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Effect of NPS Fertilizers Application and Irrigation System on Growth and Yield of Snap Bean (Phaseolus vulgaris l): A Review

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Abstract
Snap bean (*Phaseolus vulgaris* L.) is the most important vegetable crop for export and local market. Even though snap bean is many important, the yield haven been obtained is low mainly due to decline soil fertility and irrigation system problems. Now a day's Ethiopian soils not only limiting phosphorus and nitrogen nutrients, but also sulfur is a major problem. Water stress that reduced yield and pod quality of snap bean. Irrigation schedule is very crucial to make the most efficient use of irrigation system to avoid excessive water and shortage problem. Snap bean required high amount of nitrogen fertilizer, due to its weak fixation capacity of atmospheric nitrogen. Application of nitrogen at 150 kg N ha^{-1} increased growth and pod yield parameters snap bean. The optimum rate of phosphorus at 21 kg P ha^{-1} was applied at the time of seeding in the form of triple super phosphate for snap bean production in Ethiopia. Application of sulfur at 30 kg S ha^{-1} increased nitrogen, phosphorus and sulfur nutrient availability. Today there is lack of information on snap bean production in Ethiopia, especially NPS fertilizers application and under different irrigation system. Snap bean producers needs optimum rate of NPS fertilizers application and with different irrigation system, so research institutions and higher learning educations generate information to snap bean producers in Ethiopia at site-specific.
Keywords: Fertilizers, Irrigation System, Snap bean, Yield
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1. Introduction

Snap bean (*Phaseolus vulgaris* L.) comprises a group of common bean that has been selected for succulent pods with reduced fiber primarily grown for its young edible and fleshly pods (Myer and Baggett, 1999; Getachew, 2006). It is the most important vegetable crop which is rich in protein, carbohydrates, calcium, vitamins and amino acids. It is also the most important vegetables crop have been exported from developing countries and several African countries have focused on exporting snap beans to high-value European markets (Ghonimy *et al.,* 2009).

In Ethiopia, the production of snap beans started by large commercial farmers in the early 1970s. It is mainly produced in upper awash and the lake region in eastern Shoa (EHPEA, 2011). Its' production in Ethiopia has increased from time to time both for export and local markets (Hussein *et al*., 2015). It is the most important export vegetable crop extensively produced for export with the highest share (94%) among all vegetables (Lemma *et al*., 2006; Lemma, 2011). Globally, the yield for snap bean ranges between 8 and 10 t ha^{-1}, with high yields of more than 14 t ha^{-1} being recorded in China, USA and Latin America (CIAT, 2006). The average pod yield in smallholder farms in eastern and central Africa is low ranging between 4 and 8 t ha^{-1} (Kimani *et al*., 2004) due to poor soil fertility and inadequate moisture (Amare and Haile, 1989).

Water stress problems can reduce pod yield about 20% when water stress persisted for 15 days before blooming, 18-22 days during blooming, or 15 days before ripening. Water stress cause high fiber content in the green pods (Mack *et al*., 1982). Scheduling water application is very critical to make the most efficient use of irrigation system to avoid excessive water and shortage (Hakan *et al*., 2008; Mohamed *et al.,* 2012). Other factor declining soil fertility is a major problem in snap bean production areas in eastern Africa including Ethiopia. Previously, Ethiopian smallholder farmers were limited to DAP and urea, fertilizers that only delivered N and P nutrients (Khalid, 2013). Farmers and farmer corporative union have already requested that the government make the new blended fertilizers more available (MOA, 2014). Soil tests show that many croplands lack of other essential nutrients such as sulfur, boron, potassium, zinc, and copper (ATA, 2015).

The N fertilizer requirement of snap bean is high, due to its weak fixation capacity of atmospheric N compared to other beans (Feleafel and Mirdad, 2014). In the tropics region, the amount of available P in soils is largely insufficient to meet the demand of beans and thus, P deficiency is prevalent in bean crops (Azmera and Pellegrino, 2017). Snap bean has high demand of sulfur due to production of several protein containing materials and fatty acids. Now, day's S deficiency is becoming widespread throughout the world due to the use of sulfur-free fertilizers, intensive cropping, and use of high-yielding varieties (Alemu *et al.,* 2016). Thus, this review was carried out with the following objectives:

- To review the effect NPS fertilizers application on growth and yields of snap bean.
- To review the effect of different irrigation system on growth and yield of snap bean.

2. Effect of NPS Fertilizers and Irrigation System on Growth and Yield of Snap Bean

2.1. Snap Bean Production

Suitable production areas of snap bean in Ethiopia have been indicated as the areas with altitude between 1000-2100 m.a.s.l. Mean maximum and minimum temperature of less than 32⁰C and greater than 10⁰C, respectively with a rainfall ranging from 350 to 700 mm well distributed over 70-90 days (Amare and Haile, 1989). It is grow best in well-drained soils high in organic matter with pH 5.5 to 6.5. They are sensitive to cold and even a slight frost can cause damage. Its' require a continuous supply of moisture, especially during pod set and pod development (Michael and Orzolek, 2002).

2.2. Effect of NPS Fertilizers Application on Growth and Yield of Snap Bean

2.2.1. Effect of nitrogen on growth and yield of snap bean

Nitrogen requirement of snap bean is high due to lack of NOD genes, hence it does not have effective nodules and this makes them poor in symbiotic nitrogen fixing (Kushwaha, 1994). According to Andrea *et al.* (2008) stated that N application increased the vegetative growth, fresh and dry weight pods, reproductive parts, and improves pod quality, but the highest N doses delayed the ripening of snap bean. As N levels, increases from 0 to 150 kg ha^{-1} the growth and yield attributing of snap bean parameters were increased. Application of 100 $kg \cdot N \cdot ha^{-1}$ increased pod yield by 42 and 17% as compared to the control and rhizobial inoculation, respectively (Table 1) (Hussein *et al.*, 2015). According to Tesfaye (2017) showed that application of 92/69 N P_2O_5 kg ha^{-1} gave the highest pod yield (Figure 1). The mineral N in the soil is mainly nitrate (NO_3^-) and to a lesser extent ammonium ($NH4^+$) (Kamanu *et al.*, 2012). Nitrogen deficiency results in stunted, reduction yield and chlorotic leaves in snap bean (Feleafel and Mirdad, 2014).

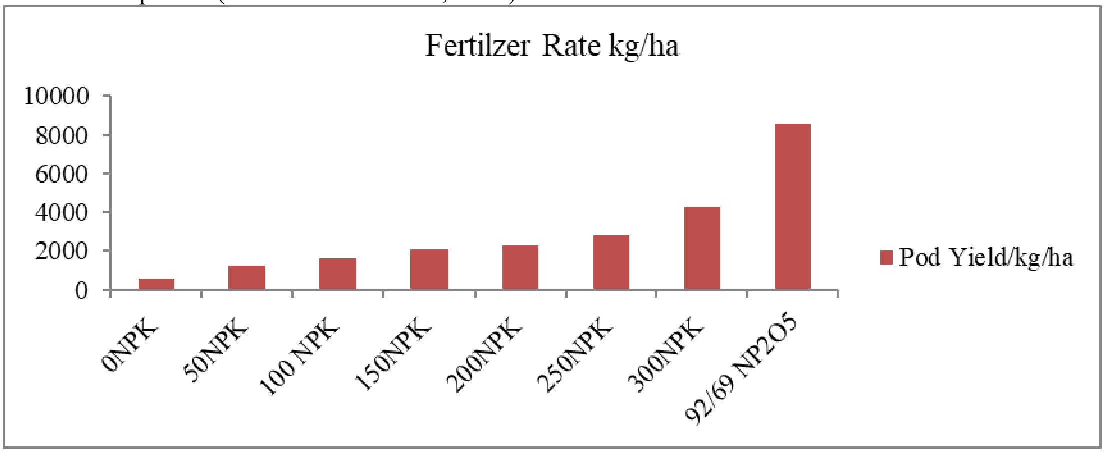

Figure 1. Mean pod yield of snap bean as affected by different rates of fertilizer application
Source: Tesfaye, 2017

Table 1. Pod marketable yield, length, diameter, titratable acidity and total soluble solids (TSS) of snap bean affected by nitrogen treatment and cultivars.

N. Treatment	Marketable yield (t/ha)	Pod length (mm)	Pod diameter (mm)	Titratable acidity (%)	TSS (ºBrix)
100 kg N ha^{-1}	20.54ᵃ	125.0	7.56	0.0769ᵃ	5.54
Rhizobium etli (HB) 429)	16.92b	122.0	7.49	0.0747ᵃ	5.50
Zero N	14.39ᶜ	120.2	7.38	0.0701ᵇ	5.46
Cultivar					
Andante	11.70c	106.4ᵉ	6.01ᵉ	0.0765ᵃ	5.44ᵇ
Boston	17.94ᵇ	123.1ᵇᶜ	7.11ᵈ	0.0768ᵃ	5.41ᵇ
Contender Blue	16.94ᵇ	112.8ᵈ	7.38ᶜᵈ	0.0747ᵃᵇ	5.47ᵃᵇ
Lomami	18.14ᵃᵇ	122.7ᶜ	7.44ᶜᵈ	0.0775ᵃ	5.51ᵃᵇ
Melkassa 1	20.60ᵃ	125.8ᵇᶜ	8.68ᵃ	0.0668ᶜ	5.49ᵃᵇ
Melkassa 3	16.95ᵇ	133.8ᵃ	8.32ᵇ	0.0726ᵃᵇᶜ	5.56ᵃ
Paulista	17.98ᵇ	126.5ᵇᶜ	7.36ᶜᵈ	0.0700ᵇᶜ	5.57ᵃ
Volta	18.00b	128.1ᵇ	7.48ᶜ	0.0763ᵃ	5.56ᵃ

Means followed by the different letters in a treatment grouping column differ significantly based on LSD, P<0.05.
Source: Hussein *et al.*, 2015

2.2.2. Effect of phosphorus on growth and yield of snap bean

Phosphorus plays a vital role in protein synthesis, photosynthesis, respiration, energy reactions, genetic transfer, cell division and development of new tissue (Raghothama and Karthikeyan, 2005; Ali *et al.,* 2013). It is also essential as a component on structure of DNA, RNA, ATP, ADP, NADPH, which act on growth and development of vegetative and generative organs: flower, fruit and pods (Yadav *et al*., 2014). Plants absorb P mostly in soluble (H_2PO4^- and HPO_4^{-2}) forms (Raghothama and Karthikeyan, 2005). The phosphate fertilization of soils has always been important, because it fixed as water insoluble Fe and Al phosphates in acidic soils or Ca and Mg phosphate in alkaline soils (Singh and Kapoor, 1994).

According to Rafat and Sharifi (2015) revealed that application of P at 50 kg P ha^{-1} increased plant height, pod length, pods number plant^{-1} and pod yield (Table 2). Snap beans applied 100 kg P ha^{-1} produced 71% greater pod yield than controls (Faegheh and Hashem, 2015). The recommended rate of P 21 kg P ha^{-1} was applied at the time of seeding in the form of TSP for snap bean production in Ethiopia (Hussein *et al*., 2015).

Table 2. Effect of phosphorus fertilizers on growth, yield and yield components

P (kg ha^{-1})	PH (cm)	PL (cm)	NPP	PY (kg ha^{-1})	BY (kg ha^{-1})	HI (%)
0	26.67c	14.30b	17.00d	3833.33c	6760.00c	56.71b
25	29.00bc	15.67b	19.00bc	4043.33b	6946.67a	58.21b
50	33.00a	18.37a	21.00a	4310.00a	6920.00ab	62.19a
75	30.67ab	16.17ab	20.00ab	4303.33a	6823.33bc	63.17a
100	27.67bc	15.17b	17.67cd	3923.33bc	6300.00d	62.29a
LSD (5%)	3.78	2.61	1.85	147.2	100.55	2.06

The columns having common letter (s) do not differ significantly at 5% level of significance P = Phosphorus fertilizers. PH Plant height, PL = Pod length, NPP = Number of pods per plant, PY = Pod yield, BY = Biological yield, HI = Harvest index

Source: (Rafat and Sharifi, 2015)

2.2.3. Effect of sulfur on growth and yield of snap bean

Sulfur is one of the essential nutrients for plant growth with crop requirement similar to phosphorus. Its' serves important structural, regulatory and catalytic functions in the context of proteins, and as a major cellular redox buffer in the form of the tri-peptide glutathione and certain proteins such as thioredoxin, glutaredoxin and protein disulfide isomerase. Application of sulfur at 45 kg S ha^{-1} increased number of fresh and dry nodule weight and nodules plant^{-1} (Figure 2).

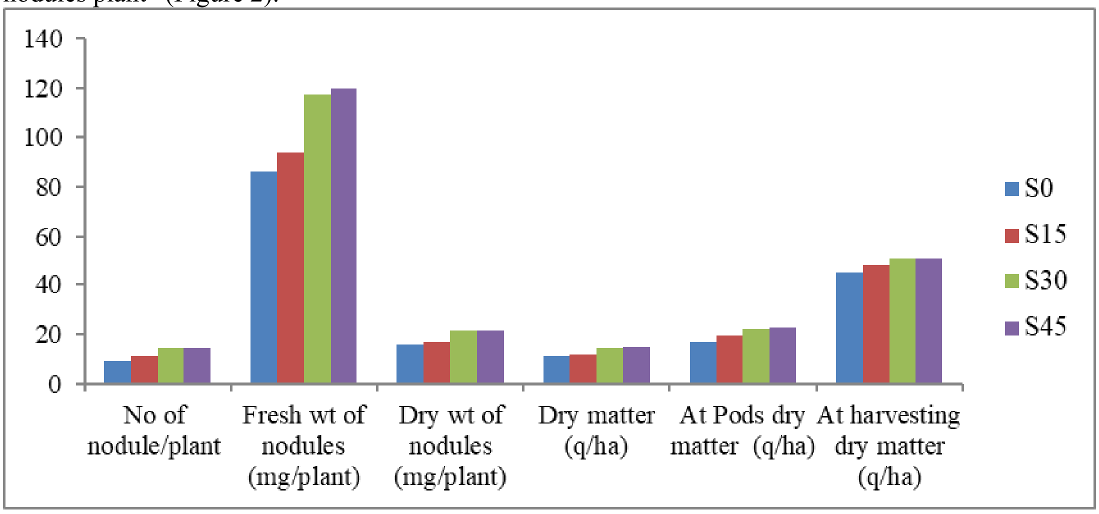

Figure 2. The effect of sulfur application on growth and yield of snap bean (Var. Contender)

Source: Mumtaz *et al.,* 2014

Application of sulfur from 0 to 30 kg S ha^{-1} increased N, P, K, S, and B by 6.43, 22.22, 26.92, 18.30 and 46.53 in pods, respectively (Mumtaz *et al.*, 2014) (Figure 3). Application of gypsum at the rate of 60 Kg ha^{-1} produced significantly higher pod length (Singh and Aggarwal, 1998). Although the dry weight of nodules at higher levels of S showed a tendency to increase, but this was not significantly beyond 20 kg S ha^{-1} (Ganeshhamurthy and Reddy, 2000). The available form of sulfur in plant is sulfate (SO_4^{-2}) (Rob *et al.*, 2013). Sulfur is immobile in plants, does not readily move from old to new growth, leads chlorosis of younger leaves and at later stages; leaves show necrotic symptoms and die (Khan and Mazid, 2011).

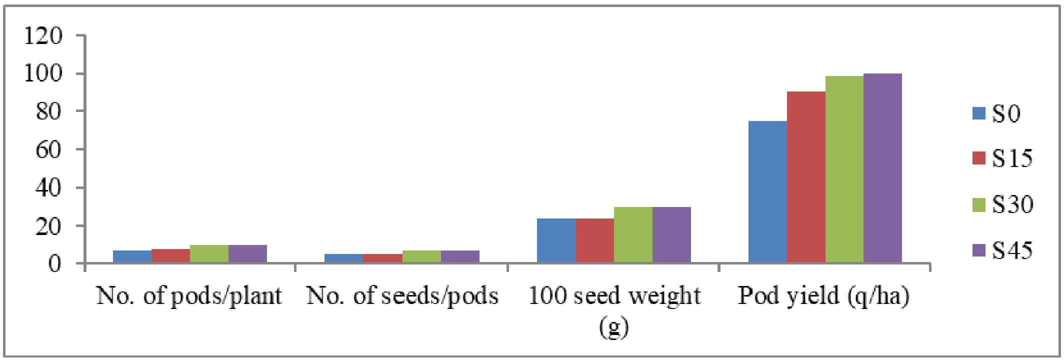

Figure 3. The effect of sulfur fertilizer on yield and yield attributing characters of snap bean
Source: Mumtaz *et al*., 2014

2.3. Effect of Irrigation System on Growth and Yield of Snap Bean

According to FAO (2002) declared that to choose an irrigation method, the farmer must know the advantages and disadvantages of the various methods. The suitability of the various irrigation methods, i.e. surface and pressurized irrigation depends mainly on the following factors: natural conditions, type of crop, type of technology, previous experience with irrigation, required labor inputs, costs and benefits.

2.3.1. Furrow Irrigation

Traditionally, farmers in the central rift valley of Ethiopia have been using the most conventional surface irrigation system; most commonly furrow irrigation system (Abdulaziz, 2015). This method is best suited to deep, moderately permeable soils and uniform relatively flat slopes. It requires smaller initial investment compared to drip irrigation systems (Michael, 1997). Furrows provide better on-farm water management flexibility under many surface irrigation conditions. The discharge per unit width of the field substantially reduced and topographical variations can be more severe (Walker, 1989).

Table 3. Effect of different irrigation systems and irrigation regimes on vegetative growth characters of beans

Treatments	Growth characters					Dry weight (gm)		
	PH (cm)	BNP	LNP	PNP	LA (cm)	Stem	Leaves	Total plant
SD	46.89a	8.81a	25.03a	3.39b	2592b	4.74a	6.10a	13.08a
SSD	47.99a	8.38b	23.23a	3.62a	2629a	4.99a	5.89a	13.16a
GP	46.33a	8.13c	21.33c	3.27b	2007c	3.58c	3.95b	9.19b
FI	42.72b	8.09c	18.67d	2.32c	1754d	4.29a	3.93b	8.27c
100% ETc	47.49a	8.44a	22.75a	3.42a	2649a	4.00b	Ns	11.99a
80% ETc	46.08b	8.33ab	21.98b	3.31a	2107b	3.79c	Ns	10.56b
60% ETc	44.16c	8.30b	21.61c	2.71b	1980c	4.47	Ns	10.22

PH: Plant height, BNP: Branches no per plant, LNP: Leaves per plant, PNP: Pods per plant, LA: Leave area, SD: Surface drip, SSD: subsurface drip, GP: gated pipes, FI: furrow irrigation
Source: El-Noemani *et al.,* 2010

2.3.2. Drip irrigation

Drip irrigation is an irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters (Sabreen *et al*., 2014). Compared to sprinkler and furrow irrigation methods (with efficiencies of 60-70% in high management systems), drip irrigation can achieve 90-95% efficiency (Isaya, 2001). Its' allows small, but frequent application of water with minimum losses (Taha *et al*., 2011).

Drip irrigation use in adverse factors, low hazards, and conservation of proper soil structure, possible control of pests and weeds and decreasing the adverse effect of salinity. However, the disadvantages of this system include increases in capital expenditure, incidents of orifices clogging, incidents of salinity build-up and need for technical handling (Charles, 2007). Snap bean pod diameter was increase with increasing irrigation level to 100% pan (Abdel-Mawgoud, 2006). The highest values number of branches, number of leaves, leaves area and leaf dry weight were recorded at surface followed by sub-surface drip irrigation (Table 3) (El-Noemani *et al*., 2010).

3. Summary and Conclusions

Snap bean is one of the most important vegetable crop both for export and local market, but the yield is low due to two key abiotic constraints are low soil fertility and water stress. Water stress during the blossom pod set period can cause blossom and pods to drop; resulting to poor pod quality and reduced yield.

Now a day's soil tests show that cropland lacks not only N and P, but also other essential nutrients such as sulfur nutrient. As N levels increases from control to 150 kg N ha^{-1} the growth and yield attributing of snap beans parameters were increased. As P fertilized applied at 21 kg P ha^{-1} gave higher pod yields. The highest pod yield obtained by application of 30 kg S ha^{-1}, which might be due to the cumulative favorable effect of higher number of branches and pods $plant^{-1}$.

Generally, today there is lack of information on snap bean production in Ethiopia, especially NPS fertilizers application and under different irrigation system, so research institution and higher learning education generate information to snap bean producers at site-specific.

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