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Effect of seed size and sowing depth on seedling emergence and seed yield of pea (*Pisum sativum*)

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Abstract
A field experiment was carried out at experimental field of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P.) during November 2016 to February 2017. The experiment was laid out in Randomized Block Design (RBD) with 6 treatments and each replicated thrice. Seeds are graded into large (37.60g in 180 seeds) and small seeds (25.28g in 180 seeds) and sown at different sowing depth viz. 3cm, 5cm and 7cm. Large seed sown at 3cm depth produced maximum number of seedlings and higher plant height. Large seeds sown at 5cm sowing depth produced higher harvest index (66.46%). In small seeds, seeds sown at 5cm depth had higher shoot length (11.94 cm) and dry weight after harvest (11.15 g) and small seeds sown at 3cm depth produced better plant height (42.58) and higher number of leaves (72.75).

Keywords: *Pisum sativum*, large seed, small seed, seedling emergence, seed yield.

Introduction
Seed size is the main factor that affects seeding rates. Environmental variation affects the seed size and result in production of smaller seeds under unfavourable conditions. Seeds thus produced affect the germination seed vigour, field stand and processing recovery (Dighe and Patil, 1981) [3]. The possible effect of seed size on germination is associated with the length of the structure that form the seedling, but not necessarily with the subsequent biochemical conversion of storage reserves into germinating tissues. reported that the seed size does not affect the yield "per-se", but better field stand with vigorous seedlings helps to perform ideally under the existing environment. Bigger seeds are associated with greater seed vigour and germination (Dighe and Patil, 1981) [3] in sorghum. Often farmer retained seeds, lacked seed vigour reflected in the seedling emergence, seedling vigour and seedling biomass.
Large seed size significantly increased seedling survival compared to small seed size by 25%. Result indicated that the post-sowing compaction and increased seed size may benefit seedling survival. The use of differing seed size physical parameters as discriminating criteria for seed among varieties and different species has been previously reported. showed that small muskmelon seeds had the lowest percentage germination, emergence, and the lowest seedling growth demonstrating that the there is an association between seed parameters and seed quality.
Another factor which determines the emergence and yield of crop in the field is sowing depth. Too shallow sowing results in poor germination due to inadequate soil moisture at the top soil layer. On the other hand, deep sowing can also significantly reduce crop emergence and yield. The deeper the seeds are placed the more time it will take for them to emerge from the soil. The seeds sown deeper should produce shorter seedlings than the seeds sown at recommended depth of the crop

Materials and methods
The experiment was carried out with KSP110 pea variety in the experimental field of Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad during the period from November 2016 to February 2017.
Two factors were included in the experiment viz. Seed size and depth of sowing. Seeds are sorted by hand into large seed (37.60 g in 180 seeds) and small seeds (25.28g in 180 seeds). Seeds are sown at 3cm, 5cm and 7cm. The resulted six treatment combinations are arranged in Randomized Block Design with three replications.
The parameters measured in the trial included: seedling emergence, seedling height, seedling length (3 weeks after sowing), dry weight of plant at 40 days after sowing, plant height, number of leaves, number of branches, plant dry weight after harvest, 100-seeds weight and harvest index.

Results and discussions

Effect of seed size and sowing depth did not significantly influence the seedling emergence (Table no.1). Large seeds sown at 3cm depth, T3 (large seed + 3cm sowing depth), emerged more rapidly than the small seeds sown at 3cm depth, T0 (small seed + 3cm sowing depth). On 13th day after sowing, lowest seedling emergence was recorded in small seed sown at 3cm depth, T0 (small seed + 3cm sowing depth) (14.67). In small seeds, seeds sown at 5cm depth, T1 (small seed + 5cm sowing depth), showed higher seedling emergence than 3cm depth sowing on 8th, 9th and 10th day after sowing. On 13th day after sowing, highest seedling emergence in small seed was recorded in T2 (small seed + 7cm sowing depth) (16.67).

Highest seedling heights were recorded in large seeds sown at 3cm depth (Table no.2), T3 (large seed + 3cm sowing depth) (3.38cm, 3.68cm, 3.98cm and 4.66cm). At 13th day after sowing, small seeds sown at 7cm depth, T2 (small seed + 7cm sowing depth), had the lowest seedling height (3.41cm). Seedling heights tend to decreased with the increased in sowing depth and larger seeds were able to produced higher seedling height than the small seed sizes at different sowing depths. The corresponding increased in the parameter stated due to the larger size seeds, may be as a result of a large embryo and high food reserves for the supply of energy. This finding is supported by the fact that larger size seeds in turn produced larger embryo and have a high respiration rate that result in greater field emergence than the small size seeds. Nagaraju (2001) [12] noticed seedling length (25.26cm), field emergence (80%) in large seeds compared to small seeds (22.33cm, 77.83%) respectively, in sunflower.

The highest root length was recorded in large seed at 5cm depth (Table no.3), T4 (large seed + 5cm sowing depth) (8.17cm) on 3 weeks after sowing. Small seeds sown at 7cm depth, T2 (small seed + 7cm sowing depth), had the shortest root length (3.50cm). Large seed sown at 5cm depth, T4 (large seed + 5cm sowing depth), produced highest shoot length (14.63cm). Small seed sown at 7cm depth, T2 (small seed + 7cm sowing depth), had the shortest shoot length (10.5cm). In both seed sizes, seeds sown at 5cm depth produced higher shoot length. M.I. El-Abady (2015) observed that seed size significantly influence the shoot development in maize. The tallest shoot was obtained from large seeds (30.66cm) while, the lowest one (25.66cm) was obtained from small seeds. Similarly, large seeds produced the tallest shoot through the different depth. Planting at 6cm depth shoot length of the large seeds were 24.33cm. Meanwhile, the shortest one was produced from small seeds (16.00cm).

Highest dry weight at 40 days after sowing was recorded in large seed sown at 5cm depth (Table no.3), T4 (large seed + 5cm sowing depth) (1.44g) and lowest was recorded in small seed sown at 7cm depth, T2 (small seed + 7cm sowing depth) (0.64g). In small seeds plant dry weight decreased with the increased in sowing depth.

Large seed sown at 3cm depth, T3 (large seed + 3cm sowing depth), had the highest plant height (49.50cm) and small seed sown at 5cm depth (Table no.4), T1 (small seed + 5cm sowing depth), had the lowest (35.33cm). 3cm sowing depth produced higher plant height in both the seed sizes. In small seeds, seed sown at 7cm depth, T2 (small seed + 7cm sowing depth), produced higher plant height (41.17cm) than the seed sown at 5cm depth, T1 (small seed + 5cm sowing depth) (35.33cm). Nagaraju (2001) [12] observed higher plant height (97.83cm) in plants raised by larger seed size (3.0mm oblong hole screen) compared to small seeds (seeds passed through 3.00mm screen) plant height (90.50cm) in sunflower.

Maximum number of branches was recorded in large seed sown at 3cm depth, T3 (large seed + 3cm sowing depth) (16.58) and the minimum was recorded in small seed sown at 3cm depth, T0 (small seed + 3cm sowing depth) (11.42) (Table no.4). Number of branches decreased with the increased at sowing depth in large seed while in small seed it was increased with increased at sowing depth. Number of leaves were higher in large seed sown at 3cm depth, T3 (large seed + 3cm sowing depth) (96.58) and lowest in small seed sown at 5cm depth, T0 (small seed + 3cm sowing depth) (67.83). Mohammed Hefjul Kabir (2004) [9] observed that seed size had no significant effect on total leaf number per plant but highest leaf number (94.00) was recorded in large seeds in groundnut.

Large seed sown at 3cm depth, T3 (large seed + 3cm sowing depth), had the highest plant dry weight after harvest (11.21g) (Table no.5). Small seed sown at 3cm depth, T0 (small seed + 3cm sowing depth), had the lowest plant dry weight after harvest (7.39g). In small seeds, seeds sown at 5cm depth, T1 (small seed + 5cm sowing depth), produced higher plant weight after harvest (11.15g). Small seed sown at 5cm depth, T1 (small seed + 5cm sowing depth), produced higher 100-seed weight (18.92g) and the lowest recorded in small seed sown at 3cm depth, T0 (small seed + 3cm sowing depth) (15.15g) (Table no.5). In large seed, 100-seed weight tends to increased with increased at sowing depth from 5cm to 7cm but in small seed it was decreased with increased at sowing depth from 5cm to 7cm.

Large seed sown at 5cm sowing depth, T4 (large seed + 5cm sowing depth), produced higher harvest index (66.46%) and small seed sown at 5cm depth, T1 (small seed + 5cm sowing depth), produced lowest harvest index (40.28%) (Table no.5). Harvest index increased when sowing depth was increased from 5cm to 7cm in small seeds. Rezapour. R *et al*., (2013) [13] reported in soybean that the large seeds harvest index was 11.94% higher than small seeds. Singh and Kailasanathan (1976) [14] reported that larger seeds of spring wheat produced higher yields than smaller seeds.

On the basis of result obtained, it was concluded that large seed sown at 3cm depth produced maximum number of seedlings, higher plant height and more vigorous plants resulted in more yield. In small seeds, seeds sown at 5cm depth have higher shoot length and higher dry weight after harvest.

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