 176.730             | 1.083                        | 0.913                     | 0.693                 | 14.033                               |
| L3. *<br>120kg/h                      | 40.200                  | 6.230                      | 132.767                     | 180.877             | 0.923                        | 1.173                     | 0.310                 | 18.533                               |
| L3. *<br>140kg/h                      | 55.130                  | 6.460                      | 128.913                     | 175.727             | 0.727                        | 0.633                     | 0.403                 | 19.633                               |
| L4. * 80kg/h                          | 57.300                  | 4.100                      | 131.667                     | 146.937             | 0.927                        | 0.780                     | 0.617                 | 14.033                               |
| L4. *<br>100kg/h                      | 59.333                  | 5.900                      | 133.663                     | 178.897             | 1.600                        | 0.870                     | 0.310                 | 15.267                               |
| L4. *<br>120kg/h                      | 63.233                  | 5.260                      | 128.400                     | 181.504             | 0.830                        | 1.633                     | 0.133                 | 12.733                               |
| L4. *<br>140kg/h                      | 50.200                  | 7.300                      | 134.067                     | 180.920             | 1.567                        | 1.940                     | 0.440                 | 18.333                               |
| <b>LSD (<math>p \leq 0.05</math>)</b> | <b>9.664</b>            | <b>n.s</b>                 | <b>2.061</b>                | <b>n.s</b>          | <b>0.272</b>                 | <b>0.502</b>              | <b>0.27</b>           | <b>1.755</b>                         |

n.s not significant

Concerning to the character days to maturity the values restricted between 156.963 days recorded by the interaction line number 3 and 100 kg/h to 170.763 days for the interaction between line number 4 and 120kg/h. Maximum value for the character leaf dry weight was 3.623g recorded by the association between line number 1 coupled with 140kg/h, while the lowest values was 0.210g recorded by the association between line number 1 couple with 80kg/h. The maximum value for the character number of bacterial nodules/plant recorded 19.967 by the association line number 3 and 120kg/h while, the lowest was 13.00 by the interaction of line number 1 and 80kg/h.

The effect of the interaction between lines and seeding rates on growth and forage characters as the average of both locations represent in the table 4.3b. It was noticed that the interaction effect was highly significant for the characters days to %50 flowering, leaf dry weight, leaf stem ratio and number of bacterial nodules/plant, but for the rest it was not significant. The highest values for the characters days to %50 flowering, leaf dry weight were 127.260 days and 2.520g recorded by the interaction between line number 4 and 140kg/h, while the lowest values were 122.763days and 0.148g respectively recorded by the association line number 3 with 140kg/h for the character days to %50 flowering and line number 1 under 80kg/h for the character leaf dry weight respectively.

Concerning to the character leaf stem ratio the values were restricted between 0.483 for the interaction line 4 coupled with 120kg/h to 4.362 recorded by the interaction between line number 1 and coupled with 140kg/h. Regarding to the character number of bacterial nodules/plant the values ranged between 9.730 recorded by the interaction between line number 4 under 140kg/h to 19.80

recorded by the association of line number 3 and coupled with 120kg/h. Seeding rate is one of the elements that affect yield and growth. High plant population adversely affects development and plant growth, while suboptimal plant population results in high yield per plant but lower yield per unit area (Singh *et al.*, 1992). Results that describe yield response to plant population (Al-Rifaei *et al.*, 2004).

**Table (3b)** Effect of interaction between lines and seeding rates on some growth and forage characters for grass pea at Kanipanka locations.

| Kanipanka Location                    |                      |                            |                             |                     |                              |                           |                       |                                      |
|---------------------------------------|----------------------|----------------------------|-----------------------------|---------------------|------------------------------|---------------------------|-----------------------|--------------------------------------|
| Seeding rate<br>*Line                 | Plant height<br>(cm) | No. of<br>branch/<br>plant | Days to<br>%50<br>flowering | Days to<br>maturity | Leaf<br>dry<br>weight<br>(g) | Stem dry<br>weight<br>(g) | Leaf<br>stem<br>ratio | No. of<br>bacterial<br>nodules/plant |
| L1.*80kg/h                            | 58.930               | 5.733                      | 120.280                     | 157.570             | 0.210                        | 1.447                     | 0.417                 | 13.000                               |
| L1. *<br>100kg/h                      | 53.000               | 5.300                      | 118.403                     | 161.627             | 1.050                        | 0.557                     | 2.205                 | 16.167                               |
| L1. *<br>120kg/h                      | 58.930               | 5.530                      | 120.470                     | 157.890             | 1.220                        | 1.633                     | 1.776                 | 13.467                               |
| L1. *<br>140kg/h                      | 59.130               | 5.267                      | 119.387                     | 159.670             | 3.623                        | 2.177                     | 5.152                 | 19.833                               |
| L2. * 80kg/h                          | 59.830               | 5.267                      | 119.437                     | 167.263             | 0.853                        | 1.207                     | 1.084                 | 18.367                               |
| L2. *<br>100kg/h                      | 55.830               | 5.267                      | 120.450                     | 158.263             | 2.530                        | 0.880                     | 3.432                 | 14.267                               |
| L2. *<br>120kg/h                      | 61.200               | 5.833                      | 121.250                     | 165.820             | 1.923                        | 1.910                     | 3.232                 | 16.500                               |
| L2. *<br>140kg/h                      | 56.000               | 6.533                      | 119.610                     | 158.957             | 3.353                        | 3.100                     | 3.090                 | 14.600                               |
| L3. * 80kg/h                          | 52.580               | 5.600                      | 119.523                     | 162.890             | 1.833                        | 0.877                     | 2.822                 | 14.130                               |
| L3. *<br>100kg/h                      | 70.830               | 5.660                      | 120.447                     | 156.963             | 3.033                        | 1.383                     | 2.493                 | 17.500                               |
| L3. *<br>120kg/h                      | 61.170               | 6.630                      | 118.704                     | 167.963             | 1.393                        | 2.373                     | 2.145                 | 19.967                               |
| L3. *<br>140kg/h                      | 62.000               | 7.133                      | 116.613                     | 164.590             | 1.480                        | 3.063                     | 3.770                 | 19.000                               |
| L4. * 80kg/h                          | 62.000               | 4.800                      | 121.100                     | 160.847             | 1.897                        | 1.183                     | 2.749                 | 15.067                               |
| L4. *<br>100kg/h                      | 65.160               | 5.067                      | 118.673                     | 158.960             | 2.550                        | 1.217                     | 2.421                 | 17.467                               |
| L4. *<br>120kg/h                      | 70.430               | 5.467                      | 120.433                     | 170.763             | 1.060                        | 3.140                     | 0.834                 | 13.933                               |
| L4. *<br>140kg/h                      | 56.830               | 6.867                      | 120.453                     | 167.763             | 3.487                        | 3.513                     | 3.951                 | 19.030                               |
| <b>LSD (<math>p \leq 0.05</math>)</b> | <b>n.s</b>           | <b>n.s</b>                 | <b>1.764</b>                | <b>2.195</b>        | <b>0.615</b>                 | <b>n.s</b>                | <b>n.s</b>            | <b>1.911</b>                         |

n.s not significant

**Table (3c)** Effect of interaction between lines and seeding rates on some growth and forage characters for grass pea at Average of both locations

| Average of both Locations |                   |                     |                       |                  |                     |                     |                 |                                |
|---------------------------|-------------------|---------------------|-----------------------|------------------|---------------------|---------------------|-----------------|--------------------------------|
| Seeding rate *Line        | Plant height (cm) | No. of branch/plant | Days to %50 flowering | Days to maturity | Leaf dry weight (g) | Stem dry weight (g) | Leaf stem ratio | No. of bacterial nodules/plant |
| L1.*80kg/h                | 51.880            | 4.980               | 124.860               | 166.790          | 0.148               | 0.977               | 0.603           | 12.330                         |
| L1. * 100kg/h             | 46.780            | 5.300               | 124.873               | 168.740          | 0.880               | 0.598               | 1.696           | 15.210                         |
| L1. * 120kg/h             | 51.681            | 6.080               | 125.048               | 169.200          | 1.028               | 1.480               | 1.351           | 12.700                         |
| L1. * 140kg/h             | 43.480            | 6.167               | 125.468               | 168.180          | 2.370               | 1.910               | 4.362           | 19.150                         |
| L2. * 80kg/h              | 59.830            | 5.230               | 124.817               | 174.718          | 0.650               | 0.990               | 0.843           | 15.170                         |
| L2. * 100kg/h             | 55.831            | 5.467               | 124.461               | 168.701          | 1.840               | 0.820               | 2.127           | 14.460                         |
| L2. * 120kg/h             | 61.200            | 6.210               | 126.970               | 173.910          | 1.845               | 1.670               | 1.904           | 14.480                         |
| L2. * 140kg/h             | 56.000            | 6.700               | 126.171               | 168.335          | 2.230               | 2.470               | 2.035           | 13.880                         |
| L3. * 80kg/h              | 53.620            | 5.750               | 125.476               | 172.190          | 1.380               | 0.870               | 1.691           | 14.080                         |
| L3. * 100kg/h             | 71.181            | 5.760               | 124.473               | 166.840          | 2.050               | 1.148               | 1.593           | 18.010                         |
| L3. * 120kg/h             | 50.685            | 6.430               | 125.735               | 174.420          | 1.150               | 1.770               | 1.227           | 19.800                         |
| L3. * 140kg/h             | 58.560            | 6.790               | 122.763               | 170.150          | 1.103               | 1.840               | 2.086           | 16.510                         |
| L4. * 80kg/h              | 59.650            | 4.450               | 126.383               | 153.892          | 1.412               | 0.980               | 1.680           | 15.160                         |
| L4. * 100kg/h             | 62.240            | 5.483               | 126.168               | 168.928          | 2.070               | 1.040               | 1.360           | 15.100                         |
| L4. * 120kg/h             | 66.830            | 5.363               | 124.410               | 176.133          | 0.940               | 2.380               | 0.483           | 16.130                         |
| L4. * 140kg/h             | 53.515            | 7.080               | 127.260               | 174.341          | 2.520               | 2.720               | 2.195           | 9.730                          |
| <b>LSD (p&lt;0.05)</b>    | <b>n.s</b>        | <b>n.s</b>          | <b>1.328</b>          | <b>n.s</b>       | <b>0.437</b>        | <b>n.s</b>          | <b>1.189</b>    | <b>1.271</b>                   |

n.s not significant

Data in Table 4; illustrate the effect of locations on growth and forage characters of grass pea the effect of locations was highly significant for the characters days to maturity, leaf dry weight, stem dry weight, leaf stem ratio and number of bacterial nodules/plant, while it was significant for the character plant height and not significant for the rest. It was observed from this table the exceeding second location for most characters compared to the first location reached 15.36, 98.990, 71.29, 209.500 and 9.4% for the characters plant height, leaf dry weight, stem dry weight, leaf stem ratio and number of bacterial nodules/plant respectively. But regarding the character days to maturity, Qlyasan location predominated Kanipanka location by 9.259%. These results confirm the suitability of the second location to grow this crop compare to first location.

**Table (4)** Effect of locations on some growth and forage characters of grass pea.

| Locations                             | Plant height (cm) | No. of branch/plant | Days to %50 flowering | Days to maturity | Leaf dry weight (g) | Stem dry weight (g) | Leaf stem ratio | No. of bacterial nodules/plant |
|---------------------------------------|-------------------|---------------------|-----------------------|------------------|---------------------|---------------------|-----------------|--------------------------------|
| Qlyasan                               | 52.080            | 5.910               | 131.000               | 177.000          | 0.990               | 1.080               | 0.840           | 14.980                         |
| Kanipanka                             | 60.080            | 5.740               | 119.703               | 162.000          | 1.970               | 1.850               | 2.600           | 16.390                         |
| <b>LSD (<math>p \leq 0.05</math>)</b> | <b>7.34</b>       | <b>n.s</b>          | <b>n.s</b>            | <b>5.69</b>      | <b>0.153</b>        | <b>0.45</b>         | <b>0.943</b>    | <b>0.422</b>                   |

n.s not significant

Data represent in Table 5a and Appendix 2 illustrate the averages of seed yield and it is components for grass pea at both locations and their average due to genotypes. At Qlyasan location the differences among lines were highly significant for the characters 100 seed weight, seed yield, biological yield and harvest index, while it was significant for the number of pods/plant and not significant for the rest. At Knipanka location the differences among lines were highly significant 100 seed weight, seed yield, biological yield and harvest index only and not significant for the rest. As the average of both locations the difference among lines were highly significant for all characters except Weight of seeds/pod(g) was significant but pod length and number of seeds/ pod were not significant.

At Qlyasan location line number 2 produced maximum values for the number of seeds/pod, seed yield and harvest index recording 3.260 pod, 5712.721kg/h and 0.457 respectively. Line number 3 recorded the highest value for pod length, 100 seed weight and biological yield producing 3.258cm, 12.790g and 14232.150kg/h respectively. The highest values for the character number of pods/plant and Weight of seeds/pod (g) were 33.400 pods 0.490g respectively, for line number 4. The lowest value for the characters 100 seed weight, seed yield and harvest index were 9.503, 3519.466 kg/h and 0.290 recorded by line number 4. Line number 1 recorded the lowest value for the number of seeds/pod and biological yield with 30.200 and 11437.360 respectively. The character number of seeds/pod and Weight of seeds/pod (g) indicated minimum value with 2.883 and 0.373 respectively and the lowest value due to the character pod length was 3.035. At Kanipanka location the highest value due to the number of seeds/pod seed weight, seed yield, biological yield and harvest index were 3.411, 12.240, 1.023, 15472.981 and 0.509 respectively exhibited by line number 3. Line number 4 recorded the lowest value for pod length, seed yield, biological yield and harvest index with 3.321 cm, 4894.647 kg/h, 14352.633 kg/h and 0.340 respectively. The lowest value for the number of pods/plant, number of seeds/pod Weight of seeds/pod (g) and 100 seed weight were 31.502, 3.068g, and 8.881 respectively recorded by line number 1 table 5b. As the average of both locations line number 3 recorded the highest value for the characters 100 seed weight, seed yield, biological yield and harvest index reached 12.520, 6243.940 kg/h, 14852.560 kg/h and 0.427 respectively.

Maximum value for number of pods/plant, number of seeds/pod and Weight of seeds/pod (g) were 33.710, 3.206 and 0.480 g recorded by line number 4 respectively. But minimum pod length was obtained by variety number 1. The lowest value for the characters number of pods/plant, number of seeds/pod, Weight of seeds/pod (g), 100 seed weight and biological yield were 30.850, 0.355 g, 9.296 and 12895.690 kg/h respectively recorded by line number 1, while line number 4 produced minimum values for the characters pod length, seed yield and harvest index with 3.248cm, 4207.146 kg/h and 0.315 respectively. Table 5c. Results indicated that as plant population increases, lower harvest index obtained. This could be due to the increase in biological yield as the number of plants per unit area increased with no significant increases in seed yield leads to lower harvest indexes. With results of (Dantuma, 1983) high plant population preferable early full canopy development and increased light interception (Al-Rifae *et al.*, 2004). Agung and McDonald (1998) who revealed that for any given cultivar, the average number of seeds/pod is a relatively stable character.

**Table (5a)** Means of seed yield and its components of grass pea lines at Qlyasan locations their average

| Qlyasan Location                |                    |                 |                   |                         |                    |                  |                          |               |
|---------------------------------|--------------------|-----------------|-------------------|-------------------------|--------------------|------------------|--------------------------|---------------|
| Line                            | No. of pods /plant | Pod length (cm) | No. of seeds/ pod | Weight of seeds/pod (g) | 100 seed weight(g) | Seed yield kg /h | Biological yield( kg/ h) | Harvest index |
| L.1                             | 30.200             | 3.189           | 2.955             | 0.390                   | 9.710              | 5097.847         | 11437.360                | 0.417         |
| L.2                             | 31.800             | 3.035           | 3.260             | 0.433                   | 10.100             | 5712.721         | 11804.130                | 0.457         |
| L.3                             | 31.900             | 3.258           | 2.883             | 0.373                   | 12.790             | 4816.856         | 14232.150                | 0.344         |
| L.4                             | 33.400             | 3.175           | 3.109             | 0.490                   | 9.503              | 3519.466         | 12185.970                | 0.290         |
| <b>LSD</b><br>( $p \leq 0.05$ ) | <b>1.974</b>       | <b>n.s</b>      | <b>n.s</b>        | <b>n.s</b>              | <b>0.623</b>       | <b>358.47</b>    | <b>726.768</b>           | <b>0.039</b>  |

n.s not significant

**Table (5b)** Means of seed yield and its components of grass pea lines at Kanipanka locations and their average

| Kanipanka Location              |                    |                 |                   |                         |                    |                  |                          |               |
|---------------------------------|--------------------|-----------------|-------------------|-------------------------|--------------------|------------------|--------------------------|---------------|
| Line                            | No. of pods /plant | Pod length (cm) | No. of seeds/ pod | Weight of seeds/pod (g) | 100 seed weight(g) | Seed yield kg /h | Biological yield( kg/ h) | Harvest index |
| L.1                             | 31.502             | 3.443           | 3.068             | 0.319                   | 8.881              | 5667.014         | 14354.027                | 0.395         |
| L.2                             | 33.001             | 3.566           | 3.146             | 0.392                   | 9.301              | 4983.554         | 14637.460                | 0.345         |
| L.3                             | 32.904             | 3.356           | 3.411             | 0.420                   | 12.240             | 7671.023         | 15472.981                | 0.509         |
| L.4                             | 34.070             | 3.321           | 3.303             | 0.470                   | 9.123              | 4894.647         | 14352.633                | 0.340         |
| <b>LSD</b><br>( $p \leq 0.05$ ) | <b>n.s</b>         | <b>n.s</b>      | <b>n.s</b>        | <b>n.s</b>              | <b>0.707</b>       | <b>480.886</b>   | <b>531.86</b>            | <b>0.37</b>   |

n.s not Significant

**Table (5c)** Means of seed yield and its components of grass pea lines at both locations and their average

| Average of both Locations       |                    |                 |                   |                         |                    |                  |                          |               |
|---------------------------------|--------------------|-----------------|-------------------|-------------------------|--------------------|------------------|--------------------------|---------------|
| Line                            | No. of pods /plant | Pod length (cm) | No. of seeds/ pod | Weight of seeds/pod (g) | 100 seed weight(g) | Seed yield kg /h | Biological yield( kg/ h) | Harvest index |
| L.1                             | 30.850             | 3.316           | 3.011             | 0.355                   | 9.296              | 5382.430         | 12895.690                | 0.406         |
| L.2                             | 32.400             | 3.300           | 3.203             | 0.413                   | 9.700              | 5348.137         | 13220.790                | 0.401         |
| L.3                             | 32.390             | 3.307           | 3.147             | 0.396                   | 12.520             | 6243.940         | 14852.560                | 0.427         |
| L.4                             | 33.710             | 3.248           | 3.206             | 0.480                   | 9.313              | 4207.146         | 13269.300                | 0.315         |
| <b>LSD</b><br>( $p \leq 0.05$ ) | <b>1.941</b>       | <b>n.s</b>      | <b>n.s</b>        | <b>0.074</b>            | <b>0.461</b>       | <b>293.728</b>   | <b>441.035</b>           | <b>0.026</b>  |

n.s not significant

Data in Table 6a explain the effect of seeding rate on seed yield and its components for grass pea at both locations and their average. At Qlyasan location the characters seed yield, biological yield and harvest index responded high significantly to the effect of seeding rate, also at Knipanka location were high significant difference among the characters seed yield and biological yield observed by effecting of seeding rate while as the average of both locations the effect of seeding rate was highly significant for all characters except 100 seed weight which was significant and not significant for the rest. The application of 80kg/h produced the highest value for the character harvest index at both locations with 0.420. Maximum value of seed yield and biological yield at Knipanka locations recorded by the application of 140 kg with 7037.310kg/h and 15428.200kg/h respectively at the first location and 7341.477 kg/h and 19094.823 kg/h respectively at the second location. As the average of both locations using 140 kg/h seeds produced maximum values for the number of pods/plant, weight of seed/pod, seed yield biological yield and harvest index with 33.940, 0.462g, 6864.39 kg/h 3, 17261.489 and 0.426 respectively, while the lowest value for the number of pods/plant, 100 seed weight, seed yield, biological yield and harvest index recorded by the application of 80 kg/h with

31.220, 9.983g, 3166.305kg/h, 8703.368kg/h and 0.357 respectively. Crop yield is commonly proportional to total biomass production (Pilbeam *et al.*, 1992, Loss and Siddique, 1997). Concerning the effect of plant population on biological yield the higher plant populations of 100 and 150 plants/m produced the greater amounts of biomass table 6c. This could be attributed to the increase in the number of plants per unit area, and the associated increase in plant height. Similar results were reported by Castro Coelho and Aguiar Pinto (1989), who observed that at the final harvest, the dry matter yield of above-ground parts increased with increasing plant population.

**Table (6a)** Effect of seeding rates on seed yield and its components of grass pea at Qlyasan locations and their average

| Qlyasan Location                  |                    |                 |                   |                         |                    |                    |                           |               |
|-----------------------------------|--------------------|-----------------|-------------------|-------------------------|--------------------|--------------------|---------------------------|---------------|
| seeding rate plant/m <sup>2</sup> | No. of pods /plant | Pod length (cm) | No. of seeds/ pod | Weight of seeds/pod (g) | 100 seed weight(g) | Seed yield (kg /h) | Biological yield ( kg/ h) | Harvest index |
| 80kg/h                            | 30.810             | 3.275           | 3.065             | 0.445                   | 10.480             | 2329.640           | 7832.951                  | 0.294         |
| 100Kg/h                           | 31.960             | 3.065           | 3.038             | 0.388                   | 10.460             | 4260.705           | 12300.130                 | 0.350         |
| 120Kg/h                           | 31.180             | 3.110           | 3.162             | 0.403                   | 10.980             | 5519.420           | 14098.355                 | 0.399         |
| 140kg/h                           | 33.270             | 3.206           | 2.942             | 0.450                   | 10.170             | 7037.310           | 15428.200                 | 0.466         |
| <b>LSD (p≤0.05)</b>               | <b>n.s</b>         | <b>n.s</b>      | <b>n.s</b>        | <b>n.s</b>              | <b>n.s</b>         | <b>358.47</b>      | <b>726.768</b>            | <b>0.039</b>  |

n.s not significant

**Table (6b)** Effect of seeding rates on seed yield and its components of grass pea at Kanipanka locations and their average

| Kanipanka Location                |                    |                 |                   |                         |                    |                    |                           |               |
|-----------------------------------|--------------------|-----------------|-------------------|-------------------------|--------------------|--------------------|---------------------------|---------------|
| seeding rate plant/m <sup>2</sup> | No. of pods /plant | Pod length (cm) | No. of seeds/ pod | Weight of seeds/pod (g) | 100 seed weight(g) | Seed yield (kg /h) | Biological yield ( kg/ h) | Harvest index |
| 80kg/h                            | 31.630             | 3.447           | 3.152             | 0.404                   | 9.484              | 4002.972           | 9573.785                  | 0.420         |
| 100Kg/h                           | 32.940             | 3.222           | 3.165             | 0.368                   | 9.949              | 5360.705           | 13716.805                 | 0.389         |
| 120Kg/h                           | 32.280             | 3.576           | 3.314             | 0.355                   | 10.220             | 6511.085           | 16431.688                 | 0.394         |
| 140kg/h                           | 34.610             | 3.441           | 3.296             | 0.474                   | 9.893              | 7341.477           | 19094.823                 | 0.385         |
| <b>LSD (p≤0.05)</b>               | <b>n.s</b>         | <b>0.43</b>     | <b>n.s</b>        | <b>n.s</b>              | <b>n.s</b>         | <b>454.115</b>     | <b>531.86</b>             | <b>0.37</b>   |

n.s not significant

**Table (6c)** Effect of seeding rates on seed yield and its components of grass pea at Average of both locations

| Average of both Locations         |                    |                 |                   |                         |                    |                    |                           |               |
|-----------------------------------|--------------------|-----------------|-------------------|-------------------------|--------------------|--------------------|---------------------------|---------------|
| seeding rate plant/m <sup>2</sup> | No. of pods /plant | Pod length (cm) | No. of seeds/ pod | Weight of seeds/pod (g) | 100 seed weight(g) | Seed yield (kg /h) | Biological yield ( kg/ h) | Harvest index |
| 80kg/h                            | 31.220             | 3.360           | 3.108             | 0.425                   | 9.983              | 3166.305           | 8703.368                  | 0.357         |
| 100kg/h                           | 32.440             | 3.140           | 3.101             | 0.378                   | 10.205             | 4810.705           | 13008.472                 | 0.370         |
| 120Kg/h                           | 31.730             | 3.340           | 3.230             | 0.379                   | 10.605             | 6015.251           | 15265.022                 | 0.396         |
| 140kg/h                           | 33.940             | 3.323           | 3.118             | 0.462                   | 10.033             | 6864.393           | 17261.489                 | 0.426         |
| <b>LSD (p≤0.05)</b>               | <b>1.941</b>       | <b>n.s</b>      | <b>n.s</b>        | <b>n.s</b>              | <b>0.461</b>       | <b>529.472</b>     | <b>441.035</b>            | <b>0.26</b>   |

n.s not significant

Data represent in Table 7a illustrate the effect of the interaction between lines and seeding rates and seed yield and its components for grass pea at both locations and their average. At Qlyasan location the characters 100 seed weight, seed yield, biological yield and harvest index respond high significantly this effect while the character number of pods/plant respond significantly to this effect and not significant to the rest. The highest value for the number of pods/plant was 35.680 recorded by the interaction of line number 4 with the application of 100 kg/h. The highest value for the character No. of pods /plant 100 seed weight, seed yield, biological yield and harvest index were 35680g, 13.350g, 9153.597 kg/h, 18550.908 and 0.631 recorded by the interaction of line number 4 with 100 kg/h, line number 3 with 120 kg/h, line number 2 with 140kg/h line number 1 with 140 kg/h and line number 3 with 140kg/h respectively. The lowest value of the number of pods/plant, seed

yield, biological yield and harvest index were 27.070, 1540.080, 7083.940 and 0.226 recorded by the interaction of line number 1 with 80 kg/h but the lowest value of 100 seed weight was 8.083g recorded by interaction between line numbers 4 with 80kg/h.

At Kanipanka location the interaction effect was significant for the character number of pods/plant, seed yield and biological yield, but highly significant for the character harvest index and not significant for the rest. The highest value due to the character number of pods/plant, seed yield, biological yield and harvest index were 36.990, 9340.880 kg/h, 19550.908 kg/h and 0.613 recorded by the interaction of line number 4 with 100 kg/h, line number 3 with 140kg/h and line number 3 with 80kg/h respectively, but the lowest value for the character number of pods/plant was 28.720 recorded by the interaction line number 1 coupled with 120 kg/h and for the character harvest index it was 0.299 recorded by the interaction of line of line number 4 coupled with 100kg/h seeds, and the lowest value for seed yield and biological yield were 3316.273kg/h exhibited by the interaction line number 1 with 80kg/h table8b .

The interaction between lines and seeding rates as the average of both locations represent in the table 8 This effect was highly significant for the character number of pods/plant, Weight of seeds/pod (g), seed yield biological yield and harvest index but it was not significant for the rest .The highest value for the character number of pods/plant was 36.340 recorded by the interaction between line number 4 with the application of 100 kg/h, while for the character Weight of seeds/pod (g) the highest value was 0.610g recorded by the interaction of line number 2 under 140 kg/h. Maximum value for the characters seed yield and biological yield was 7849.210 and 19050.910 kg/h recorded by the interaction line number 3 with using 140kg/h. The highest value for the character harvest index was 0.500 produced by the interaction between line number 3 and 80kg/h seeds. The lowest value for the number of pods/plant, seed yield and biological yield were 28.030, 2428.410 kg/h, and 8250.610 recorded by the interaction between line number 4 coupled with using 100 kg/h but the lowest value for harvest index was 0.280 recorded by line number 4 with 100kg/h table 7c. Plant populations had significant effect on harvest indexes.

**Table (7a)** Effect of interactions of lines and seeding rates on seed yield and its components of grass pea at Qlyasan location

| Qlyasan Location                      |                    |                 |                   |                        |                     |                    |                           |               |
|---------------------------------------|--------------------|-----------------|-------------------|------------------------|---------------------|--------------------|---------------------------|---------------|
| Seeding rate *Line                    | No. of pods /plant | Pod length (cm) | No. of seeds/ pod | Weight of seeds/pod(g) | 100 seed weight (g) | Seed yield (kg /h) | Biological yield ( kg/ h) | Harvest index |
| L1.*80kg/h                            | 27.070             | 3.127           | 3.060             | 0.280                  | 10.565              | 1540.080           | 7083.940                  | 0.220         |
| L1. * 100kg/h                         | 32.067             | 3.063           | 2.940             | 0.387                  | 9.673               | 4545.177           | 11611.267                 | 0.391         |
| L1. * 120kg/h                         | 28.470             | 3.240           | 3.070             | 0.537                  | 8.687               | 6284.577           | 13035.383                 | 0.484         |
| L1. * 140kg/h                         | 33.187             | 3.327           | 2.740             | 0.357                  | 9.917               | 8021.557           | 14018.850                 | 0.574         |
| L2. * 80kg/h                          | 31.990             | 3.540           | 3.140             | 0.530                  | 10.580              | 2007.557           | 7627.721                  | 0.264         |
| L2. * 100kg/h                         | 32.260             | 2.733           | 3.240             | 0.323                  | 10.600              | 4725.873           | 11847.850                 | 0.403         |
| L2. * 120kg/h                         | 28.920             | 2.833           | 3.330             | 0.267                  | 10.89               | 6963.857           | 13214.610                 | 0.528         |
| L2. * 140kg/h                         | 33.980             | 3.033           | 3.320             | 0.613                  | 8.320               | 9153.597           | 14526.327                 | 0.631         |
| L3. * 80kg/h                          | 31.840             | 3.330           | 2.030             | 0.410                  | 12.69               | 3311.420           | 8531.726                  | 0.384         |
| L3. * 100kg/h                         | 27.820             | 3.133           | 2.680             | 0.413                  | 12.980              | 4305.537           | 12905.514                 | 0.335         |
| L3. * 120kg/h                         | 33.403             | 3.330           | 2.980             | 0.327                  | 13.350              | 5292.923           | 16940.443                 | 0.315         |
| L3. * 140kg/h                         | 34.44              | 3.233           | 2.820             | 0.340                  | 12.110              | 6357.547           | 18550.908                 | 0.343         |
| L4. * 80kg/h                          | 32.330             | 3.100           | 3.023             | 0.560                  | 8.083               | 2459.497           | 8088.419                  | 0.308         |
| L4. * 100kg/h                         | 35.680             | 3.330           | 3.283             | 0.430                  | 8.583               | 3466.233           | 12835.923                 | 0.270         |
| L4. * 120kg/h                         | 33.920             | 3.033           | 3.257             | 0.483                  | 11.013              | 3536.317           | 13202.983                 | 0.268         |
| L4. * 140kg/h                         | 31.470             | 3.233           | 2.873             | 0.490                  | 10.333              | 4616.540           | 14616.540                 | 0.315         |
| <b>LSD (<math>p \leq 0.05</math>)</b> | <b>3.948</b>       | <b>n.s</b>      | <b>n.s</b>        | <b>n.s</b>             | <b>1.245</b>        | <b>716.94</b>      | <b>1453.537</b>           | <b>0.077</b>  |

n.s not significant

**Table (7b)** Effect of interactions of lines and seeding rates on seed yield and its components of grass pea at Kanipanka location

| Kanipanka Location                    |                    |                 |                   |                         |                     |                    |                           |               |
|---------------------------------------|--------------------|-----------------|-------------------|-------------------------|---------------------|--------------------|---------------------------|---------------|
| Seeding rate *Line                    | No. of pods /plant | Pod length (cm) | No. of seeds/ pod | Weight of seeds/pod (g) | 100 seed weight (g) | Seed yield (kg /h) | Biological yield ( kg/ h) | Harvest index |
| L1.*80kg/h                            | 28.987             | 3.710           | 2.667             | 0.303                   | 7.860               | 3316.747           | 9417.273                  | 0.353         |
| L1. * 100kg/h                         | 32.770             | 3.113           | 3.220             | 0.287                   | 9.183               | 6211.843           | 13277.933                 | 0.468         |
| L1. * 120kg/h                         | 28.720             | 3.643           | 3.067             | 0.32                    | 9.847               | 5951.243           | 16035.383                 | 0.371         |
| L1. * 140kg/h                         | 35.510             | 3.303           | 3.317             | 0.367                   | 8.630               | 7188.223           | 18685.517                 | 0.385         |
| L2. * 80kg/h                          | 32.110             | 3.403           | 3.357             | 0.363                   | 8.523               | 3490.890           | 9627.721                  | 0.365         |
| L2. * 100kg/h                         | 32.630             | 3.307           | 2.977             | 0.323                   | 9.347               | 4292.540           | 12847.850                 | 0.336         |
| L2. * 120kg/h                         | 31.880             | 3.877           | 3.217             | 0.267                   | 9.437               | 5930.523           | 16547.943                 | 0.360         |
| L2. * 140kg/h                         | 35.370             | 3.677           | 3.0330            | 0.613                   | 9.897               | 6220.263           | 19526.327                 | 0.319         |
| L3. * 80kg/h                          | 33.027             | 3.003           | 3.513             | 0.407                   | 11.770              | 5811.420           | 9495.059                  | 0.613         |
| L3. * 100kg/h                         | 29.350             | 3.297           | 3.220             | 0.423                   | 12.407              | 6905.537           | 15238.847                 | 0.454         |
| L3. * 120kg/h                         | 34.107             | 3.550           | 3.513             | 0.423                   | 12.247              | 8626.257           | 17607.110                 | 0.490         |
| L3. * 140kg/h                         | 35.130             | 3.573           | 3.397             | 0.427                   | 12.547              | 9340.880           | 19550.908                 | 0.478         |
| L4. * 80kg/h                          | 32.410             | 3.670           | 3.070             | 0.543                   | 9.773               | 3392.830           | 9755.0860                 | 0.349         |
| L4. * 100kg/h                         | 36.990             | 3.170           | 3.243             | 0.437                   | 8.860               | 4032.900           | 13502.589                 | 0.299         |
| L4. * 120kg/h                         | 34.440             | 3.233           | 3.460             | 0.410                   | 9.357               | 5536.317           | 15536.317                 | 0.356         |
| L4. * 140kg/h                         | 32.440             | 3.21            | 3.437             | 0.490                   | 8.550               | 6616.540           | 18616.540                 | 0.356         |
| <b>LSD (<math>p \leq 0.05</math>)</b> | <b>4.635</b>       | <b>n.s</b>      | <b>n.s</b>        | <b>n.s</b>              | <b>n.s</b>          | <b>961772</b>      | <b>1063.719</b>           | <b>0.34</b>   |

n.s not significant

**Table ( 7c)** Effect of interactions of lines and seeding rates on seed yield and its components of grass pea Average of both locations

| Average of both Locations             |                    |                 |                   |                        |                    |                    |                           |               |
|---------------------------------------|--------------------|-----------------|-------------------|------------------------|--------------------|--------------------|---------------------------|---------------|
| Seeding rate *Line                    | No. of pods /plant | Pod length (cm) | No. of seeds/ pod | Weight of seeds/pod(g) | 100 seed weight(g) | Seed yield (kg /h) | Biological yield ( kg/ h) | Harvest index |
| L1.*80kg/h                            | 28.030             | 3.420           | 2.860             | 0.290                  | 9.210              | 2428.410           | 8250.610                  | 0.290         |
| L1. * 100kg/h                         | 32.420             | 3.090           | 3.080             | 0.340                  | 9.430              | 5378.510           | 12444.600                 | 0.430         |
| L1. * 120kg/h                         | 28.600             | 3.440           | 3.070             | 0.430                  | 9.270              | 6117.910           | 14535.380                 | 0.430         |
| L1. * 140kg/h                         | 34.350             | 3.320           | 3.030             | 0.360                  | 9.270              | 6304.890           | 16352.180                 | 0.480         |
| L2. * 80kg/h                          | 32.050             | 3.470           | 3.250             | 0.450                  | 9.550              | 2749.220           | 8627.720                  | 0.310         |
| L2. * 100kg/h                         | 32.450             | 3.020           | 3.110             | 0.320                  | 9.970              | 4509.210           | 12347.850                 | 0.370         |
| L2. * 120kg/h                         | 30.410             | 3.360           | 3.270             | 0.270                  | 10.170             | 6447.190           | 14881.280                 | 0.440         |
| L2. * 140kg/h                         | 34.680             | 3.360           | 3.180             | 0.610                  | 9.110              | 7686.930           | 17026.330                 | 0.470         |
| L3. * 80kg/h                          | 32.440             | 3.170           | 3.280             | 0.410                  | 12.240             | 4561.420           | 9013.390                  | 0.500         |
| L3. * 100kg/h                         | 28.590             | 3.220           | 2.950             | 0.420                  | 12.700             | 5605.540           | 14072.180                 | 0.390         |
| L3. * 120kg/h                         | 33.760             | 3.440           | 3.250             | 0.380                  | 12.800             | 6959.590           | 17273.780                 | 0.400         |
| L3. * 140kg/h                         | 34.790             | 3.400           | 3.110             | 0.380                  | 12.330             | 7849.210           | 19050.910                 | 0.410         |
| L4. * 80kg/h                          | 32.370             | 3.390           | 3.050             | 0.550                  | 8.930              | 2926.160           | 8921.750                  | 0.330         |
| L4. * 100kg/h                         | 36.340             | 3.250           | 3.260             | 0.430                  | 8.720              | 3749.570           | 13169.260                 | 0.280         |
| L4. * 120kg/h                         | 34.180             | 3.130           | 3.360             | 0.450                  | 10.190             | 4536.320           | 14369.650                 | 0.310         |
| L4. * 140kg/h                         | 31.960             | 3.220           | 3.160             | 0.490                  | 9.420              | 5616.540           | 16616.540                 | 0.340         |
| <b>LSD (<math>p \leq 0.05</math>)</b> | <b>2.980</b>       | <b>n.s</b>      | <b>n.s</b>        | <b>0.074</b>           | <b>n.s</b>         | <b>1058.945</b>    | <b>882.069</b>            | <b>0.052</b>  |

n.s not significant

Data in Table 8 illustrate the effect of locations on seed yield and its components of grass pea. This effect was highly significant for the number of pods/plant, 100 seed weight, seed yield and biological yield, but it was not significant for the rest. It was observed that the values recorded for the number of pods/plant, seed yield and biological yield at second location exceeded first location significantly by 3.332, 21.252 and 18.44% respectively. The first location exceeded second location for the character 100 seed weight by 6.53%. These results confirm the suitability of the second location for growing this plant compare to the first location

**Table (8)** Effect of locations on seed yield and its components of grass pea

| Locations                       | No. of pods /plant | Pod length (cm) | No. of seeds/ pod | Weight of seeds/pod(g) | 100 seed weight(g) | Seed yield (kg /h) | Biological yield(kg/h) | Harvest index |
|---------------------------------|--------------------|-----------------|-------------------|------------------------|--------------------|--------------------|------------------------|---------------|
| Qlyasan                         | 31.810             | 3.164           | 3.052             | 0.421                  | 10.525             | 4786.768           | 12414.900              | 0.377         |
| Kanipanka                       | 32.870             | 3.420           | 3.230             | 0.400                  | 9.880              | 5804.059           | 14704.275              | 0.397         |
| <b>LSD</b><br>( $p \leq 0.05$ ) | <b>0.681</b>       | <b>n.s</b>      | <b>n.s</b>        | <b>n.s</b>             | <b>0.681</b>       | <b>636.853</b>     | <b>46.942</b>          | <b>n.s</b>    |

n.s not significant

## CONCLUSION AND RECOMMENDATION

Significant differences among Lines due to most studied characters was observed, the variation of Lines performance was largely associated with climatically conditions and genetic variation existed among Lines at each location. Thus, Lines should be carefully selected for corresponding regions depending mainly on seasonal weather conditions. Increasing yield at high density can be directly attributes to large populations, and strong relationship between seed yield and plant population densities. Also It was observed that Kanipanka location is more suitable to grow this plant compare to the other location. Concluding further project is necessary on these two species under different plant population at different environmental condition. Depending on our result It can be recommended Line number (3) IF102 of grass pea under the highest plant population using 140 kg/h for planting at both locations. Kanipanka location is more suitable for growing both forage crops and seed yield compare to Qlyasan location

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### تأثير معدل البذار والموقع على بعض خطوط الهريطمان في النمو والحاصل ومكوناته لبعض التراكيب الوراثية للهريطمان *Lathyrus sativus* في منطقة السليمانية

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قسم بايو تكنولوجي والمحاصيل الحقلية - كلية علوم هندسة الزراعة في جامعة السليمانية في إقليم كردستان

#### المستخلص

اجريت هذه الدراسة في موقعين مختلفين بمحافظة السليمانية و هما قلياسان و كاننيانكا خلال الموسم الشتوي 2017-2018 بهدف تقييم استجابة اربعة خطوط من الهريطمان (IF003, IF133, IF102, IF067) تحت تأثير اربعة معدلات من بذار (80 كغم/هكتار، 100 كغم/هكتار، 120 كغم/هكتار، 140 كغم/هكتار) لمعرفة تأثير ما على نمو وحاصل البذور. زرعت التجربة في 5 كانون اول/ 2017 كاننيانكا و 6 كانون اول/ 2017 في قلياسان، وفقا لتصميم القطاعات العشوائية الكاملة RCBD بثلاث مكررات، قورنت المتوسطات حسب اختبار أقل فرق معنوي (L.S.D) تحت مستوى 5،0، فيما يخص خطوط الهريطمان كمعدل للموقعين، وجد بأن تأثير التفاعل بين خطوط مع معدل البذار كان عالي المعنوية للصفات عدد الأيام اللازمة الى 50% تزهير، وزن الاوراق الجاف، نسبة الأوراق الى السيقان وعدد العقد البكتيرية للنبات. أعلى القيم للصفات عدد الأيام اللازمة الى 50% تزهير ووزن الاوراق الجاف كانت 127,260 و 2,520 غم سجلت بين التفاعل خط رقم IF067 مع 140 كغم بذور/هكتار. تأثير المواقع على النمو والعلف كانت عالي المعنوية للصفات عدد الأيام اللازمة للنضج، وزن الاوراق الجاف، وزن السيقان الجاف، نسبة الأوراق الى السيقان وعدد العقد البكتيرية/نبات، بينما كانت معنوية للصفات طول النبات. وجد بأن الموقع الثاني سجلت أعلى القيم للصفات طول النبات، وزن الاوراق الجاف، وزن السيقان الجاف، نسبة الأوراق الى السيقان وعدد العقد البكتيرية/نبات 60,080 سم، 1,970 غم، 1,850 غم، 2,600، 16,390 على التوالي. متوسط كلا الموقعين كانت اختلاف عالي المعنوية بسبب تأثير الخطوط للصفات عدد الأيام اللازمة للنضج، وزن الاوراق الجاف، وزن البذور هكتار<sup>-1</sup>، نسبة الأوراق الى السيقان وعدد العقد البكتيرية/نبات<sup>-1</sup>. خط رقم IF067 أنتجت أعلى القيم للصفات عدد الأيام اللازمة للنضج، وزن السيقان الجاف، وزن العقد البكتيرية/نبات<sup>-1</sup> مع 155,600 يوم، 4,990، 14.27 على التوالي. تأثير معدل البذار على حاصل البذور ومكوناته لنبات الهريطمان في الموقعين ومتوسط الموقعين كانت عالي المعنوية للصفات عدد القترات نبات، لحاصل البذور، الحاصل البايولوجي، ودليل الحصاد. وكمعدل الموقعين فأن استخدام 140 كغم/هكتار بذور اعطى أعلى القيم لمعظم الصفات المدروسة.

الكلمات المفتاحية: معدل البذار، الموقع، الهريطمان، الحاصل ومكوناته، التراكيب الوراثية

## Appendices

### Appendix (1) Mean squares of variance analysis of grass pea for some growth and forage characters

| Qlyasan                   |     |                   |                        |                       |                  |                 |                     |                     |                                 |
|---------------------------|-----|-------------------|------------------------|-----------------------|------------------|-----------------|---------------------|---------------------|---------------------------------|
| S.O.V                     | d.f | Plant Height (cm) | No. of branches/ plant | Days to %50 flowering | Days to maturity | Leaf stem ratio | Leaf dry weight (g) | Stem dry weight (g) | No. of bacterial nodules /plant |
| Block                     | 2   | 71.16n.s          | 0.609n.s               | 0.77n.s               | 197.017n.s       | 0.065n.s        | 0.064n.s            | 0.225n.s            | 0.418n.s                        |
| Lines                     | 3   | 914.125*          | 0.62n.s                | 6.06*                 | 151.782n.s       | 4.741**         | 0.677**             | 0.577**             | 11.99**                         |
| Seeding rate              | 3   | 181.301*          | 9.049**                | 4.132n.s              | 189.65n.s        | 1.702**         | 0.819**             | 2.249**             | 27.191**                        |
| Line × Seeding rate       | 9   | 228.534*          | 1.123n.s               | 15.025**              | 236.713n.s       | 1.181**         | 0.395**             | 0.249*              | 21.858**                        |
| Error                     | 30  | 33.599            | 0.77                   | 1.528                 | 204.286          | 0.026           | 0.027               | 0.091               | 1.108                           |
| Kanipanka                 |     |                   |                        |                       |                  |                 |                     |                     |                                 |
| Block                     | 2   | 264.352*          | 0.226n.s               | 2.161n.s              | 4.467n.s         | 5.459n.s        | 0.082n.s            | 1.032n.s            | 0.687n.s                        |
| Lines                     | 3   | 93.52n.s          | 1.536n.s               | 4.913*                | 62.376**         | 0.451n.s        | 1.256**             | 1.358n.s            | 9.577**                         |
| Seeding rate              | 3   | 176.234*          | 3.463*                 | 3.699*                | 89.432**         | 11.97**         | 8.22**              | 0.669n.s            | 0.507n.s                        |
| Line × Seeding rate       | 9   | 82.334n.s         | 0.693n.s               | 4.125**               | 47.569**         | 3.32n.s         | 2.143**             | 0.488n.s            | 14.454**                        |
| Error                     | 30  | 54.941            | 0.975                  | 1.119                 | 1.733            | 2.093           | 0.136               | 0.557               | 1.314                           |
| Average of both locations |     |                   |                        |                       |                  |                 |                     |                     |                                 |
| Location                  | 1   | 1538.241*         | 0.65n.s                | 3042n.s               | 5196**           | 74**            | 22.85**             | 14.09**             | 47.88**                         |
| Error a                   | 4   | 167.5756          | 0.418                  | 1.466                 | 100.7            | 2.76            | 0.073               | 0.629               | 0.553                           |
| Lines                     | 3   | 669.129*          | 1.815n.s               | 9.532**               | 67.64n.s         | 1.69n.s         | 1.876**             | 1.293*              | 21.46**                         |
| Line×L                    | 3   | 338.516*          | 0.342n.s               | 1.441n.s              | 146.5n.s         | 3.5*            | 0.057n.s            | 0.641n.s            | 0.11*                           |
| Seeding rate              | 3   | 193.583*          | 11.25**                | 1.35n.s               | 191.3n.s         | 11.2**          | 6.278**             | 10.89**             | 44.06**                         |
| Seeding rate × Location   | 3   | 57.908**          | 1.75n.s                | 6.481*                | 87.77n.s         | 2.49*           | 2.758**             | 1.65**              | 2.011*                          |
| Line× Seeding rate        | 9   | 247.184n.s        | 0.775n.s               | 8.93**                | 185.7n.s         | 3.55**          | 1.936**             | 0.405n.s            | 39.7**                          |
| Line × Seeding rate×L     | 9   | 63.68**           | 1.04                   | 10.22**               | 98.59n.s         | 0.95n.s         | 0.602**             | 0.332n.s            | 1.152n.s                        |
| Errorb                    | 60  | 44.27             | 0.874                  | 1.324                 | 103              | 1.06            | 0.081               | 0.324               | 1.211                           |
| N.S noSignificant         |     |                   |                        |                       |                  |                 |                     |                     |                                 |
| *Significant              |     |                   |                        |                       |                  |                 |                     |                     |                                 |

**Appendix (2)** The mean squares of variance analysis of grass pea for seed yield and its components

| Qlyasan Location          |     |                   |                 |                  |                     |                    |                  |                        |               |
|---------------------------|-----|-------------------|-----------------|------------------|---------------------|--------------------|------------------|------------------------|---------------|
| S.O.V                     | d.f | No.of pods /plant | Pod length (cm) | No.of seeds/ pod | Weight of seeds/pod | 100 seed weight(g) | Seed yield kg /h | Biological yield kg/ h | Harvest index |
| Block                     | 2   | 2.385n.s          | 1.121n.s        | 0.055n.s         | 0.008n.s            | 0.198n.s           | 2444296.106**    | 791.5294n.s            | 0.016**       |
| Lines                     | 3   | 19.907*           | 0.105n.s        | 0.339n.s         | 0.033n.s            | 28.01**            | 10242643.624**   | 18733713.438**         | 0.0661**      |
| Seeding rate              | 3   | 14.227n.s         | 0.107n.s        | 0.098n.s         | 0.011n.s            | 1.38n.s            | 47663777.1339**  | 131684624.084*         | 0.0639**      |
| Line × Seeding rate       | 9   | 19.969*           | 0.134n.s        | 0.063n.s         | 0.04n.s             | 3.79**             | 3707754.554**    | 2585145.315**          | 0.0281**      |
| Error                     | 30  | 7.73              | 0.377           | 0.166            | 0.018               | 0.558              | 184903.8         | 760032                 | 0.002         |
| Knipanka Location         |     |                   |                 |                  |                     |                    |                  |                        |               |
| Block                     | 2   | 3.51n.s           | 1.395*          | 0.214n.s         | 0.015n.s            | 0.977n.s           | 74713.157n.s     | 12894.178n.s           | 0.00008n.s    |
| Lines                     | 3   | 13.34n.s          | 0.143n.s        | 0.286n.s         | 0.048n.s            | 29.98**            | 20018384.327**   | 3366797.257**          | 0.074**       |
| Seeding rate              | 3   | 2.34n.s           | 0.93*           | 0.143n.s         | 0.01n.s             | 0.651n.s           | 25216068.792**   | 198231574.302**        | 0.003n.s      |
| Line × Seeding rate       | 9   | 17.67*            | 0.187n.s        | 0.136n.s         | 0.17n.s             | 1.087n.s           | 750280.672*      | 1051414.015*           | 0.008**       |
| Error                     | 30  | 7.73              | 0.266           | 0.145            | 0.014               | 0.719              | 332754.6         | 407937                 | 0.002         |
| Average of both Locations |     |                   |                 |                  |                     |                    |                  |                        |               |
| Location                  | 1   | 27.2**            | 1.584n.s        | 0.78n.s          | 0.011n.s            | 9.769**            | 24837176.04**    | 125789709.4**          | 0.0095n.s     |
| Error a                   | 4   | 2.95              | 1.258           | 0.135            | 0.011               | 0.588              | 1259505          | 6842.85                | 0.0084        |
| Lines                     | 3   | 32.9**            | 0.022n.s        | 0.199n.s         | 0.066*              | 57.72**            | 16936293.63**    | 18492745.76**          | 0.058**       |
| Line×L                    | 3   | 0.4n.s            | 0.226n.s        | 0.425n.s         | 0.015n.s            | 0.276n.s           | 13505995.49**    | 3607764.931**          | 0.081**       |
| Seeding rate              | 3   | 33.6**            | 0.243n.s        | 0.1n.s           | 0.039n.s            | 1.911*             | 70986975.44**    | 323993433.5**          | 0.022**       |
| Seeding rate × Location   | 3   | 0.29n.s           | 0.123n.s        | 0.085n.s         | 0.006n.s            | 0.853n.s           | 1892870.487**    | 5922764.931**          | 0.044**       |
| Line× Seeding rate        | 9   | 36.2**            | 0.106n.s        | 0.079n.s         | 0.047**             | 0.819n.s           | 20810838.611**   | 2024257.36**           | 0.022**       |
| Line × Seeding rate*L     | 9   | 1.44n.s           | 0.215n.s        | 0.12n.s          | 0.01                | 4.061**            | 2312611.227**    | 1612301.968**          | 0.01132*      |
| Error b                   | 60  | 6.67              | 0.322           | 0.156            | 0.016               | 0.638              | 258829           | 583534                 | 0.002         |

N.S not Significant \*Significant

**Appendix (3)** Meteorological data for Qlyasan and Knipanka locations

| Month          | Qlyasan location |                  |                |               | Knipanka location |                 |                 |               |
|----------------|------------------|------------------|----------------|---------------|-------------------|-----------------|-----------------|---------------|
|                | Mini. Temp. (C°) | Maxi. Temp. (C°) | Avg. Temp.(C°) | Rainfall (mm) | Mini. Temp.(C°)   | Maxi. Temp.(C°) | Avg. Temp. (C°) | Rainfall (mm) |
| October        | 10.4             | 33.1             | 21.2           | 10            | 22.6              | 30              | 15.1            | -             |
| November       | 7.6              | 23.9             | 14.2           | 114.6         | 14.4              | 20              | 8.8             | 71            |
| December       | -2.5             | 17.8             | 7              | 22.2          | 10.2              | 16.1            | 4.4             | 18.5          |
| January        | 1.4              | 15.6             | 7.8            | 72.4          | 7.8               | 12.5            | 3.1             | 60            |
| February       | -2.3             | 20.9             | 8.7            | 323           | 10.3              | 14.9            | 6.1             | 281           |
| March          | 1                | 24.4             | 13             | 44.6          | 14.7              | 21.3            | 8.1             | 19            |
| April          | 2.2              | 31.6             | 17.4           | 98.6          | 17.1              | 24              | 10.5            | 90.5          |
| May            | 13               | 38.1             | 24.7           | 70.4          | 22.2              | 29.5            | 15              | 68            |
| Total rainfall |                  |                  |                | 755.8         |                   |                 |                 | 608           |